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DENTAL SIZE AND FREQUENCY OF ANOMALIES IN THE TEETH OF A SMALL-BODIED POPULATION OF MID-LATE HOLOCENE MICRONESIANS, PALAU MICRONESIA.

By

Mirriam Tawane

A thesis submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy.

Johannesburg, 2012.

DECLARATION

I declare that this thesis is my own, unaided work. It is submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Signature: 

Date: 28 March 2012

ABSTRACT

The aim of this study was to compare the size of the teeth of a sample of small-bodied fossil humans from the island of Palau, Micronesia, with modern and fossil human populations from mainland southern Africa. Four modern human population groups and a sample of Holocene human remains were examined for comparison. These included Zulus, Tswanas, Khoisan and Europeans, from the Dart Collection, University of the Witwatersrand. Several measurements of the different tooth classes were obtained from the modern population groups and compared to the Palauan sample using Univariate and Bivariate statistical methods. In addition, frequencies of anomalies were recorded for the entire modern human Dart Collection (n. 3000), and a sample of Holocene human skeletons (n. 69) for comparison with the Palauan material. The Palauans have been found to have absolutely and relatively very large teeth compared to modern and Holocene population groups. Their mesiodistal diameter (MD) and buccolingual diameter (BL) exceed the normal range of modern human populations, whereas the same measurements at the cervical enamel junction are smaller. Total root length and crown height of the Palauans are equal to those of modern humans. Estimating body size from tooth size is thus shown to be unreliable, indicating that tooth size should be viewed in relation to other factors, such as diet, which may lead to phenomena like island dwarfism. Frequencies of third molar agenesis, incisiform canines, caniniform premolars and rotated premolars were very high in the Palauan sample: third molar agenesis, incisiform canines, caniniform premolars and rotated premolars. These anomalies are mostly due to crowding, which results in erupting teeth looking like their neighbours, or failing to develop at all, as in the case of third molars, which free up space for the remaining teeth to develop.

TABLE OF CONTENTS

DECLARATION……ii
ABSTRACT……iii
TABLE OF CONTENTS……iv
ACKNOWLEDGEMENTS……vii
LIST OF TABLES……ix
LIST OF FIGURES……xii
LITERATURE REVIEW……1
Palau……1
Hominins……1
Date of Palau remains……1
Anomalies……1
Aims……1
Hypotheses……1
Palau Micronesia……1
Homo floresiensis……2
Location of Palau……2
History of the Palauans……2
Diagram of the location of Palau……3
MORPHOLOGY OF THE PERMANENT TEETH……5
TOOTH ANOMALIES……5
Congenital absence of third molars……5
Incisiform canines……7
Caniniform premolars……8
Rotated premolars……8
Tooth and body size relationship……10
MATERIALS AND METHODS……13
1. Tooth Size……13

Diagram of the dental arch.....14

Measurements Taken.....14
Mesiodistal Diameter.....14
Buccolingual Diameter.....15
Mesiodistal Diameter at cervical enamel junction 15
Buccolingual Diameter at cervical enamel junction.....15
Crown height.....15
Total root length.....16
Tooth Wear …….....…….16

SURFACES OF THE TEETH.....18

Definition of the surfaces of teeth …….....18
Labial surface 18
Buccal surface 18
Lingual surface 18
Palatal surface.....18
Occlusal surface.....18
Mesial surface……..…19
Distal surface……...19

2. Survey of Anomalies.....19

Holocene Human Skeletons…….....19

RESULTS…….....20

Mandibular central incisors……20

Maxillary central incisors……..48

Mandibular lateral incisors……73

Maxillary lateral incisors…….100

Mandibular canines…….126

Maxillary canines……147

Mandibular 3rd premolar…….174

Maxillary 3rd premolar…….201

Mandibular 4th premolar……..225

Maxillary 4th premolar…….246

Mandibular 1st molar……268

Maxillary 1st molar……..289

Mandibular 2nd molar……...305

Maxillary 2nd molar……..329

Anomalies……...344

DISCUSSION……..355

CONCLUSION……365

REFERENCES……368

APPENDIX……..390

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LIST OF TABLES

Table 1: MD diameters of the mandibular central incisors…….....20

Table 2: BL diameters of the mandibular central incisors…….....22

Table 3: Crown height of the of the mandibular central incisors…….....24

Table 4: MD (cej) diameters of the mandibular central incisors…….....26

Table 5: BL (cej) diameters of the mandibular central incisors…….....27

Table 6: Total root length of the mandibular central incisors…….....29

Table 7: Summary of bivariate analyses between Palau and Modern human population.....31

Table 8: MD diameters of the maxillary central incisors…….....48

Table 9: BL diameters of the maxillary central incisors…….....50

Table 10: Crown height of the of the maxillary central incisors…….....51

Table 11: MD (cej) diameters of the maxillary central incisors…….....53

Table 12: BL (cej) diameters of the maxillary central incisors…….....55

Table 13: Total root length of the maxillary central incisors…….....56

Table 14: MD diameters of the mandibular lateral incisors….....73

Table 15: BL diameters of the mandibular lateral incisors…….....75

Table 16: Crown height of the of the mandibular lateral incisors…….....77

Table 17: MD (cej) diameters of the mandibular lateral incisors…….....79

Table 18: BL (cej) diameters of the mandibular lateral incisors…….....80

Table 19: Total root length of the mandibular lateral incisors…….....83

Table 20: MD diameters of the maxillary lateral incisors….....100

Table 21: BL diameters of the maxillary lateral incisors…….....102

Table 22: Crown height of the of the maxillary lateral incisors…….....104

Table 23: MD (cej) diameters of the maxillary lateral incisors…….....106

Table 24: BL (cej) diameters of the maxillary lateral incisors 108

Table 25: Total root length of the maxillary lateral incisors 109

Table 26: MD diameters of the mandibular canines.....126
Table 27: BL diameters of the mandibular canines 128
Table 28: CH of the mandibular canines 130
Table 29: MD (cej) diameters of the mandibular canines.....131
Table 30: BL (cej) diameters of the mandibular canines…….....133
Table 31: Total root length of the mandibular canines…….....135
Table 32: MD diameters of the maxillary canines…….....147
Table 33: BL diameters of the maxillary canines…….....149
Table 34: Crown height of the of the maxillary canines…….....151
Table 35: MD (cej) diameters of the maxillary canines….....153
Table 36: BL (cej) diameters of the maxillary canines…….....155
Table 37: Total root length of the maxillary canines…….....156
Table 38: MD diameters of the mandibular 3rd premolars…….....174
Table 39: BL diameters of the mandibular 3rd premolars…….....176
Table 40: Crown height of the of the mandibular 3rd premolars…….....178
Table 41: MD (cej) diameters of the mandibular 3rd premolars…….....180
Table 42: BL (cej) diameters of the mandibular 3rd premolars…….....182
Table 43: Total root length of the mandibular 3rd premolars…….....184
Table 44: MD diameters of the maxillary 3rd premolars…….....201
Table 45: BL diameters of the maxillary 3rd premolars…….....203
Table 46: Crown height of the of the maxillary 3rd premolars…….....204
Table 47: MD (cej) diameters of the maxillary 3rd premolars….....206
Table 48: BL (cej) diameters of the maxillary 3rd premolars…….....208
Table 49: Total root length of the maxillary 3rd premolars…….....209
Table 50: MD diameters of the mandibular 4th premolars…….....225
Table 51: BL diameters of the mandibular 4th premolars…….....227

Table 52: Crown height of the of the mandibular 4th premolars…….....229

Table 53: MD (cej) diameters of the mandibular 4th premolars…….....230

Table 54: BL (cej) diameters of the mandibular 4th premolars…….....234

Table 55: Total root length of the mandibular 4th premolars…….....235

Table 56: MD diameters of the maxillary 4th premolars …….....246

Table 57: BL diameters of the maxillary 4th premolars …….....248

Table 58: Crown height of the of the maxillary 4th premolars …….....250

Table 59: MD (cej) diameters of the maxillary 4th premolars …….....252

Table 60: BL (cej) diameters of the maxillary 4th premolars …….....254

Table 61: Total root length of the maxillary 4th premolars …….....255

Table 62: MD diameters of the mandibular 1st molars…….....268

Table 63: BL diameters of the mandibular 1st molars…….....270

Table 64: Crown height of the of the mandibular 1st molars…….....272

Table 65: MD (cej) diameters of the mandibular 1st molars…….....274

Table 66: BL (cej) diameters of the mandibular 1st molars…….....275

Table 67: Total root length of the mandibular 1st molars…….....277

Table 68: MD diameters of the maxillary 1st molars…….....289

Table 69: BL diameters of the maxillary 1st molars…….....291

Table 70: Crown height of the of the maxillary 1st molars…….....293

Table 71: MD (cej) diameters of the maxillary 1st molars…….....294

Table 72: BL (cej) diameters of the maxillary 1st molars…….....296

Table 73: Total root length of the maxillary 1st molars…….....298

Table 74: MD diameters of the mandibular 2nd molars…….....306

Table 75: BL diameters of the mandibular 2nd molars…….....307

Table 76: Crown height of the of the mandibular 2nd molars…….....309

Table 77: MD (cej) diameters of the mandibular 2nd molars…….....311

Table 78: BL (cej) diameters of the mandibular 2nd molars…….....313

Table 79: Total root length of the mandibular 2nd molars…….....314

Table 80: MD diameters of the maxillary 2nd molars…….....330

Table 81: BL diameters of the maxillary 2nd molars…….....332

Table 82: MD (cej) diameters of the maxillary 2nd molars…….....334

Table 83: BL (cej) diameters of the maxillary 2nd molars…….....336

Table 84: Frequency of the anomalies observed in the three human samples…….344

LIST OF FIGURES

Figure 1: Diagram illustrating the location of Palau.....3

Figure 2: Diagram of the mandibular teeth illustrating the surfaces of the teeth 14

Figure 3: Crown diameter and cervical diameter measurements in upper incisors 15

Figure 4: Crown diameter and cervical diameter measurements in molars.....16

Figure 5: Univariate plot of the MD diameters of the mandibular central incisors.....21

Figure 6: Univariate plot of the BL diameters of the mandibular central incisors.....23

Figure 7: Univariate plot of the crown height of the mandibular central incisors…….25

Figure 8: Univariate plot of the MD (cej) diameters of the mandibular central incisors……...27

Figure 9: Univariate plot of the BL (cej) diameters of the mandibular central incisors……28

Figure 10: Univariate plot of the total root length of the mandibular central incisors……..30

Figure 11: Bivariate plot of the MD vs. BL diameters of the mandibular central incisors…..…32

Figure 12: Bivariate plot of the MD diameter vs. CH of the mandibular central incisors…….33

Figure 13: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular central incisors..34

Figure 14: Bivariate plot of the MD vs. BL (cej) diameters of the mandibular central incisors...35

Figure 15: Bivariate plot of the MD diameters vs. TRL of the mandibular central incisors.....36

Figure 16: Bivariate plot of the BL diameters vs. CH of the mandibular central incisors……...37

Figure 17: Bivariate plot of the BL vs. MD (cej) diameters of the mandibular central incisors...39

Figure 18: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular central incisors…40

Figure 19: Bivariate plot of the BL diameters vs. TRL of the mandibular central incisors.....41
Figure 20: Bivariate plot of the CH vs. MD (cej) diameters of the mandibular central incisors...42
Figure 21: Bivariate plot of the CH vs. BL (cej) diameters of the mandibular central incisors....43
Figure 22: Bivariate plot of the CH vs. TRL of the mandibular central incisors…….....44
Figure 23: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular central incisors.....45
Figure 24: Bivariate plot of the MD (cej) diameter vs. TRL of the mandibular central incisors..46
Figure 25: Bivariate plot of the MD (cej) diameter vs. TRL of the mandibular central incisors..48
Figure 26: Univariate plot of the MD diameters of the maxillary central incisors……49
Figure 27: Univariate plot of the BL diameters of the maxillary central incisors…….51
Figure 28: Univariate plot of the CH of the maxillary central incisors…….52
Figure 29: Univariate plot of the MD (cej) diameters of the maxillary central incisors……...54
Figure 30: Univariate plot of the BL (cej) diameters of the maxillary central incisors……..56
Figure 31: Univariate plot of the TRL of the maxillary central incisors……...57
Figure 32: Bivariate plot of the MD vs. BL diameters of the maxillary central incisors…….....58
Figure 33: Bivariate plot of the MD diameters vs. CH of the maxillary central incisors……..59
Figure 34: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary central incisors……...60
Figure 35: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary central incisors…..61
Figure 36: Bivariate plot of the MD diameters vs. TRL of the maxillary central incisors……62
Figure 37: Bivariate plot of the BL diameters vs. CH of the maxillary central incisors….....63
Figure 38: Bivariate plot of the BL vs. MD (cej) diameters of the maxillary central incisors…..64
Figure 39: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary central incisors…...65
Figure 40: Bivariate plot of the BL diameters vs. TRL of the maxillary central incisors…….....66
Figure 41: Bivariate plot of the CH vs. MD (cej) diameters of the maxillary central incisors…..67
Figure 42: Bivariate plot of the CH vs. BL (cej) diameters of the maxillary central incisors…...68
Figure 43: Bivariate plot of the CH vs. TRL of the maxillary central incisors…….....69
Figure 44: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary central incisors……...70
Figure 45: Bivariate plot of the MD (cej) diameters vs. TRL of the maxillary central incisors……...71

Figure 46: Bivariate plot of the BL (cej) diameters vs. TRL of the maxillary central incisors……...72
Figure 47: Univariate plot of the MD diameters of the mandibular lateral incisors……..74
Figure 48: Univarite plot of the BL diameters of the mandibular lateral incisors…….76
Figure 49: Univariate plot of the CH of the mandibular lateral incisors……...78
Figure 50: Univariate plot of the MD (cej) diameters of the mandibular lateral incisors…….80
Figure 51: Univariate plot of the BL (cej) diameters of the mandibulat lateral incisors……...82
Figure 52: Univariate plot of the TRL of the mandibular lateral incisors…….....84
Figure 53: Bivariate plot of the MD vs. BL diameters of the mandibular lateral incisors……...85
Figure 54: Bivariate plot of the MD diameters vs. CH of the mandibular lateral incisors……....86
Figure 55: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular lateral incisors……...87
Figure 56: Bivariate plot of the MD vs. BL (cej) diameters of the mandibular lateral incisors……...88
Figure 57: Bivariate plot of the MD diameters vs. TRL of the mandibular lateral incisors……..89
Figure 58: Bivariate plot of the BL diameters vs. CH of the mandibular lateral incisors…….....90
Figure 59: Bivariate plot of the BL vs. MD (cej) diameters of the mandibular lateral incisors……...91
Figure 60: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular lateral incisors……...92
Figure 61: Bivariate plot of the BL diameters vs. TRL of the mandibular lateral incisors……...93
Figure 62: Bivariate plot of the CH vs. MD (cej) diameters of the mandibular lateral incisors……..94
Figure 63: Bivariate plot of the CH vs. BL (cej) diameters of the mandibular lateral incisors……...95
Figure 64: Bivariate plot of the CH vs. TRL of the mandibular lateral incisors……...96
Figure 65: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular lateral incisors……..97
Figure 66: Bivariate plot of the MD (cej) diameters vs. TRL of the mandibular lateral incisors…….98
Figure 67: Bivariate plot of the BL (cej) diameters vs. TRL of the mandibular lateral incisors…….99
Figure 68: Univariate plot of the MD diameters of the maxillary lateral incisors……...101

Figure 69: Univariate plot of the BL diameters of the maxillary lateral incisors……103
Figure 70: Univariate plot of the CH of the maxillary lateral incisors……105
Figure 71: Univariate plot of the MD (cej) diameters of the maxillary lateral incisors……..107
Figure 72: Univariate plot of the BL (cej) diameters of the maxillary lateral incisors……109
Figure 73: Univariate plot of the TRL of the maxillary lateral incisors……..110
Figure 74: Bivariate plot of the MD vs. BL diameters of the maxillary lateral incisors…….111
Figure 75: Bivariate plot of the MD diameters vs. CH of the maxillary lateral incisors…….112
Figure 76: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary lateral incisors…113
Figure 77: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary lateral incisors….114
Figure 78: Bivariate plot of the MD diameters vs. TRL of the maxillary lateral incisors……...115
Figure 79: Bivariate plot of the BL diameters vs. CH of the maxillary lateral incisors……..116
Figure 80: Bivariate plot of the BL vs. MD (cej) diameters of the maxillary lateral incisors….117
Figure 81: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary lateral incisors…..118
Figure 82: Bivariate plot of the BL diameters vs. TRL of the maxillary lateral incisors……119
Figure 83: Bivariate plot of the CH vs. MD (cej) diameters of the maxillary lateral incisors…120
Figure 84: Bivariate plot of the CH vs. BL (cej) diameters of the maxillary lateral incisors…..121
Figure 85: Bivariate plot of the CH VS. TRL of the maxillary lateral incisors……...122
Figure 86: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary lateral incisors.....123
Figure 87: Bivariate plot of the MD (cej) diameters vs. TRL of the maxillary lateral incisors..124
Figure 88: Bivariate plot of the BL (cej) diameters vs. TRL of the maxillary lateral incisors…125
Figure 89: Univariate plot of the MD diameters of the mandibular canines……...127
Figure 90: Univariate plot of the BL diameters of the mandibular canines…….129
Figure 91: Univariate plot of the CH of the mandibular canines…….131
Figure 92: Univariate plot of the MD (cej) diameters of the mandibular canines……...132
Figure 93: Univariate plot of the BL (cej) diameters of the mandibular canines……134
Figure 94: Univariate plot of the TRL of the mandibular canines……...136
Figure 95: Bivariate plot of the MD vs. BL diameters of the mandibular canines……..137
Figure 96: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular canines……138
Figure 97: Bivariate plot of the MD vs. BL (cej) diameters of the mandibular canines…….139
Figure 98: Bivariate plot of the MD diameters vs. TRL of the mandibular canines……...140

Figure 99: Bivariate plot of the BL vs. MD (cej) diameters of the mandibular canines…….141
Figure 100: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular canines…….142
Figure 101: Bivariate plot of the BL diameters vs. TRL of the mandibular canines……...143
Figure 102: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular canines...144
Figure 103: Bivariate plot of the MD (cej) diameters vs. TRL of the mandibular canines…….145
Figure 104: Bivariate plot of the BL (cej) diameters vs. TRL of the mandibular canines……..146
Figure 105: Univariate plot of the MD diameters of the maxillary canines……148
Figure 106: Univariate plot of the BL diameters of the maxillary canines…….150
Figure 107: Univariate plot of the CH of the maxillary canines……..152
Figure 108: Univariate plot of the BL (cej) diameters of the maxillary canines…….154
Figure 109: Univariate plot of the MD (cej) diameters of the maxillary canines……156
Figure 110: Univariate plot of the TRL of the maxillary canines……157
Figure 111: Bivariate plot of the MD vs. BL diameters of the maxillary canines……...158
Figure 112: Bivariate plot of the MD diameters vs. CH of the maxillary canines……..159
Figure 113: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary canines…….160
Figure 114: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary canines……..161
Figure 115: Bivariate plot of the MD diameters vs. TRL of the maxillary canines……162
Figure 116: Bivariate plot of the BL diameters vs. CH of the maxillary canines……163
Figure 117: Bivariate plot of the BL vs. MD (cej) diameters of the maxillary canines……..164
Figure 118: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary canines……166
Figure 119: Bivariate plot of the BL diameters vs. TRL of the maxillary canines……..167
Figure 120: Bivariate plot of the CH vs. MD (cej) diameters of the maxillary canines……..168
Figure 121: Bivariate plot of the CH vs. BL (cej) diameters of the maxillary canines……...169
Figure 122: Bivariate plot of the CH vs. TRL of the maxillary canines……..170
Figure 123: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary canines…..171
Figure 124: Bivariate plot of the MD (cej) diameters vs. TRL of the maxillary canines……172
Figure 125: Bivariate plot of the BL (cej) diameters vs. TRL of the maxillary canines…….173
Figure 126: Univariate plot of the MD diameters of the mandibular 3rd premolars……175
Figure 127: Univariate plot of the BL diameters of the mandibular 3rd premolars…….177
Figure 128: Univariate plot of the CH of the mandibular 3rd premolars…….179
Figure 129: Univariate plot of the MD (cej) diameters of the mandibular 3rd premolars……181

Figure 130: Univariate plot of the BL (cej) diameters of the mandibular 3rd premolars…….183
Figure 131: Univariate plot of the TRL of the mandibular 3rd premolars……...185
Figure 132: Bivariate plot of the MD vs. BL diameters of the mandibular 3rd premolars……...186
Figure 133: Bivariate plot of the MD diameters vs. CH of the mandibular 3rd premolars……..187
Figure 134: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular 3rd premolars.....188
Figure 135: Bivariate plot of the MD vs. BL (cej) diameters of the mandibular 3rd premolars.....189
Figure 136: Bivariate plot of the MD diameters vs. TRL of the mandibular 3rd premolars……190
Figure 137: Bivariate plot of the BL diameters vs. CH of the mandibular 3rd premolars……...191
Figure 138: Bivariate plot of the BL vs. MD (cej) diameters of the mandibular 3rd premolars..192
Figure 139: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular 3rd premolars…193
Figure 140: Bivariate plot of the BL diameters vs. TRL of the mandibular 3rd premolars…….194
Figure 141: Bivariate plot of the CH vs. MD (cej) diameters of the mandibular 3rd premolars..195
Figure 142: Bivariate plot of the CH vs. BL (cej) diameters of the mandibular 3rd premolars...196
Figure 143: Bivariate plot of the CH vs. TRL of the mandibular 3rd premolars……..197
Figure 144: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular 3rd premolars……..198
Figure 145: Bivariate plot of the MD (cej) diameters vs. TRL of the mandibular 3rd premolars.....199
Figure 146: Bivariate plot of the BL (cej) diameters vs. TRL of the mandibular 3rd premolars.....200
Figure 147: Univariate plot of the MD diameters of the maxillary 3rd premolars……...202
Figure 148: Univariate plot of the BL diameters of the maxillary 3rd premolars……204
Figure 149: Univariate plot of the CH of the maxillary 3rd premolars……205
Figure 150: Univariate plot of the MD (cej) diameters of the maxillary 3rd premolars……...207
Figure 151: Univariate plot of the BL (cej) diameters of the maxillary 3rd premolars……209
Figure 152: Univariate plot of the TRL of the maxillary 3rd premolars……..210
Figure 153: Bivariate plot of the MD vs. BL diameters of the maxillary 3rd premolars…….211
Figure 154: Bivariate plot of the MD diameters vs. CH of the maxillary 3rd premolars…….212
Figure 155: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary 3rd premolars…213
Figure 156: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary 3rd premolars….214

Figure 157: Bivariate plot of the MD diameters vs. TRL of the maxillary 3rd premolars……...215
Figure 158: Bivariate plot of the BL vs. MD (cej) diameters of the maxillary 3rd premolars….216
Figure 159: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary 3rd premolars…..217
Figure 160: Bivariate plot of the BL diameters vs. TRL of the maxillary 3rd premolars……218
Figure 161: Bivariate plot of the CH vs. MD (cej) diameters of the maxillary 3rd premolars….219
Figure 162: Bivariate plot of the CH vs. BL (cej) diameters of the maxillary 3rd premolars…..220
Figure 163: Bivariate plot of the CH vs. TRL of the maxillary 3rd premolars…….....221
Figure 164: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary 3rd premolars.....222
Figure 165: Bivariate plot of the MD (cej) diameters vs. TRL of the maxillary 3rd premolars...223
Figure 166: Bivariate plot of the BL (cej) diameters vs. TRL of the maxillary 3rd premolars…….....224
Figure 167: Univariate plot of the MD diameters of the mandibular 4th premolars……226
Figure 168: Univariate plot of the BL diameters of the mandibular 4th premolars…….228
Figure 169: Univariate plot of the CH of the mandibular 4th premolars……..230
Figure 170: Univariate plot of the MD (cej) diameters of the mandibular 4th premolars……231
Figure 171: Univariate plot of the BL (cej) diameters of the mandibular 4th premolars…….233
Figure 172: Univariate plot of the TRL of the mandibular 4th premolars.....235
Figure 173: Bivariate plot of the MD vs. BL diameters of the mandibular 4th premolars……...236
Figure 174: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular 4th premolars.....237
Figure 175: Bivariate plot of the MD vs. BL (cej) diameters of the mandibular 4th premolars.....238
Figure 176: Bivariate plot of the MD diameters vs. TRL of the mandibular 4th premolars……239
Figure 177: Bivariate plot of the BL vs. MD (cej) diameters of the mandibular 4th premolars.....240
Figure 178: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular 4th premolars…241
Figure 179: Bivariate plot of the BL vs. TRL of the mandibular 4th premolars……..242
Figure 180: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular 4th premolars……..243
Figure 181: Bivariate plot of the MD (cej) diameters vs. TRL of the mandibular 4th premolars.....244

Figure 182: Bivariate plot of the BL (cej) diameters vs. TRL of the mandibular 4th premolars.....245
Figure 183: Univariate plot of the MD diameters of the maxillary 4th premolars……...247
Figure 184: Univariate plot of the BL diameters of the maxillary 4th premolars……249
Figure 185: Univariate plot of the CH of the maxillary 4th premolars……251
Figure 186: Univariate plot of the MD (cej) diameters of the maxillary 4th premolars……...253
Figure 187: Univariate plot of the BL (cej) diameters of the maxillary 4th premolars……255
Figure 188: Univariate plot of the TRL of the maxillary 4th premolars.....256
Figure 189: Bivariate plot of the MD vs. BL diameters of the maxillary 4th premolars……..257
Figure 190: Bivariate plot of the MD diameters vs. CH of the maxillary 4th premolars…….258
Figure 191: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary 4th premolars…259
Figure 192: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary 4th premolars….260
Figure 193: Bivariate plot of the MD diameters vs. TRL of the maxillary 4th premolars……...261
Figure 194: Bivariate plot of the BL diameters vs. CH of the maxillary 4th premolars……..262
Figure 195: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary 4th premolars…...263
Figure 196: Bivariate plot of the BL diameters vs. TRL of the maxillary 4th premolars……264
Figure 197: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary 4th premolars.....265
Figure 198: Bivariate plot of the MD (cej) diameters vs. TRL of the maxillary 4th premolars……..266
Figure 199: Bivariate plot of the BL (cej) diameters vs. TRL of the maxillary 4th premolars…267
Figure 200: Univariate plot of the MD diameters of the mandibular 1st molars…….269
Figure 201: Univariate plot of the BL diameters of the mandibular 1st molars……...271
Figure 202: Univariate plot of the CH of the mandibular 1st molars……...273
Figure 203: Univariate plot of the MD (cej) diameters of the mandibular 1st molars…….275
Figure 204: Univariate plot of the BL (cej) diameters of the mandibular 1st molars……...276
Figure 205: Univariate plot of the TRL of the mandibular 1st molars…….278
Figure 206: Bivariate plot of the MD vs. BL diameters of the mandibular 1st molars……279
Figure 207: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular 1st molars…..280
Figure 208: Bivariate plot of the MD vs. BL (cej) diameters of the mandibukar 1st molars…...281
Figure 209: Bivariate plot of the MD diameters vs. TRL of the mandibular 1st molars……..282
Figure 210: BL vs. MD (cej) diameters of the mandibular 1st molars…….283

Figure 211: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular 1st molars…….284
Figure 212: Bivariate plot of the BL diameters vs. TRL of the mandibular 1st molars……...285
Figure 213: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular 1st molars.....286
Figure 214: Bivariate plot of the MD (cej) diameters vs. TRL of the mandibular 1st molars….287
Figure 215: Bivariate plot of the BL (cej) diameters vs. TRL of the mandibular 1st molars…...288
Figure 216: Univariate plot of the MD diameters of the maxillary 1st molars……290
Figure 217: Univariate plot of the BL diameters of the maxillary 1st molars……..292
Figure 218: Univariate plot of the CH diameters of the maxillary 1st molars……294
Figure 219: Univariate plot of the MD (cej) diameters of the maxillary 1st molars……295
Figure 220: Univariate plot of the BL (cej) diameters of the maxillary 1st molars…….297
Figure 221: Univariate plot of the TRL of the maxillary 1st molars……298
Figure 222: Bivariate plot of the MD vs. BL diameters of the maxillary 1st molars……...299
Figure 223: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary 1st molars…….300
Figure 224: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary 1st molars……...301
Figure 225: Bivariate plot of the BL vs. MD (cej) diameters of the maxillary 1st molars……...302
Figure 226: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary 1st molars……303
Figure 227: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary 1st molars.....304
Figure 228: Univariate plot of the MD diameters of the mandibular 2nd molars……307
Figure 229: Univariate plot of the BL diameters of the mandibular 2nd molars……..308
Figure 230: Univariate plot of the CH of the mandibular 2nd molars……..310
Figure 231: Univariate plot of the MD (cej) diameters of the mandibular 2nd molars……312
Figure 232: Univariate plot of the BL (cej) diameters of the mandibular 2nd molars……314
Figure 233: Univariate plot of the TRL of the mandibular 2nd molars……315
Figure 234: Bivariate plot of the MD vs. BL diameters of the mandibular 2nd molars……...316
Figure 235: Bivariate plot of the MD diameters vs. CH of the mandibular 2nd molars……...317
Figure 236: Bivariate plot of the MD vs. MD (cej) diameters of the mandibular 2nd molars…..318
Figure 237: Bivariate plot of the MD vs. BL (cej) diameters of the mandibular 2nd molars…...319
Figure 238: Bivariate plot of the MD diameters vs. TRL of the mandibular 2nd molars…….320
Figure 239: Bivariate plot of the BL diameters vs. CH of the mandibular 2nd molars……321

Figure 240: Bivariate plot of the BL vs. MD (cej) diameters of the mandibular 2nd molars…...322
Figure 241: Bivariate plot of the BL vs. BL (cej) diameters of the mandibular 2nd molars……323
Figure 242: Bivariate plot of the BL diameters vs. TRL of the mandibular 2nd molars……..324
Figure 243: Bivariate plot of the CH vs. MD (cej) diameters of the mandibular 2nd molars…..325
Figure 244: Bivariate plot of the CH vs. BL (cej) diameters of the mandibular 2nd molars……326
Figure 245: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the mandibular 2nd molars.....327
Figure 246: Bivariate plot of the MD (cej) diameters vs. TRL of the mandibular 2nd molars…328
Figure 247: Bivariate plot of the BL (cej) diameters vs. TRL of the mandibular 2nd molars…..329
Figure 248: Univariate plot of the MD diameters of the maxillary 2nd molars……331
Figure 249: Univariate plot of the BL diameters of the maxillary 2nd molars…….333
Figure 250: Univariate plot of the MD (cej) diameters of the maxillary 2nd molars……...335
Figure 251: Univariate plot of the BL (cej) diameters of the maxillary 2nd molars…….337
Figure 252: Bivariate plot of the MD vs. BL diameters of the maxillary 2nd molars……..338
Figure 253: Bivariate plot of the MD vs. MD (cej) diameters of the maxillary 2nd molars……339
Figure 254: Bivariate plot of the MD vs. BL (cej) diameters of the maxillary 2nd molars……..340
Figure 255: Bivariate plot of the BL vs. MD (cej) diameters of the maxillary 2nd molars……..341
Figure 256: Bivariate plot of the BL vs. BL (cej) diameters of the maxillary 2nd molars……...342
Figure 257: Bivariate plot of the MD (cej) vs. BL (cej) diameters of the maxillary 2nd molars.....343
Figure 258: Histogram illustrating the frequency of anomalies in the three samples…….344

CHAPTER 1
INTRODUCTION

1.1 Background

A recently discovered small-bodied population of hominins from Palau, Micronesia, dating to between 1420-2890 BP has been shown to exhibit a number of unusual traits, including extremely small stature, facial size reduction and high degrees of robusticity (Berger *et al*., 2008a, b; Gallagher, 2008). They also appear to possess very large teeth and a high frequency of interesting tooth forms, normally observed at very low frequencies in modern human populations. Analysis shows four main dental anomalies: congenital absence of the third molar, incisiform canines, caniniform premolars and rotated premolars. Very little literature exists on the latter three anomalies, which motivates for the large-scale examination of their frequency, form and severity in modern and prehistoric people. The aim of this study was to compare the size and shape of the teeth of the Palauan fossil sample with those of modern humans, as well as examine the frequency of tooth anomalies in the Palau Island sample and non-island derived modern and Holocene human populations. It was hypothesized that the Palau hominins exhibit a high frequency of dental anomalies and a high megadontia quotient relative to body size.

While Fitzpatrick *et al.* (2008) have argued that the early Palauans were not small-bodied; Berger *et al.* (2008b) have provided a femoral length of 402 ±14 mm, a statute indicating that they were indeed small people, a conclusion supported by Gallagher (2008). By being small-bodied, the Palauans seem to have followed what is called the "island rule", a term used to describe the phenomenon whereby small-bodied species increase in size, while larger animals tend to dwarf (Foster, 1964; Bromham, 2007). The classic example for mammals is the pygmy

elephant found on several islands, including the well known example of *Stegodon* found on Flores Island (van den Berg, 1999; van den Berg, *et al.,* 2001; van den Berg *et al.,* 2008). Bromham, *et al*. (2007) found that primates also follow the island rule, which supports claims that *Homo floresiensis* represents an insular dwarf population of hominins. Millien *et al.* (2006), based on a dataset comprising of 170 populations of 88 species, calculated 826 evolutionary rates, found that morphological evolution can be accelerated in mammals living on islands. However, Meiri *et al.* (2008) show that the rule can be broken when phylogenetic comparative methods are applied to large data sets. They found clade-specific patterns in which carnivores and artiodactyls (large mammals) shifted to dwarfism, but rodents (small mammals) were variable, with heteromyids shifting to dwarfism and murids shifting to gigantism.

The introduction to this thesis is divided into four sections, starting with a brief background on the geographical location and peopling of Palau, followed by a brief description of the morphology of permanent teeth, explanations of the four tooth anomalies, and background to the relationship between tooth and body size.

1.2 Palau, location and peopling

Palau, often referred to as Belau, (Rainbird, 2004) is situated among the Western Caroline Islands on the Western Pacific rim, approximately 600 km from the nearest large land mass. (Fitzpatrick, *et al*., 2003; Callaghan, *et al.,* 2007). The Caroline Islands are one of the three main island groups making up Micronesia. The other two are the Marianas, and the Marshall Islands (Figure 1). The Caroline Islands are divided into the eastern and western groups, with Yap and the Palau Islands belonging to the latter (Craib, 1983; Fitzpatrick, *et al*., 2007; Welch, 2002). The Palau archipelago comprises the largest dominating volcanic island of Babeldaob and hundreds of small islands south of the capital Koror, collectively known as the Rock Islands

(Berger *et al*, 2008; Clark, 2005; Liston, 2005; Masse *et al*., 2006; Nelson *et al*., 2006, Rainbird, 2004; Welch, 2002).



Figure 1. Map illustrating the location of Palau (Graphic maps.com.)

Palauans are thought to have fed on plants (Welch, 2002) and marine resources (Fitzpatrick *et al*., 2005, 2007); and are believed to have been fishing as early as 1700 BP, based on an assemblage of well preserved fish remains recovered from the site of Chelechol ra Orrak on the Rock Island of Palau. However, the timing of the first occupation of Palau is unclear. Several factors suggest different ages. Paleoenvironmental evidence suggests that the large island of

Babeldaob may have been colonized by 4300 BP (Athens *et al*., 2002; Dickingson *et al*., 2007). Accelerator Mass Spectrometry (AMS) age estimates for charcoal fragments and carbonised residues adhering to pot sherds are 3150±90 BP to 4330±90BP (Clark, 2004). These ages imply that human arrival in western Micronesia might have occurred as early as 4500 BP, a date consistent with the palaeoenvironmental evidence. However, re-dating of the objects suggests that occupation was later, around 3000-2650 BP. In light of this, Clark *et al*. (2006) now place human arrival in southern Palau no earlier than 3100-2900 BP. According to Fitzpatrick (2002, 2003), the first settlement of Palau was also around 3000 BP based on AMS dating of human bones, as well as radiocarbon dating of charcoal and snail shell. Liston (2005) advocates a similar age based on several *Conus* shells, with the oldest date being 2890±110 BP.

Early Palauans have been suggested to have migrated from Taiwan, Indonesia, New Guinea or the Philippines. This is based on linguistic, archaeological, historic, and genetic evidence (Bellwood, 1985; Clark *et al*., 2006; Craib, 1983; Lum *et al*., 1998; Lum *et al*., 2000; Lum *et al*., 2002. Devlin, *et al*. (2001), used linkage equilibrium to infer evolutionary history of the Palauans. They found that their data was consistent with the theory of Lum *et al*.(1998), which states that South East Asians initially settled Remote Oceania, but since then the populations experienced an extensive male-biased gene flow from both South East Asia and Near Oceania.

According to Intoh (1997), based on linguistic data, Palauans may have originated from the Philippines or the island of Indonesia. He further claims that this dispersal took place about 2000 BP or a little earlier. Callaghan *et al*., (2007 & 2008), using computer simulated drift voyagers also concluded that the Philippines are the most likely origin for the early Palauans. Mitochondrial DNA suggests people who founded Palau were of South East Asian ancestry (Hertzberg *et al.,* 1989; Lum, 1998), which is in agreement with the analysis of language trees

(Gray and Jordan, 2000). This is consistent with the express train theory, which suggests a single wave of migration sweeping through the region (Diamond, 1988). In contrast, Nuclear DNA suggests both Southeast Asia and Melanesia as the places of origin of the Palauans (the extant population of Remote Oceania) (Serjeantson, 1985; Martinson, 1996).

2. Morphology of the permanent teeth

Teeth are white and hard structures composed mainly of calcium phosphate in the form of crystalline hydroxyapatite and collagen fibres in different percentages. A tooth consists of two main anatomical elements, a crown and a root(s), joined by a cervical region. The crown is coated with a layer of enamel, a hard crystalline tissue, while a bone-like material called cement coats the root (Bergqvist, 2003). Adult humans have 32 permanent teeth. These are classified as incisors, canines, premolars and molars (Shroff, 1966; Scott *et al*., 1977; Scott *et al*., 1997; Hillson, 2005; White *et al*, 2005; and Scheid, 2007).

3. Tooth anomalies

3.1 Congenital absence of third molars

Agenesis (congenital absence) of one or more third molars occurs with varying frequency in different human populations (Keene, 1964; Anderson *et al.*, 1973). Nanda (1954) conducted a study on 216 European women with an age range of 18-21 years. In his findings, third molars showed absence in the mandible more often than in the maxilla, with 9% of third molars missing. Third molars, which were reduced in size, were noticed only in subjects who had agenesis of one or more third molars. According to Nanda (1954), this suggests a causal relationship between the reduction in size and agenesis of third molars, both being influenced by the same or related factors.

Garn *et al.* (1962) found that when one or more third molar teeth are missing, the incidence of other missing teeth rises by thirteen fold. They concluded that third molar agenesis is related to the differences in tooth calcification and timing of the movement of remaining teeth, and to the variability in formation and eruption sequence of the remaining teeth.

Keene (1964) studied 195 European male naval recruits for third molar absence, spacing and crowding of the teeth, and tooth size. Twenty-five percent of the men had one or more third molars missing. When third molars were congenitally missing, the teeth in both arches were more frequently spaced and less frequently crowded. This suggests that third molar agenesis in dentition may play an important role in the alignment and spacing relationships of the teeth in the dental arcade.

Vastardis (2000) used molecular genetics to explain the cause of tooth agenesis. He identified a defective gene that affects the formation of second premolars and third molars in a family that presented a recognizable and well-defined form of tooth agenesis. This was supported by the conclusion reached by Garib *et al* (2005) that tooth agenesis is hereditary.

Even though third molar agenesis has been found to occur in different frequencies in different populations (Keene, 1964; Anderson *et al.,* 1975), Crispim *et al*. (1972) found no difference between the mixed so-called White\Negro\Indian groups of Natal, Brazil, and some Causacoid populations. In the same trihybrid population, no significant differences were observed between individuals classified as “White” or “Negroid”.

3.2 Effects of morphogenetic field theory on canines and premolars

According to Field Theory, different teeth develop because their equipotential primordia are subjected to varying extrinsic factors (Osborn, 1978). Adjacent teeth within a field, subjected to

more similar extrinsic variables than non-adjacent teeth, are expected to resemble each other more than teeth at greater distances from each other, or at opposite ends of the same fields. Since tooth position influences the expression of field traits and fields weaken towards their ends, it might be expected that teeth that lie at the border between two fields (incisor\canine and canine\premolar) are more likely to be influenced by a neighbouring field than teeth that lie well within or at a more distant position in another field. In some cases, a neighbouring field appears to have an even greater effect on a border tooth than its own field. The most dramatic examples of this border phenomenon are the incisiform mandibular canine and caniniform premolar. Incisiform canines resemble the shape and appearance of an incisor tooth. The same applies to caniniform premolars, with premolars resembling canines. These border teeth have become entirely or partly integrated morphologically and functionally with new fields (Greenfield, 1993).

3.3 Incisiform canines

These are canines resembling the shape of an incisor. According to Greenfield (1993), female mandibular canines frequently have better developed incisor-like traits than males. There are different ways in which canines can be modified for use as incisors (e.g. enhancement of the mesial cristid and modification of the canine's apex to form a scraper). A mesial cristid is an incisor-like extension on the mesial surface of the mandibular canines of female anthropoids (Greenfield, 1992).

There are two kinds of selection that have an impact on the stasis or change in incisiform canine morphology: incisiform selection and weapon selection (Greenfield, 1998; Plavcan *et al*, 1996). When selection for weapon use is absent or less intense, the result is a canine favouring its use as an incisor. According to Greenfield (1992), the evolutionary changes in size and form that

enhanced incisal usage of canines in the earliest known species of the human lineage show that human canine evolution can be explained as a consequence of their diminished need as weapons as well as the pre-existing selection for their use as incisors. Since males and females have similar diets and incisor morphologies, the selection favouring incisor-like form and function of canines is equally intense in males and females. However, when dealing with aggressive behaviours (defence of the troop or of individuals against predators), the intensity for favouring tall conical canines is greater in males than in females.

3.4 Caniniform premolars

These are premolars resembling the shape of a canine. Jungers (1978) reports caniniform premolars in the teeth of *Hadropithecus stenognathus*, *Archaelemur majori* and *Archaelemur edwardsi*. These premolars and the reduced canines are reported to be the last ones to erupt, and they do so in a very restricted alveolar space. Their reduction in size decreases the chances of dental crowding. Caniniform premolars can manifest in humans mandibular premolars. They rarely manifest in maxillary premolars because upper premolars have well developed lingual cusps (Scott *et al.*, 1997).

3.5 Rotated premolars

Rotation of premolar is a common problem which orthodontists find difficult to treat. When a premolar is rotated the crown's lingual face is typically turned in a distal direction. It seems probable that both genetic and local factors contribute to this abnormality, and if the contribution of local factors could be identified, the way might be open to preventing secondary rotations of premolar teeth (Mcmullan, *et al*, 1991; Rougier, *et al*, 2006).

Knowledge concerning rotation of permanent teeth is based primarily on post-eruptive disturbances. Habitual, mechanical, or local environmental factors have been collectively called etiological factors, and are attributed to being the cause of the rotation in two different ways. The first is the rotation of teeth caused by post-eruptive disturbances, and the second is caused by pre-eruptive disturbances.

According to Kim *et al*. (1961), several factors operating in the pre-eruptive phase may influence the emergence of permanent teeth. These are the asymmetrical root resorption of deciduous molars, the early loss of the first permanent molar prior to the eruption of permanent premolars, and the pathologic involvement of the deciduous roots. These were supported by his finding that when the deciduous roots were retained beyond normal exfoliation time, the succeeding permanent tooth had a tendency to rotate. Reasons for this prolonged retention were given as the incomplete resorption of the deciduous roots, and the lack of coordination between the resorption. Kim *et al.* (1961) found that avoiding the extraction of the first permanent molar decreases the chances of the rotation of premolars. The loss of a permanent molar(s) creates abnormal drifting of adjacent teeth and consequent malocclusion.

Kram, *et al*. (1990) studied premolar rotation in a group of 15 year old Norwegian children, and concluded that factors responsible for premolar rotation are genetically determined, but that local and occlusal factors may have a role to play in the rotation of premolars.

Mcmullan, *et al*. (1991) investigated whether the rotation of teeth changed from the point of eruption until the dentition is established. They used 50 children for whom dental arch casts were taken at six month intervals and examined. The date of eruption of each premolar was noted. The rotation of each premolar was then measured at the point of eruption, and again on the cast taken

at 15 years old subjects, when the dentition was established. They found that rotation of premolars can change between the time of eruption and the established dentition, and that upper and lower second premolars have a greater tendency to normalize over a period of time than do the upper and lower first premolars.

Rougier, *et al.* (2006) studied the premolar rotation in the Pleistocene European Krapina Neanderthal dental sample, and found a high frequency of rotated premolars. The sample was compared to other Neanderthal and modern human material, and it was concluded that the cause of this pathology was biological in origin, an inherited condition common in the Krapina people.

Brown *et al.* (2004) also report a rotated maxillary 4th premolar in the hominin fossil record, in *Homo floresiensis*, a megadont small-bodied bipedal hominin that was discovered at the Liang Bua cave on the Indonesian island of Flores.

4. Tooth and body size relationship

The study of the size and shape of teeth has generated more literature than any other aspect of dental anthropology (Wolpoff, 1971). There are three different types of variation in tooth size in humans, namely microdontia, mesodontia and megadontia. Microdontia means normally-shaped but very small teeth, whereas megadontia refers to normally-shaped, but very large teeth. Mesodontia refers to medium sized teeth. Megadontia most frequently involves incisors and canines, while microdontia typically affects lateral incisors and third molars. Even so, these conditions may occur on a single tooth, several teeth, or an entire dentition (Scheid, 2007). The notion of a linear or exponential relationship between crown size and body size is persistent in the dental and paleontological literature (Garn *et al*., 1968). The megadontia observed in fossil *Gigantopithecus* and *Meganthropus* led Weindenreich (1945) to assume that in accordance with

their very large teeth, they were also gigantic in body size. For some human groups, low but positive correlations between tooth size and body measures have been noted, and some of the correlations are significant (Garn *et al*., 1967), suggesting that modern human teeth typically remain in proportion to body size (Lucas, 2007). Filipson *et al.* (1963) studied the maxillary central incisors and canines of 110 modern humans aged between 18.8 and 22.8 years old. They found no correlation between tooth width and stature, and tooth width and the length of the head, and a low correlation between tooth width and the width of the head. However, Kurten (1967) found a significant correlation between tooth and skull sizes in several mammalian species. Garn *et al*. (1968) examined the relationship between body size and the dimensions of 28 permanent teeth in 109 long-term participants in the Fels Longitudinal Studies. They found a low correlation between tooth size and body size. Henderson *et al*. (1976) also found a low, but statistically significant correlation between the tooth size and body size in a sample of modern African-Americans. Lavelle (1977) reported a low correlation for tooth and long bone size relationship in Nineteenth Century Londoners, but a high correlation for ancient Europeans (Anglo-Saxons). He argues that modern Europeans are under less selection pressure to maintain tooth size than were ancient Europeans.

Shea and Gomez (1988) studied posterior tooth size in African pygmies compared with their close relatives of normal stature, as well as Philippines pygmies compared with Philippines of normal stature. They found strong negative allometry of tooth size to skull size and tooth size to body size respectively. This was further explained as the effect of Insulin-like growth factors in dwarfed humans. Apparently these growth factors do not appear to affect the size of the dentition; hence pygmies might have larger teeth relative to their body size.

Kieser and Groeneveld (1988) studied a sample of 100 black crania to investigate allometry of jaws and teeth. They found that the postcanine teeth scaled negatively to canine area, while the total incisal surface scaled isometrically with canine are. This suggests that a reduction in the size of canines and incisors will be accompanied by an enlargement of premolar and molar size. They further found out that, with the exception to the lower central incisors, all other teeth scaled negatively to jaw length; hence their conclusion that lower jaws will be associated with relatively larger canines and smaller cheek teeth.

Brace *et al.*, 1983 proposed that human dental reduction can be explained using a model called the probable mutation effect (PME). According to the PME model, structures that are no longer functional experience a relaxation in selection pressure. This permits mutations to accumulate in the population, with the result that the concerned structures reduce in size. According to Brace *et al.* (1987), with the onset of the Last Glaciation in the Late Pleistocene between 100k and 75k, dental reduction began to occur at a rate of 1% per 2000 years, until the end of the Pleistocene, approximately 10,000 years ago. From there the reduction has proceeded at twice the previous rate, and can be considered to be 1% per 1000 years. Calgagno *et al*. (1988) are not in agreement with this model and suggest rather that hominid teeth may have reduced in size due to direct selection for smaller teeth. According to McHenry (1984), analysis of body weight and dental area of three australopithecine species (A. *afarensis, A. africanus* and *A. robustus*) shows that they all have large cheek teeth relative to body size when compared to living hominoids. According to him, the evolutionary transition from the megadont condition of *Australopithecus* to mesodontia seen in the *Homo* lineage may have occurred between 3.0 and 2.5 million years, from *Australopithecus afarensis* to *Homo habilis.* However, Ferguson (1987) proposes that it

may have occurred later between 2.5 to 2.0 million years ago, from *A. africanus*-like forms to *H. habilis,* based on his conclusion that KNM-ER 1813 (2.0 Ma) was a mesodont.

As things stand, scientists still believe that early Palauans are small bodied, and they have a high degree of megadontia relative to body size. Berger *et al.,* 2008, calculated the estimated megadontia quotients to be ranging from 1.09 to 1.31. It is this megadontia and other observed tooth anomalies on the Palauan fossil sample that will be addressed hereforth.

CHAPTER 2

MATERIALS AND METHODS

1. Tooth Size

Morphometric data and photographs of the Palauan fossil teeth were taken by Prof Lee Berger and Prof. Steven Churchill in the Belau National Museum in Palau in 2006. The six basic tooth measurements (described below) following Shaw (1932) were taken on all samples. In order to verify if the Palaun population was megadont, I followed the same measurement protocol and applied them to four modern human population groups for comparison. These included Zulus, Tswanas, Khoisan and Europeans. The European population groups measured refers to the South African whites who have been in South Africa for two or more generations. The teeth of 100 specimens were measured from each population group, 50 of which were males and 50 females. See Figure 2 for the terminology used for the anatomical orientation of teeth.

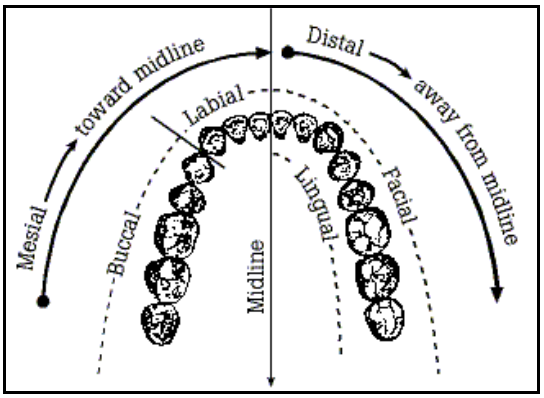

Figure 2. Diagram of the human mandibular teeth showing terminology for anatomical orientation. (www.uic.edu)

The measurements that were taken are as follows:

1) Mesiodistal diameter of the crown (MD)

This is taken as the greatest mesiodistal dimension parallel to the occlusal and labial surface. In the incisors and canines it was measured across the cutting edges (Figure 3). In premolars and molars it was measured along the middle of the crown, from articulation to articulation if the teeth were still in position in the jaws (Figure 4). On the teeth that have been extracted from the jaws it was measured from the middle of the upper border of the articulate facet anteriorly to a similar point of a similar facet posteriorly.

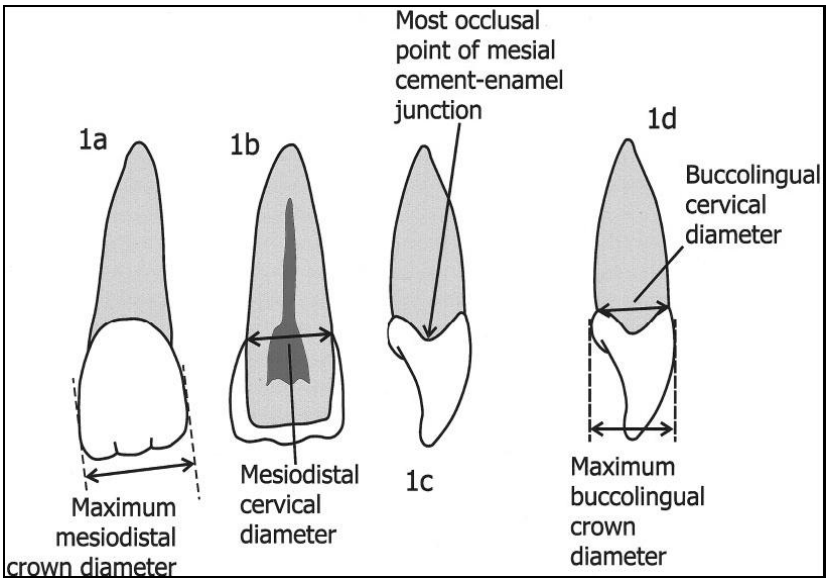

Figure 3. Crown diameter and cervical diameter measurements for upper incisors. a: Labial view, b: Mesiodistal section, c and d: Mesial view. After Hillson *et al.*, 2005.

2) Buccolingual diameter of the crown (BL)

This measurement is the greatest distance between the labial and lingual surfaces of the crown. It was taken at right angles to the mesiodistal diameters.

3) Mesiodistal diameter taken at the cervical enamel junction [MD (cej)]

4) Buccolingual diameter taken at the cervical enamel junction [BL (cej)]

5) Crown height (CH)

The crown height of incisors, canines and premolars was measured from the cervicoenamel junction on the labial aspect to the cutting edge for all the anterior teeth, and to the most prominent point of the buccal cusp for all premolars. That of the upper and lower molars was measured from the cervicoenamel junction on the lingual surface to the most prominent part of the mesio-lingual cusp.

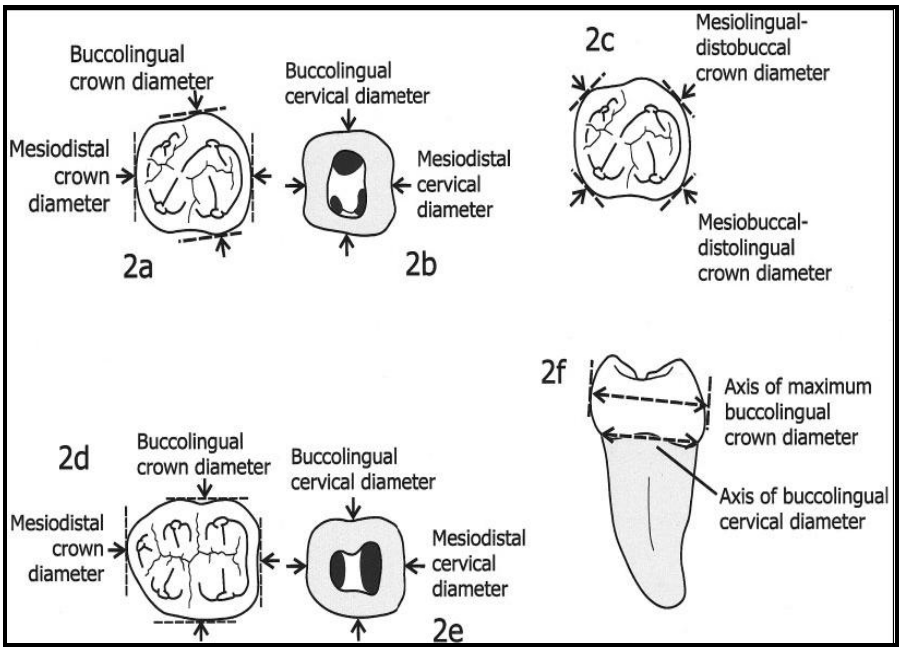

Figure 4. Crown diameter and cervical diameter measurements for molars. a, c: Upper molar occlusal view. b: upper molar transverse section at cervix. d: Lower molar occlusal view. e: Lower molar transverse section at cervix. f: Lower molar mesial view. After Hillson *et al.*, 2005.

6) Total root length (TRL)

This is taken from the apex of the root to the enamel edge of the crown at the cervix on the labial aspect.

All the above mentioned measurements follow Shaw, 1932. They were taken using vernier calipers; Sylvac, Switzerland. All measurements were taken to 0.1 mm.

7) Wear

Tooth Wear

Tooth wear is the non-carious loss of tooth structure, which typically falls into three main categories: abrasion, attrition and erosion. Tooth abrasion and attrition are caused by mechanical reasons, with attrition resulting from direct tooth-on-tooth contacts, whereas abrasion is produced by contact with foreign materials. Tooth erosion is a non-bacterial chemical process which begins when the tooth structure comes in contact with the acids in foods and beverages. (Hillson *et al.*, 2005; Scott *et al.*, 1988.)

The rate of wear depends on diet and environmental factors. Hunter-gatherers and agriculturalists usually exhibit different amount of wear. Meat is non-abrasive compared to plants foods, therefore this reduce the amount of mastication needed to prepare foods, and this leads to less wearing of the teeth.

Most dental wear is limited to the occlusal and interproximal surfaces, but certain dietary habits can wear the lingual surfaces of the teeth.

In this study wear was measured according to scales. The scales ranged from 0 to 3.

Scale: 0: No wear

1: Mild wear

This involves dentine exposure on less than 1\3 of the tooth surface.

2: Moderate wear

This involves dentine exposure of more than 2\3 of the tooth surface.

3: Severe wear

This normally involves secondary dentine exposure and loss of tooth height (Bartlett, 2005).

Definition of the surfaces of the teeth

Anatomical definitions vary from author to author. Definitions of anatomical areas of the teeth used in this study (after Shaw, 1966) are as follows:

1) Labial surface:

The surface of the tooth which is in contact with the lips and is found only on the upper and lower incisor and canine teeth.

2) Buccal surface:

The surface which is in contact with the cheeks and is found on all premolars and molar teeth.

3) Lingual surface:

The surface which is in contact with the tongue and is found on all the lower teeth.

4) Palatal surface:

The surface which faces towards the hard palate and is found on all the upper teeth.

5. Occlusal surface:

The surface of molar and premolar teeth which comes into contact or occludes with the analogous surface of the opposing member in the opposite jaw.

6) Mesial surface:

The surface of the tooth which is directed toward the mid-line of the dental arch, the mid-line lying between the two central incisors.

7) Distal surface:

The surface of the tooth which is directed away from the mid-line of the dental arch.

2. Survey of the anomalies

The entire sample of the modern human Dart Collection, comprising 3000 specimens, and a Holocene human sample of 69 specimens from the Iziko Museum were examined to record the presence of the four anomalies. (Tables 2 and 3). The human Dart collection comprises 31 population groups (tribes), 7 of which are from sub-Saharan countries. These include Zimbabwe, Malawi, Mozambique, Swaziland, Botswana, Namibia, and Zambia. The European population groups measured refers to the South African whites who have been in South Africa for two or more generations. Degree of expression, orientation and other characters the amount of wear on the teeth and caries were noted for observed anomalies. These were compared and contrasted with the Palauan sample. Photographs of the teeth with anomalies were taken using a Nikon D40 digital camera at 300x magnification.

The Holocene human skeletons

The Holocene Human skeletons were ideal for the comparison of anomalies with the Palauan sample because they are of the same age, but are from mainland. These skeletons were excavated at different locations around the Western Cape region, stretching along the coastal peninsula. The skeletons used date from 60yrsBP to 6120yrsBP (Morris, 1992). So far only dental caries

have been reported from the Hunter-gatherer population of the Late Pleistocene inhabitants of the Cape Province (Sealy *et al.,* 1992).

CHAPTER 3

RESULTS

The results of all teeth studied will be presented here in the form of tables and univariate and bivariate plots.

Mandibular Central Incisors

The size of mandibular central incisors was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in Table 1 for each population group for comparison with the Palauan sample of mandibular central incisors. In addition the univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement (variable).

Table 1: MD diameters of the mandibular central incisors

Population Groups	**MD Diameter**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.13	0.47	5.66-6.77	5
Khoisan females	5.02	0.29	4.69-5.25	3
Tswana males	5.53	0.34	4.92-5.88	22
Tswana females	5.28	0.28	4.66-5.75	19
Zulu males	5.51	0.27	4.93-6.00	20
Zulu females	5.37	0.39	4.80-5.93	28
European males	5.20	0.30	4.48-5.72	41
European females	5.10	0.35	4.29-5.69	29

Five Palauan mandibular central incisors were available for comparison with the modern human sample. Out of the 400 modern human samples measured, the Khoisan was the least represented, with only three measurable individuals. The mean of the MD diameter of the Palauans is a millimeter larger than most of the population groups. It is followed by the Tswana and Zulu males respectively. The Khoisan females have the lowest mean of all the populations measured. The females of the modern human population groups have means lower than the males of similar groups. The standard deviations of all the populations studied are very small, showing the clustering of data around the means of the different populations.

The MD diameter of the Palau sample ranges from 5.66-6.77 mm. Khoisan females have the smallest mean range from 4.69-5.25 mm, while Tswana males have the largest mean of all the modern human population groups, from 4.92-5.88 mm. This shows that the MD diameter of the Palauans falls markedly above the normal range of modern human variation.

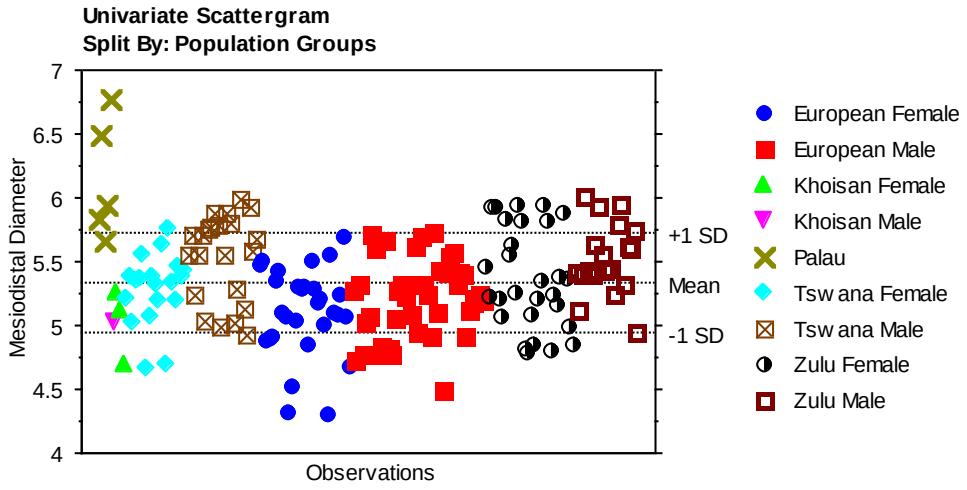

Figure 5: Univariate plot of the MD diameters of the mandibular central incisors.

The Palauans have very large MD diameters compared to the modern human population groups measured. Zulu males and females are similar to each other, and are comparable to Tswana males. Tswana females are slightly smaller than Tswana males. There is little difference between the European sexes. Generally, there is little sexual dimorphism among the modern human population groups measured.

Table 2: BL diameters of the mandibular central incisors

Population group	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.45	0.26	6.24-6.83	5
Khoisan females	3.16	1.1	2.81-3.78	3
Tswana males	4.32	0.42	3.37-4.95	23
Tswana females	4.29	0.50	2.90-4.99	19
Zulu males	4.46	0.41	3.73-5.05	19
Zulu females	4.00	0.50	3.08-4.94	28
European males	3.50	0.59	2.50-4.53	41
European females	3.32	0.57	2.41-4.40	29

Five Palauan mandibular central incisors were available for comparison with the modern human sample. As for the MD diameter, the BL diameter is very large compared to the modern human population groups measured. The mean is twice that of the Khoisan females and European population groups. The mean of the Palauans is followed by Zulu and Tswana males respectively. Khoisan females have the lowest mean of all the populations measured, and it is similar to that of Europeans. The males of the modern human sample have means that are larger than those of the females. The standard deviation of the Palauans is the smallest indicating the clustering of data around the mean of the group whereas the standard deviation of the European males is the largest. The BL diameter of the Palauans ranges from 6.24-6.83 mm. Khoisan females have the smallest mean, ranging from 2.81-3.78 mm, whereas Zulu males have the

largest mean of all the modern human population groups, ranging from 3.73-5.05 mm. Tswana and Zulu population groups are comparable with one another. These ranges show that the BL diameter of the Palauans falls well above the normal range of modern human variation.

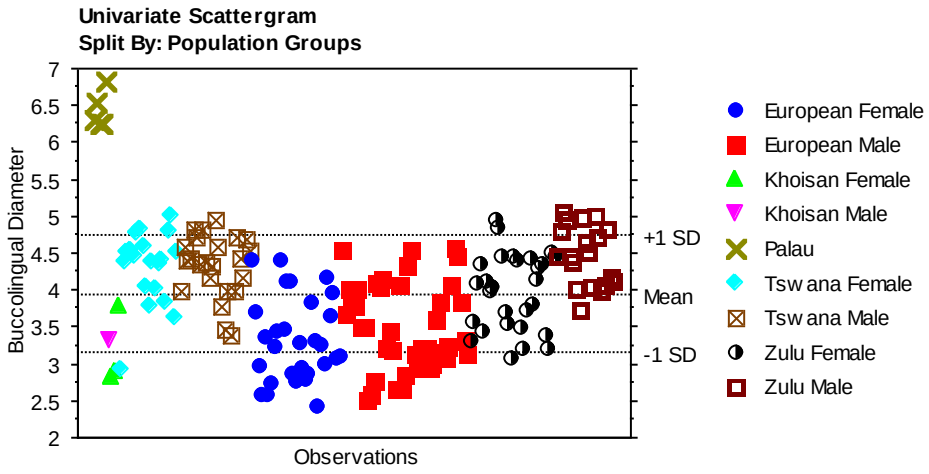

Figure 6: Univariate plot of the BL diameters of the mandibular central incisors.

This diagram illustrates the relationship between the BL diameters of the mandibular central incisors of the different human population groups. The mean of the BL diameter of the Palauans is large compared to all modern human population groups. The modern human population groups do not vary that much, although sometimes males tend to be slightly larger than females. The Tswana and Zulu males are about equal to each other, and the same applies to the females of similar groups. Some of the European samples are similar to some of the aforementioned groups. Khoisan population groups are similar to most of the Europeans, which are at the lower end of modern human variation, while the Tswanas and Zulus are more clustered at the upper end of the variation. The BL diameters of the Palau population exceed those of modern humans to an extreme degree.

Table 3: CH of the mandibular central incisors

Population Groups	Crown Height			
	Mean	***Std dev***	***Range***	***N***
Palau	9.50			
Khoisan females	7.33	1.18	6.62-7.70	3
Tswana males	8.66	1.07	7.18-10.34	17
Tswana females	8.25	0.77	6.88-9.58	19
Zulu males	8.59	0.98	7.07-10.43	20
Zulu females	8.26	0.68	7.07-9.61	28
European males	8.05	0.64	6.51-9.15	29
European females	8.04	0.90	5.94-9.05	29

Only one measurement of the Palauans was available (see figure 7.) for comparison with the modern human sample. Khoisan females were the least represented, with only three individuals. The Palauan crown height is 9.5 mm. Even though only a single value (and therefore not necessarily representative of the whole population), it is larger than most of the CH of the modern human sample. It is followed by the means of the Tswana and Zulu males respectively. Khoisan females have the lowest means of all the populations measured. The females of the modern humans have means that are smaller than those of the males of their similar groups.

The standard deviations of the Khoisan females and Tswana males are higher compared to other population groups measured. This indicates the scattering of primary data around the means of the different population groups. The crown height of the groups measured cover a wide range, for example, European females range from 5.64-9.05 mm. Tswana males have the largest mean of all the modern human groups measured, ranging from 7.18-10.34 mm. Khoisan females have the lowest mean, ranging from 6.62-7.70 mm. The Palauan 9.50 mm crown height falls within the upper range of modern human variation.

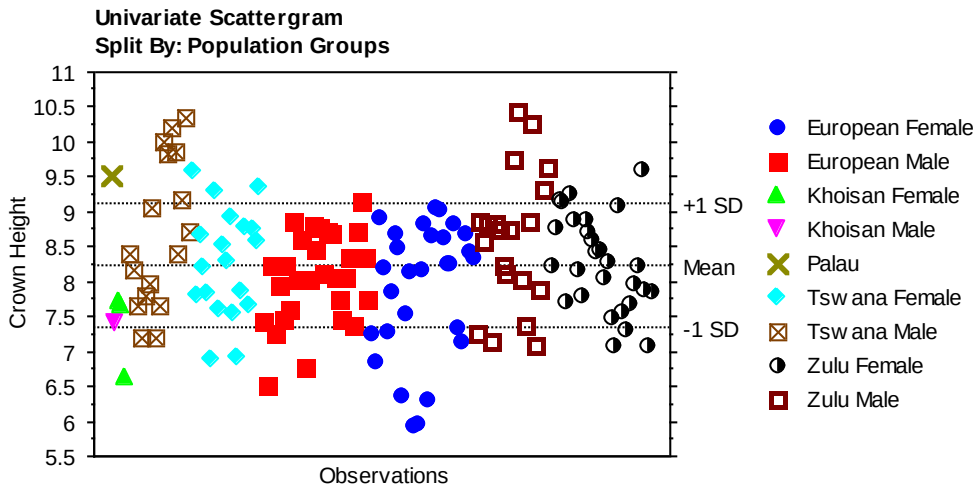

Figure 7: Univariate plot of the CH of the mandibular central incisors.

The only available measurement for the Palauan falls within the upper range of modern human variation. Tswana and Zulu males are very similar to each other, and so are the females of these two groups. Khoisan population groups are among the smallest of all the populations measured. Sexual dimorphism is extensive on the Tswanas and Zulus, but moderate on the Europeans and Khoisan. This is evidenced by the ranges of the groups presented on the table above. For Example Tswana males and females range from 7.18-10.34 mm and 6.88-9.58 mm, while European males and females from 6.51-9.15 mm and 5.94-9.05 mm respectively. The crown height measurements of all the groups are very scattered, showing the high amount of variability that can be observed in a particular tooth class and measurement.

Table 4: MD (cej) diameters of the mandibular central incisors

Population Groups	**MD (cej) diameter**			
	Mean	***Std dev***	***Range***	***N***
Palau	4	0.16	3.80- 4.20	5
Khoisan females	3.18	0.51	3.10-3.25	3
Tswana males	3.79	0.34	3.26-4.61	23
Tswana females	3.78	0.29	3.38-4.56	18
Zulu males	3.8	0.44	3.09-4.67	19
Zulu females	3.79	0.38	3.07-4.46	28
European males	3.73	0.29	3.20-4.32	41
European females	3.70	0.27	3.00-4.35	29

Four Palauan mandibular central incisors were available for comparison with the modern human population groups. The Khoisan population groups are the least represented, with only 3 females and no males present. The mean of the MD (cej) diameter of the Palauans is slightly greater than the means of the other human population groups. It is followed by the means of the Zulu males. The mean of Tswana males is equal to that of Zulu females. The means of the females of the modern human population groups are smaller than those of the males of their groups. Khoisan females have the lowest mean of all the groups measured. The means of the Europeans are smaller than those of the Palauans, Zulu and Tswanas, but larger than the ones of Khoisan females. The standard deviation of the Palauans is smaller than those of the modern human samples. The Palauans range from 3.80-4.20 mm. Khoisan females range from 3.10-3.25 mm. Zulu males have the largest mean of all the modern humans measured, ranging from 3.09-4.67 mm. These ranges show that the MD (cej) diameters of the Palauans falls within the normal range of modern human variation. Three of the four modern human groups studied record individuals possessing teeth with larger MD (cej) diameters than the Palauans.

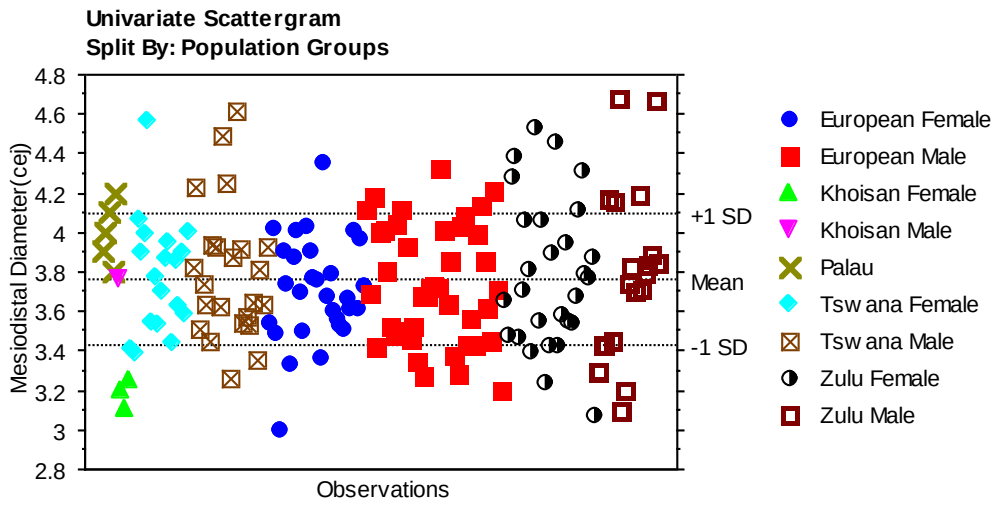

Figure 8: Univariate plot of the MD (cej) diameters of the mandibular central incisors.

The MD (cej) diameters of the Palau population fall within the normal range of modern human variation. Three groups, the Tswana, Zulu and European have some individuals with MD diameters that are larger than the Palauans. The Khoisan are among the smallest of the modern human samples measured. There is little difference between the modern human population groups. Tswana and Zulu males are very similar to each other, and males and females of the same modern human group do not vary that much.

Table 5: BL (cej) diameters of the mandibular central incisors

Population group	**BL (cej) diameter**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.06	0.38	5.90-6.70	5
Khoisan females	5.07	0.67	4.49-5.80	3
Tswana males	5.89	0.25	5.64-6.45	23
Tswana females	5.57	0.39	5.06-6.25	19
Zulu males	5.82	0.46	4.76-6.55	19
Zulu females	5.62	0.51	3.79-6.52	28
European males	5.72	0.48	4.67-6.43	41
European females	5.55	0.47	4.53-6.27	29

Five Palauan mandibular central incisors were available for comparison with the modern human sample. The Khoisan group was the least represented. The mean of the BL (cej) diameter of the Palau population is larger than the means of the modern human population groups measured. It is followed by the mean of Tswana males. Zulu males have the second largest mean of the modern human populations, range from 4.76-6.55 mm. The means of the males of the modern human population groups are larger than those of the females. Tswana males have the lowest standard deviation of all the groups studied, showing that the data clustered around the mean of the group. Other groups also have low standard deviations. The BL (cej) diameters of the Palauans range from 5.90-6.70 mm. Tswana males have the highest mean of all the modern human populations studied, ranging from 5.64-6.21 mm. Khoisan females have the lowest mean range from 4.49-5.80 mm. These ranges show that the BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

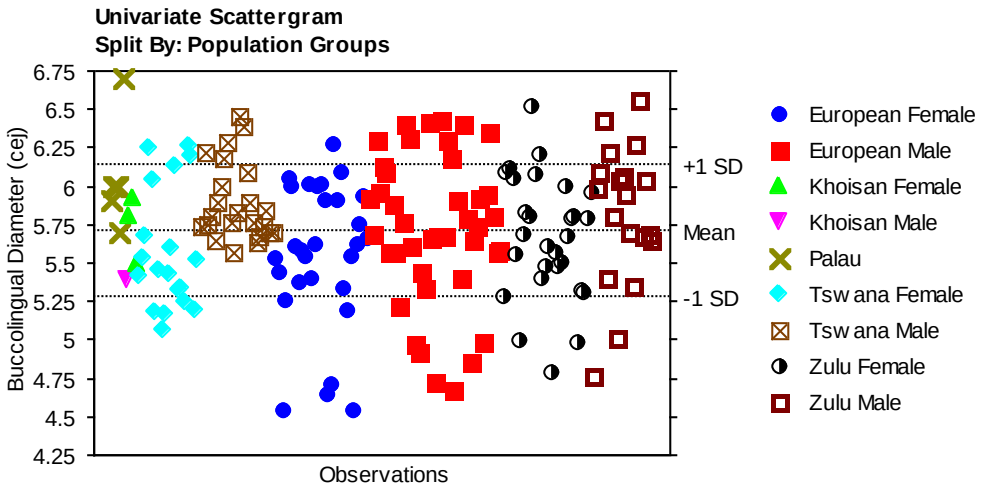

Figure 9: Univariate plot of the BL (cej) diameters of the mandibular central incisors.

One BL (cej) diameter of the Palau sample is larger than all of the BL (cej) diameters of modern human populations. The rest are smaller than and equal to some of the modern human population groups. There is not much difference between the modern human population groups; Tswana, Zulu and European groups are comparable to one another. The males and females of these different groups are to some extent similar to each other. There is equal clustering of data of all groups at the upper end of the range of variation.

Table 6: Total root length of the mandibular central incisors.

Population group	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	11.91	0.98	10.56-12.85	4
Tswana females	12.14	1.77	10.27-13.79	3
Zulu males	11.17	1.43	10.01-13.85	6
European females	12.97	0.45	12.65-13.28	2

Most of the teeth measured were intact, enabling measurement of the roots in the majority of cases. Sometimes when the teeth were loose the roots were broken and therefore could not be measured. No measurements were obtained for the Khoisan population group. The mean of the TRL of the Palauans is larger than the mean of Zulu males, but smaller than that of Tswana and European females. European females have the lowest standard deviation of all the groups measured as the data for this group are close to the mean.

The Palau population ranges from 10.56-12.85 mm. Zulu males have the lowest mean, ranging from 10.01-13.85 mm. European females have the highest mean of all the populations measured, ranging from 12.65-13.28 mm. These ranges show that the total root length of the Palau population falls within the normal range of modern human variation.

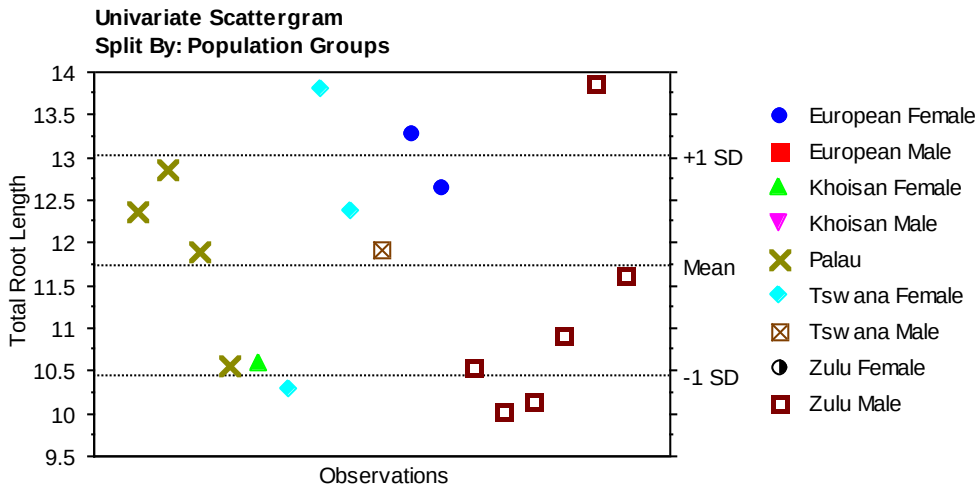

Figure 10: Univariate plot of the total root length of the mandibular central incisors.

The total root lengths of the Palauans are normal in comparison to the modern human population groups, and are equal to most of them. Zulu males and Tswana females have the most spread data, ranging from 10.01-13.85 mm and 10.27-13.79 mm respectively. There is little difference the total roots length of the modern human population groups.

Bivariate Analysis

The following is the table of all the bivariate analyses done in this study.

Table 7: Bivariate analysis carried out in the Palauan and modern human samples.

Teeth	MD vs. BL	MD vs. CH	MD vs. MD (cej)	MD vs. BL (cej)	MD vs. TRL	BL vs. CH	BL vs. MD (cej)	BL vs. BL (cej)	BL vs. TRL	CH vs. MD (cej)	CH vs. BL (cej)	CH vs. TRL	MD (cej) vs. BL (cej)	MD (cej) vs. TRL	BL (cej) vs. TRL
Man central Incisor	p>0.001	P=0.218.	p=0.0003	p=0.0106	p=0.7679	p=0.0923	p=0.0027	p<0.0001	p=0.7982	p=0.2424	p=0.06505	p=0.8237	p=0.0090	p=0.0122	p=0.6347
Max central Incisor	p=0.0919	p=0.2794	p=0.0001	p= 0.021	p=0.8235	p=0.2903	p=0.9245	p=0.5959	p=0.2097	p=0.0853	p=0.1795	p=0.8940	p=0.0811	p=0.5593	p=0.2137
Man Lateral Incisor	p<0.0001	p=0.0013	p=0.0001	p<0.0001	p=0.3488	p=0.5600	p=0.0007	p<0.0001	p=0.4204	p=0.0009	p=0.0259	p=0.5172	p<0.0001	p=0.6641	p=0.7759
Max Lateral Incisor	p=0.0002	p=0.0217	p<0.0001	p<0.0001	p=0.0005	p=0.7114	p=0.0001	p<0.0001	p=0.2548	p=0.2507	p=0.1432	p=0.6807	p=0.0056	p=0.1734	p=0.1019
Man canines	p<0.0001		p<0.0001	p<0.0001	P<0.0007		p<0.0001	p<0.0001	p=0.0033				p<0.0001	p=0.0145	p=0.0717
Max Canines	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p=0.2025	p<0.0001	p=0.0214	p<0.0001	p=0.3969	p<0.0001	p<0.0001	p=0.0152	p<0.0001	p=0.0259	p=0.2458
Man 3rd Premolars	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p=0.1296	p<0.0001	p<0.0001	p<0.0001	p=0.3139	p<0.0001	p<0.0001	p=0.4891	p< 0.001	p=0.3443	p=0.8001
Max 3rd Premolars	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p=0.6006		p<0.0001	p<0.0001	p=0.8646	p=0.0105	p< 0.0001	p=0.4256	p<0.0001	p=0.2507	p=0.5150
Man 4th Premolars	p<0.0001		p<0.0001	p<0.0001	p=0.0120		p<0.0001	p<0.0001	p=0.4584				p<0.0001	p=0.8708	p=0.9126
Max 4th Premolars	p<0.0001	p<0.0001	p=0.0026	p<0.0001	p=0.1543	p<0.0001		p<0.0001	p=0.5652				p=0.0007	p=0.4894	p=0.526
Man 1st Molars	p<0.0001		p<0.0001	p<0.0001	p=0.1534		p<0.0001	p<0.0001	p=0.0031				p<0.0001	p=0.9257	p=0.1654
Max 1st Molars	p<0.0001		p<0.0001	p<0.0001			p=0.0005	p<0.0001					p=0.0005		
Man 2nd Molars	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p>0.9999	p=0.0173	p=0.0002	p<0.0001	p=0.2653	p=0.0520	p=0.4746		p<0.0001	P=0.0603	p=0.0634
Max 2nd Molars	p<0.0001		p<0.0001	p<0.0001			p<0.0001	p<0.0001					p<0.0001		

The first variables compared were the crown measurements, the MD and BL diameters of the mandibular central incisors.

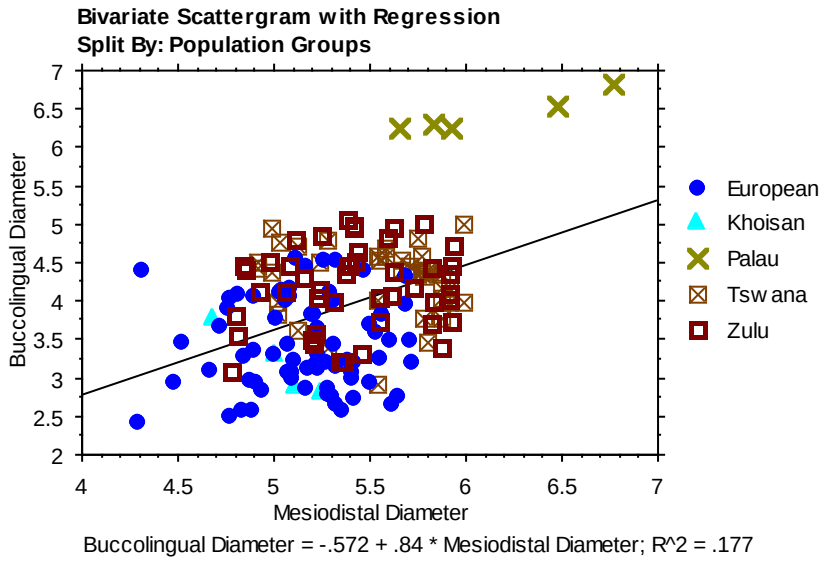

Figure 11: Bivariate plot of the MD and BL diameters of the mandibular central incisors.

The BL diameter of the Palauan sample falls above the range of modern human populations measured in this study. All of the BL diameters of the Palauans are greater than those of the modern human populations. They range from 6.24-6.83 mm. They are followed by a cluster of the BL diameters of the Tswana and Zulu population groups. These groups range from 2.90-4.99 cm and 3.08–5.05 mm respectively. The European and Khoisan population groups are clustered on the lower end of the range of modern human variation. The difference between the Palauans and the Tswana and Zulu population groups is smaller than that between the Palauans and Europeans and Khoisan. The BL diameter of the Tswana and Zulu population groups are similar to each other, and are larger than those of the European and Khoisan population groups. They are clustered at the upper end of the range of modern human variation.

The MD diameter of the Palau population is also greater than the MD diameters of the modern human population groups measured. Two of them fall above the normal range of modern human variation, but three fall within the observed range. A Pearson correlation coefficient was calculated to assess the relationship between MD and BL diameters. There is a positive correlation between the two variables, (r=0.42, n=164, p<0.0001, 95% CI 0.285-0.539).

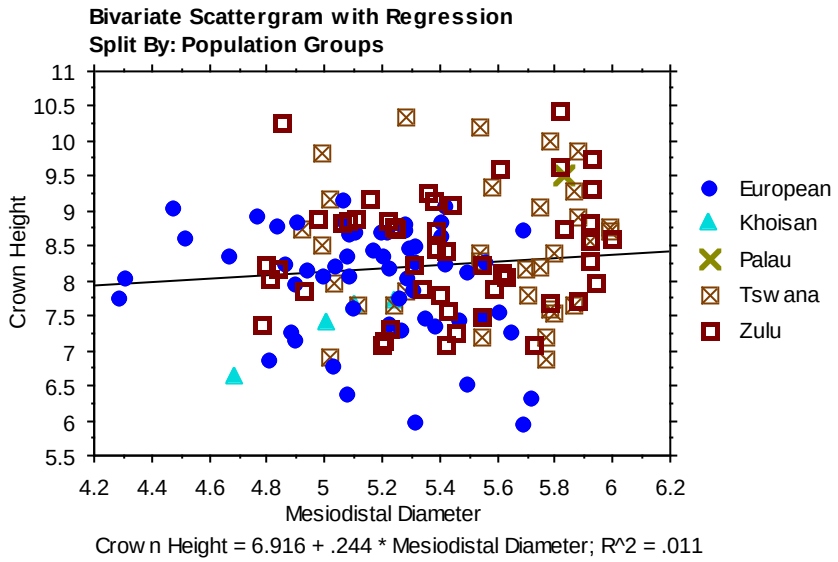

Figure 12: Bivariate plot of the MD diameters and CH of the mandibular central incisors.

Only one crown height measurement in the Palauan sample was available for the study. The crown height of the Palauans is plotted on the upper end of the range of modern human variation. There is little difference between the crown heights of modern humans, but most of the crown heights of the European population are clustered below the regression line.

The MD diameter of the Palauans falls within the upper range of modern human variation. The difference between the Palauans and the Tswana and the Zulu population groups is smaller than the difference between the Palauans and the European and the Khoisan population groups. The

MD diameters of the Tswana and the Zulu population groups are similar, and are larger than the MD diameters of the European and Khoisan population groups. There is a low positive correlation between the MD diameter and crown height, (r= 0.104, n= 142, p= 0.2178, 95 % CI -0.062-0.264). The correlation between the two variables is not statistically significant, meaning an increase in MD diameter does not significantly relate to an increase in crown height.

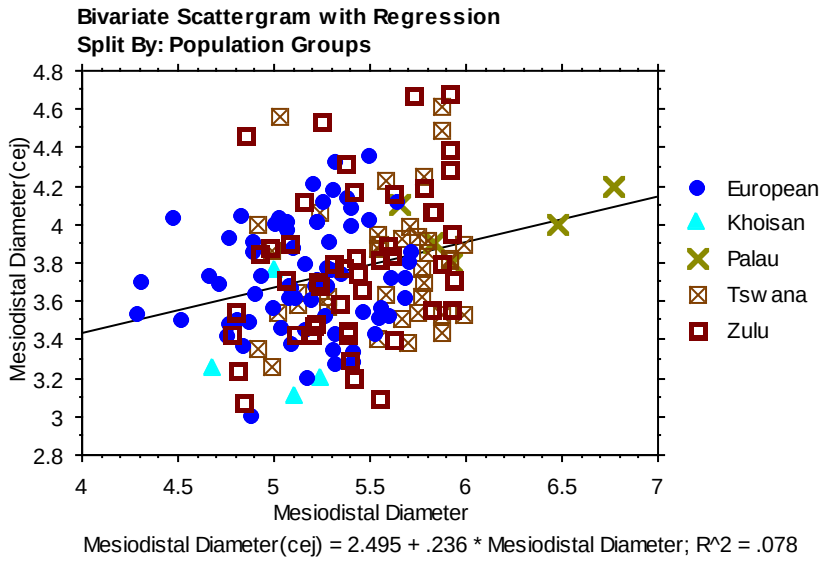

Figure 13: Bivariate plot of the MD and the MD (cej) diameters of the mandibular central incisors.

The MD (cej) diameter of the Palau sample is equal to and smaller than some of the diameters of modern humans. It ranges from 3.80-4.20 mm. The MD (cej) diameters of the Zulu population groups, which are clustered on the upper end of the range of modern human variation, range from 3.07-4.67 mm, while the Khoisan population group, clustered on the lower end, ranges

from 3.10-3.76 mm. This indicates the narrowing of the Palauan mandibular central incisors at the cervical enamel junction. The MD (cej) diameters of the modern human population groups do not vary much. They are evenly disrtibuted along the regression line, with similar quantities of the different groups on either side of the line.

The MD diameter of the Palau population is large compared to those of the modern human population groups, though some are equal to those of the modern human sample. There is little difference between the modern human population groups, but most of the Tswana and the Zulu population groups are clustered on the upper end of the range of variation. The European and Khoisan population groups are at the lower end. There is a positive correlation between these two variables, (r= 0.28, n= 163, p= 0.0003, 95% CI 0.132-0.416).

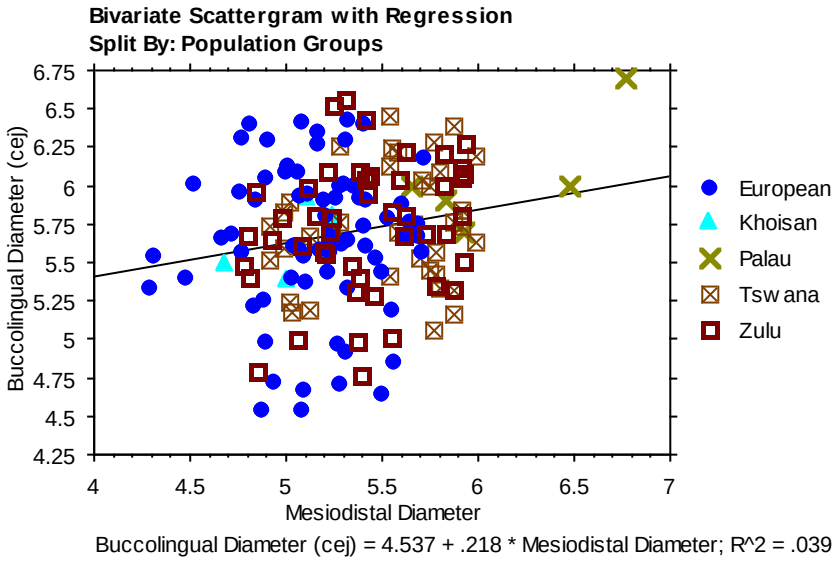

Figure 14: Bivariate plot of the MD and BL (cej) diameters of the mandibular central incisors.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. A few are larger and smaller, but most are equal to the BL (cej) diameters of the modern human sample. The BL (cej) diameter of the Palauans ranges from 5.90-6.70 mm. There is little difference between the BL (cej) diameters of the modern human population groups. Equal numbers of the Tswana, Zulu and European population groups are on either side of the regression line. All of the BL (cej) diameters of the Khoisan population group are on the lower end of the range of modern human variation, but are plotted very close below the regression line. The Tswana and the Khoisan population groups range from 5.06-6.45 mm and 5.30-5.90 mm respectively. These ranges indicate a constriction of the mandibular central incisors of the Palauans at the cervical enamel junction. There is a low positive correlation between the MD and BL (cej) diameter of the humans measured, (r= 0.20, n= 164, p= 0.0106, 95% CI 0.047-0.342).

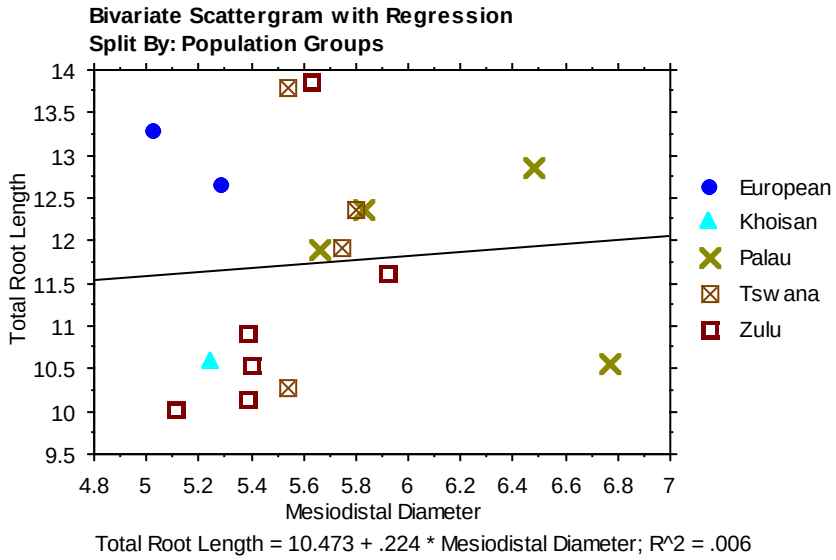

Figure 15: Bivariate plot of the MD diameters and the TRL of the mandibular central incisors.

The total root length (TRL) of the Palau population is equal to the total root lengths of modern humans. Three are equal to those on the upper end of modern human variation, whereas one is

equal to those on the lower end. There is little difference in the total root lengths of modern humans. The Zulu population groups are clustered below the regression line on the lower end of the range of modern human variation, while the majority of the Tswana population groups, as well as the only two available Europeans, are on the upper end of the range.

The MD diameter of the Palau population falls within and above the range of modern human variation. Two are exceptionally large, whereas two are equal to those of modern humans. The MD diameters of the Tswana and Zulu population groups are larger than those of the European and the Khoisan population groups, making the difference between them and the Palauans smaller than those of the Palauans and the two remaining modern human population groups. There is a low positive correlation between the MD diameter and TRL, (r= 0.08, n= 17, p= 0.7679, 95% CI -0.418-0.539). Therefore the correlation between these two variables is not statistically significant.

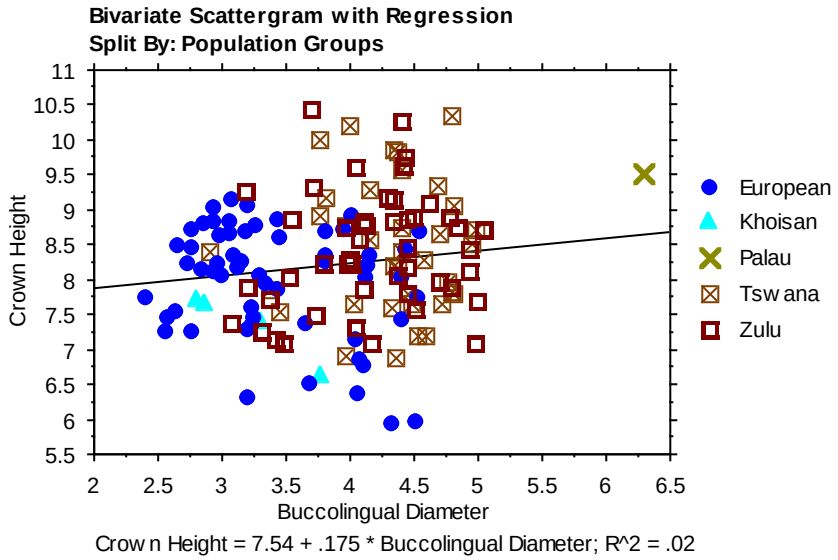

Figure 16: Bivariate plot of the BL diameters and CH of the mandibular central incisors.

Only one measurement of the crown height of the Palauan mandibular central incisors was available for this comparison. It is large compared to most of the modern human sample, but still falls within the range of modern human variation. There are a few crown heights of the modern human sample that are larger than this measurement. The crown heights of the human sample do not vary much from each other. The crown heights of the Khoisan population group are among the smallest of the modern humans measured. The crown heights of the Tswana, Zulu and European population groups are evenly distributed along the regression line. This variable is widely spread, with the Tswana and the Zulu population groups ranging from 6.56–10.34 mm and 6.28–10.26 mm respectively.

The BL diameter of the Palau population is greater than that of the modern human population groups. It is followed by those of the Tswana and the Zulu populations, then the European and Khoisan population groups. This makes the difference between the Palau and the European and Khoisan populations to be greater when compared to the difference between the Tswana and the Zulu populations. The difference between the Palau and European population group is mostly evident in the BL diameter, whereas their crown heights do not vary that much. The BL diameters of the Tswana and Zulu population groups are clustered close to each other, on the upper end of the range of modern human variation, a bit further from Europeans and Khoisan. There is a low positive correlation between the BL diameter and CH, ($r= 0.140$, $n= 145$, $p= 0.0923$, 95% CI -0.023-0.297). Therefore the correlation between these two variables is not statistically significant.

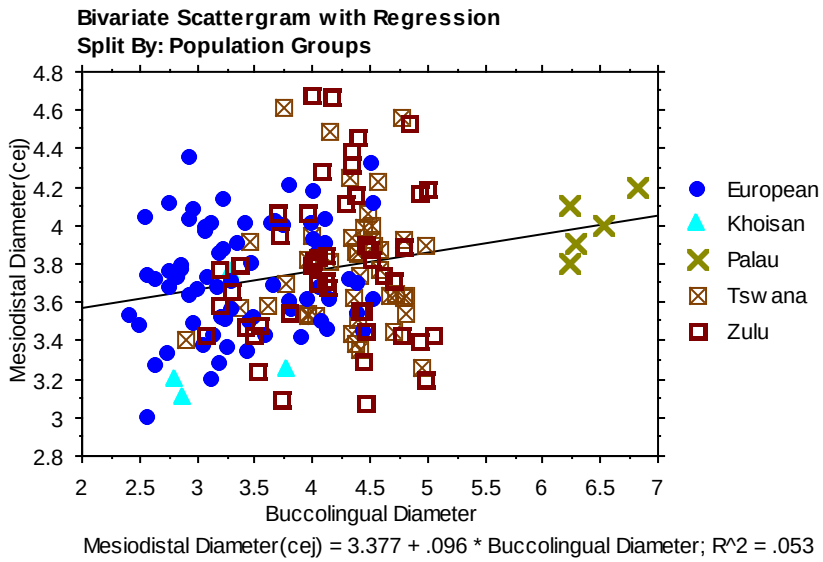

Figure 17: Bivariate plot of the BL diameters and the MD (cej) diameter of the mandibular central incisors.

The BL diameter of the Palauan sample is much larger than those of the modern human sample. It is followed by a cluster of the Tswana and the Zulu population groups, which are on the upper end of the range of modern human variation. The Khoisan and the European population groups are clustered on the lower end of modern human variation. The Tswana and the European population groups range from 2.90-4.99 mm and 2.41-4.54 mm respectively.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. It is larger than the MD (cej) diameters of the Khoisan and European population groups, which are on the lower end of the range of modern human variation, but smaller than the MD (cej) diameters of the Tswana and the Zulu population groups on the upper end. The MD (cej) diameters of the modern human sample are very wide ranging, from 3.00-4.67 mm. The Khoisan and most of the European sample are at the lowest end, with the Tswana and the Zulu samples at

the upper end of the range of modern human variation. There is a low correlation between the BL and MD (cej) diameter, (r= 0.23, n= 167, p= 0.0027, 95% CI 0.081-0.369).

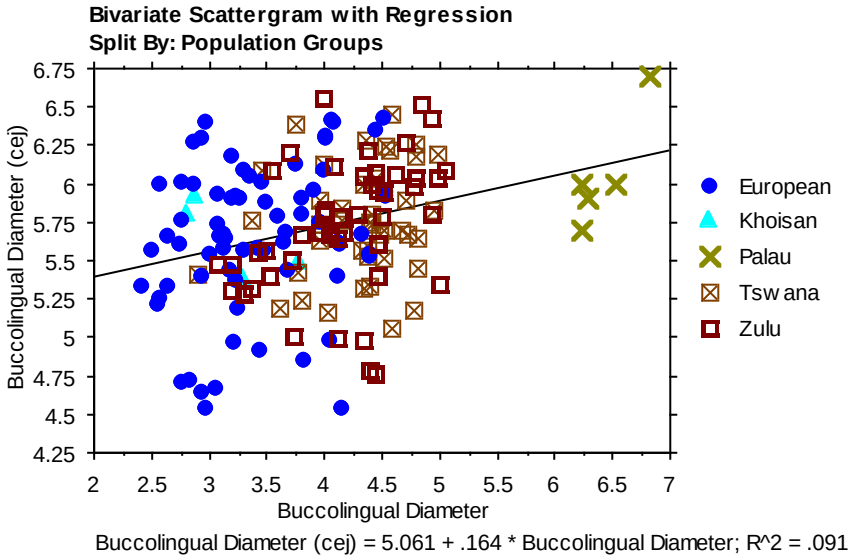

Figure 18: Bivariate plot of the BL and the BL (cej) diameters of the mandibular central incisors.

The BL (cej) diameter of the Palauans falls within the range of modern human variation. Most of the BL (cej) diameters of the Palau population are equal to the BL (cej) diameters that are clustered on the middle of the modern human range. The BL (cej) diameters of the modern human sample are not that different from each other. The Tswana, Zulu and European population groups are mostly clustered on the upper end of the modern human range. Some of the Khoisan populations are above the regression line, whereas others are below. There is a low positive correlation between the BL and BL (cej), (r= 0.30, n= 168, p< 0.0001, 95% CI 0.157-0.433).

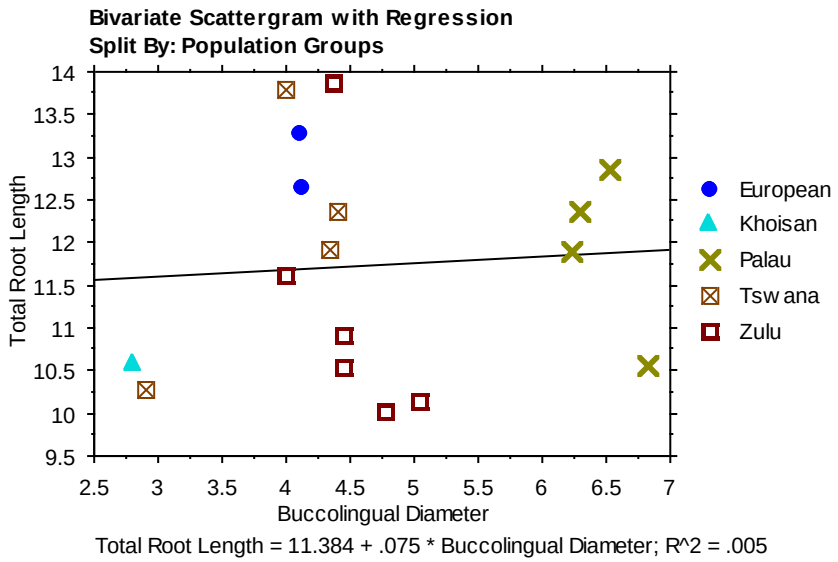

Figure 19: Bivariate plot of the BL diameters and the TRL of the mandibular central incisors.

The total root length of the Palauans falls within the range of modern human variation. There is little difference between the total root lengths of the modern human population groups. Most of the Zulu population groups are clustered on the lower end of modern human variation. The BL diameter of the Palau sample is greater than the BL diameters of the entire modern human sample measured. It is followed by those of the Zulu population groups. The Khoisan population group has the smallest BL diameter of all the populations measured, making the difference between them and the Palauans the greatest in all the modern humans measured. There is a low positive correlation between the two variables, (r= 0.07, n= 17, p= 0.7982, 95% CI -0.426-0.531).

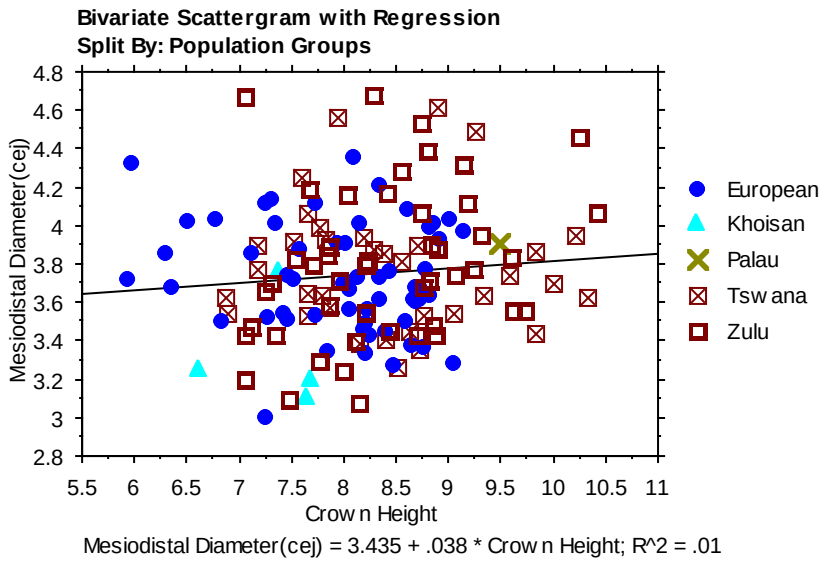

Figure 20: Bivariate plot of the CH and the MD (cej) diameters of the mandibular central incisors.

The crown height of the Palau population falls within the range of modern human variation. A few of the crown heights of modern humans are greater than the crown heights of the Palauans, but the difference between the Palauans and the modern human sample is not very big. There is no difference at all between the crown heights of the modern humans. The Tswana, Zulu and European population groups are evenly distributed along the graph. They all range from the 6.00-10.50 mm mark. The Khoisan population groups range from 6.62-8.66 mm. The difference between the Palauans and the modern humans is the greatest when comparing the Palauans to the Khoisan population groups.

The MD (cej) diameter of the Palauans falls within the range of modern human variation. It is equal to the MD (cej) diameters of the modern humans, plotting in the middle of the modern human range. There is little difference between the MD (cej) diameters of the modern human sample, but the majority of the Khoisan population group is on the lower end of the modern

human range. This makes the difference between Palauans and the Khoisan to be greater than the other other modern human groups. There is a low positive correlation between these two variables, (r= 0.098, n= 144, p= 0.2424, 95% CI -0.067-0.258). However the correlation between the two is not statistically significant.

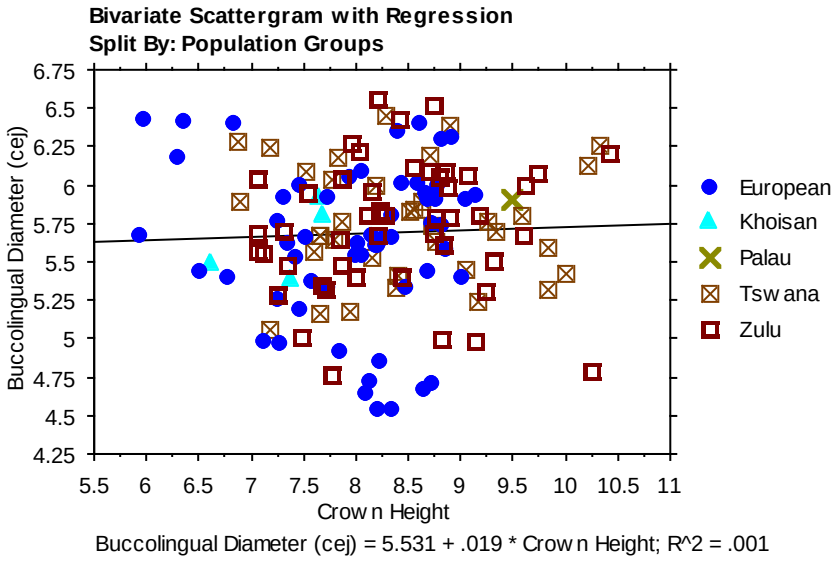

Figure 21: Bivariate plot of the CH and the BL (cej) diameters of the mandibular central incisors.

The crown height of the Palauan population falls within the range of modern human variation. A few of the crown heights of the modern humans are larger than the crown heights of the Palauans. There is little difference between the crown heights of modern humans. The Tswana, Zulu and European population groups are widely spread along the entire graph, with most of the variables clustered in the middle of the range of modern human variation. The crown height of the Khoisan population group is similar to the rest of the modern humans.

The BL (cej) diameter of the Palauan population falls within the range of modern human variation. It is equal to the BL (cej) diameters of the modern humans in the middle of the modern

human range. The BL (cej) diameters of modern humans are very similar to one another, but the Khoisan population groups are among the smallest of the modern humans measured. The groups are evenly distributed along the regression line. There is a low positive correlation between the two variables, (r= 0.04, n= 145, p= 0.06505, 95% CI -0.126-0.200). The correlation between these two variables is not statistically significant.

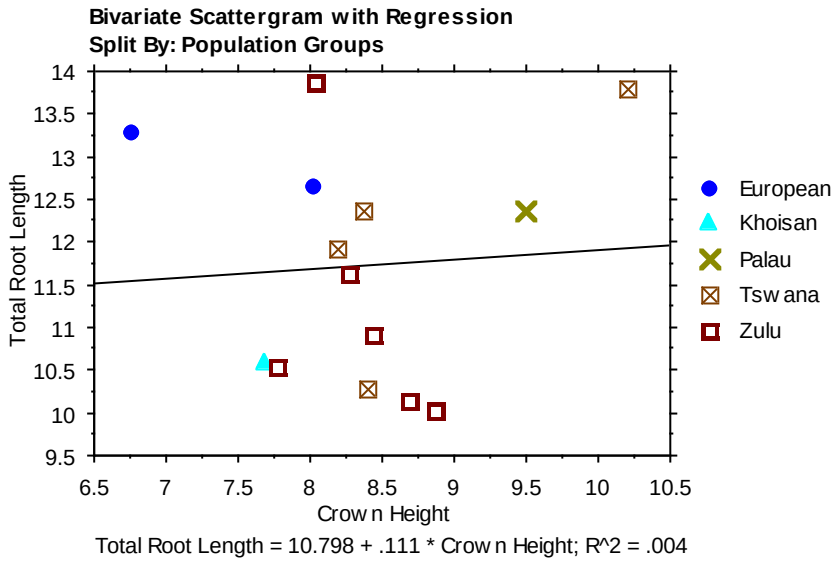

Figure 22: Bivariate plot of the CH and the TRL of the mandibular central incisors.

The total root length and the crown height of the Palauans fall within the range of modern human variation. There is no difference at all between the Palau population and the modern human sample concerning the two variables shown in the graph. The total root lengths of the Zulu population group are clustered on the lower end of the modern human range, whereas Europeans are on the upper end. There is a low positive correlation between the CH and TRL, (r= 0.07, n= 14, p= 0.8237, 95% CI -0.481-0.577). Therefore the correlation between these two variables is not statistically significant.

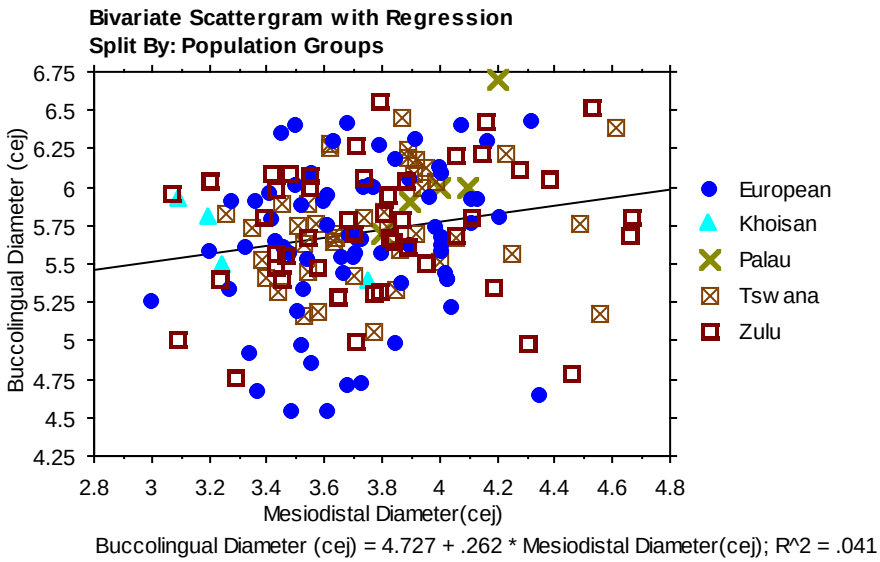

Figure 23: Bivariate plot of the MD (cej) and the BL (cej) diameters of the mandibular central incisors.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. One of the BL (cej) diameters is at the uppermost range, while most of the measurements are equal to those of the modern human sample. There is little difference among the modern human population groups, but the Tswana and the Zulu population groups are clustered on the upper end of the range of variation.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Just like the BL (cej) diameter, the MD (cej) diameter of the Palauans does not vary that much from those of the modern human sample. The MD (cej) diameters of the Palauans are equal to the MD (cej) diameters of the modern humans, which are on the upper end of the modern human variation. There is also little difference between the modern human population groups. The MD (cej) diameters of the modern humans are comparable with one another, but few of the MD (cej) diameters of the Tswana and the Zulu population groups are larger than those of the European

and Khoisan. There is a low positive correlation between the MD and BL (cej), (r= 0.20, n= 167, p= 0.0090, 95% CI 0.051-0.343). Therefore the correlation between these two variables is statistically significant.

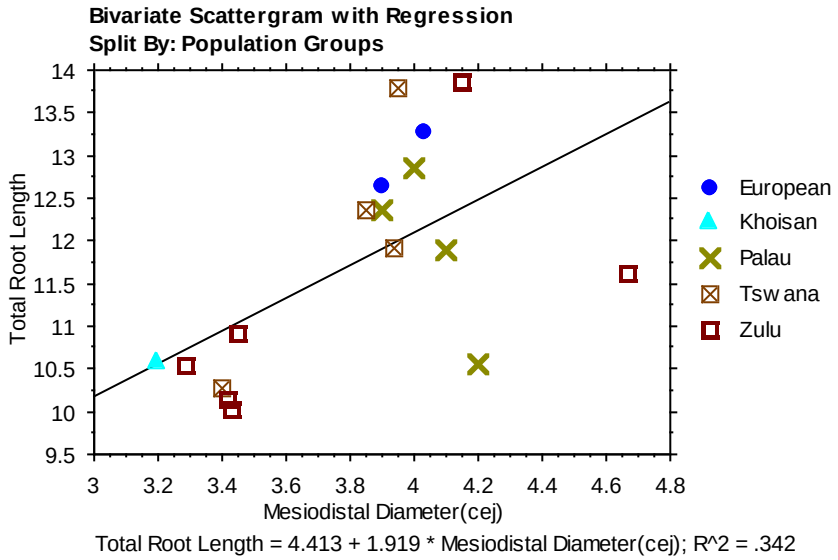

Figure 24: Bivariate plot of the MD (cej) diameters and the TRL of the mandibular central incisors.

The MD (cej) diameter of the Palau population is equal to those of modern humans. There is also little difference between the MD (cej) diameters of the modern human populations. A few of the Tswana and the Zulu population groups are on the lower end of the range, close to the Khoisan population.

The total root length of the Palau population is equal to those of the modern humans measured. Two are below, whereas two are above the regression line. The Khoisan population group is among the smallest of the modern human sample. The European population group is on the upper end of the range of variation. The total root lengths of the Tswana and the Zulu population

groups cover a very wide range. Some are on the lower end, while others are on the upper end of the range. There is a low positive correlation between the two variables, (r= 0.59, n= 17, p= 0.0122, 95% CI 0.145-0.832). The correlation between the MD (cej) and TRL is statistically significant.

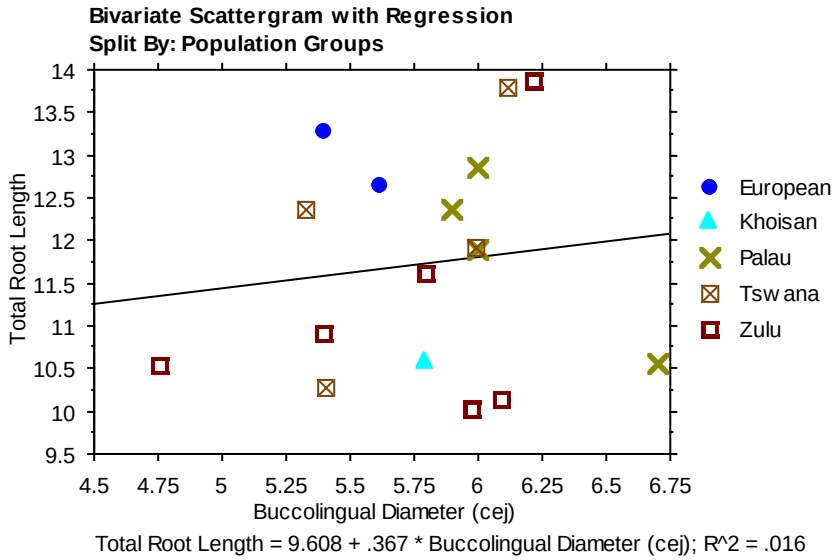

Figure 25: Bivariate plot of the BL (cej) diameters and the TRL of the mandibular central incisors.

The total root length of the Palau population is equal to those of modern humans. There is little difference between the total root lengths of modern humans. The Khoisan population group is among the smallest of the modern human populations measured. The Tswana and Zulu population groups cover a wide range of variation. The European population group is on the upper end of the range of human variation.

The BL (cej) diameter of the Palau population is equal to those of modern humans.The Tswana and Zulu population groups are equal to each other, and are larger than most of the European and

Khoisan. The European and Khoisan are in the middle of the range of modern human variation. There is a low positive correlation between the BL (cej) and TRL, (r= 0.13, n= 17, p= 0.6347, 95% CI -0.377-0.572). The correlation between these two variables is not statistically significant.

Maxillary Central Incisors

The size of the maxillary central incisors was examined using the measurements described in Chapter 2. The format which was followed when discussing the results of the mandibular central incisors will be followed here, and in all the teeth analyzed.

Table 8: MD diameters of the maxillary central incisors

Population Groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.43	0.76	7.40-9.39	7
Tswana males	9.15	0.42	8.43-9.70	14
Tswana females	8.61	0.58	7.41-9.50	13
Zulu males	8.73	0.52	7.86-9.50	9
Zulu females	8.59	0.41	7.88-9.29	19
European males	8.40	0.53	7.58-9.23	23
European females	8.31	0.53	7.86-8.87	15

Seven Palauan maxillary central incisors were available for comparison with the modern human sample. No measurements were obtained from the Khoisan population. The mean of the MD diameter of the Palauans is smaller than the means of the modern human population groups, except for Europeans. The Tswana males have the highest mean of all the groups, followed by Zulu males. The females have lower means compared to the males of their respective groups. Just like the Tswana males, the Tswana females have the highest mean of all the females studied. The European population groups are smaller than the other two modern human population

groups, but their mean is the closest to the Palauans. The Palau population has the highest standard deviation of all the populations measured, showing the widespread distribution of the individual data from the population mean.

The standard deviations of the remaining groups show that the data of the MD diameters were more clustered. The Tswana males, have the largest mean, range from 8.43-9.70 mm. European females range from 7.86-8.87 mm. The Palauans range from 7.40-9.39 mm. These ranges show that, although having a smaller mean than most modern human groups, the MD diameter of the Palauans falls comfortably within the normal range of modern human variation.

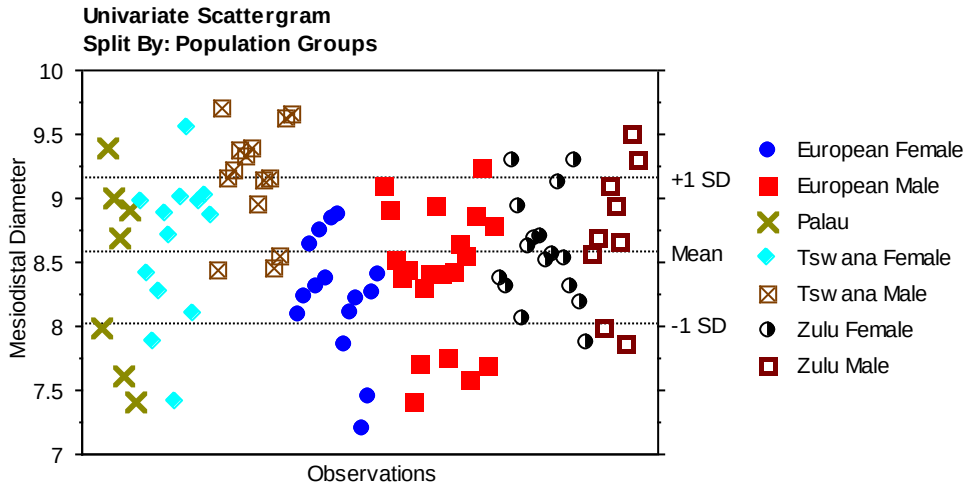

Figure 26: Univariate plot of the MD diameters of the maxillary central incisors.

The MD diameter of the Palau population is equal to most of the MD diameters of the modern humans. Some of the modern human males are slightly larger than the Palauans, especially the Tswana and Zulu males. Tswana and Zulu males are very similar to each other, and so are the females of these two groups. European males are slightly comparable with the Tswana and Zulu females. Sexual dimorphism is moderate on all of the groups of the modern humans.

Table 9: BL diameters of the maxillary central incisors

Population Groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.16	0.46	6.53-7.90	6
Tswana males	5.28	0.89	4.15-6.99	16
Tswana females	5.08	0.68	4.14-6.07	14
Zulu males	5.52	0.95	4.05-6.68	10
Zulu females	4.95	0.66	4.07-6.02	20
European males	4.69	0.7	3.62-6.01	24
European females	4.26	0.54	3.62-5.77	18

Six Palauan maxillary central incisors were available for comparison with the modern human samples. No measurements were obtained form the Khoisan population groups. The mean of the BL diameter of the Palau teeth is very large compared to the rest of the modern human populations. The Palauans are followed by the Zulu and the Tswana males respectively. The means of the females of all the groups studied are smaller than the means of the males of their respective groups. The Tswana females have the highest mean of all the females measured. The European population groups have the lowest mean compared to the Palauans and the other modern human groups.

The standard deviation of the Palau population is the smallest of all the groups measured. This shows that of all the populations studied, the MD diameter data of the Palauans are clustered around its population mean. The Zulu males have the highest mean of all the modern human populations studied. They range from 4.17-6.68 mm. The mean of the European females is the smallest, ranging from 3.62-5.77 mm. The MD diameter of the Palauans ranges from 6.53-7.90 mm. These ranges show that the MD diameter of the Palau population falls above the normal range of modern human variation.

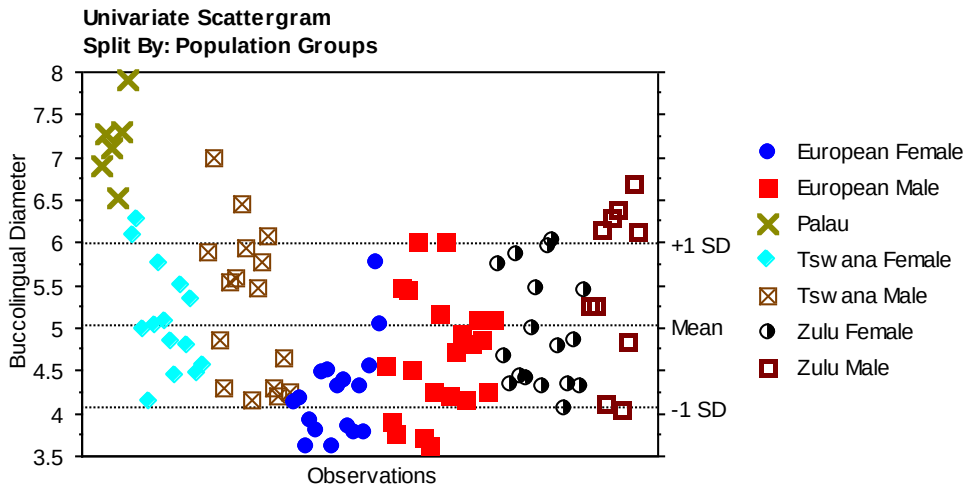

Figure 27: Univariate plot of the BL diameters of the maxillary central incisors.

The BL diameter of the Palau population is large compared to the BL diameter of the modern human populations, whereas few are equal to those of the Tswana and Zulu males. There is little difference between the BL diameters of the modern human population groups. The males of the Tswana and the Zulu populations are very similar to each other, and the same applies to the females of those groups. Most of the European population groups are at the lower end of the range of modern human variation, making them smaller than most of the groups studied.

Table 10: Crown height of the of the maxillary central incisors

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau	10.36	0.78	9.55-11.10	3
Tswana males	10.61	0.86	9.16-11.81	11
Tswana females	10.37	0.46	9.74-11.12	14
Zulu males	10.44	0.89	9.28-11.69	10
Zulu females	10.38	0.52	9.71-11.20	19
European males	10.27	0.56	9.02-11.03	16
European females	10.04	0.55	9.27-10.87	18

Three Palauan maxillary central incisors were available for comparison with the modern human sample. The Khoisan population group was not available for this comparison. The mean of the crown height of the Palau population is greater than the means of the European population groups, but smaller than the means of the Tswana and Zulu population groups. The Tswana males have the highest mean of all the populations measured, while European females have the lowest. The mean of all the females measured are smaller than the mean of the males of their respective groups. All of the groups measured have small standard deviations, with Tswana females having the smallest. This indicates that the primary data of the different population groups is clustered around the means of the groups. Tswana males range from 9.16-11.81 mm, whereas European females range from 9.27-10.87 mm. The Palauans range from 9.55-11.10 mm. These ranges show that the crown height of the Palau population falls within the normal range of modern human variation.

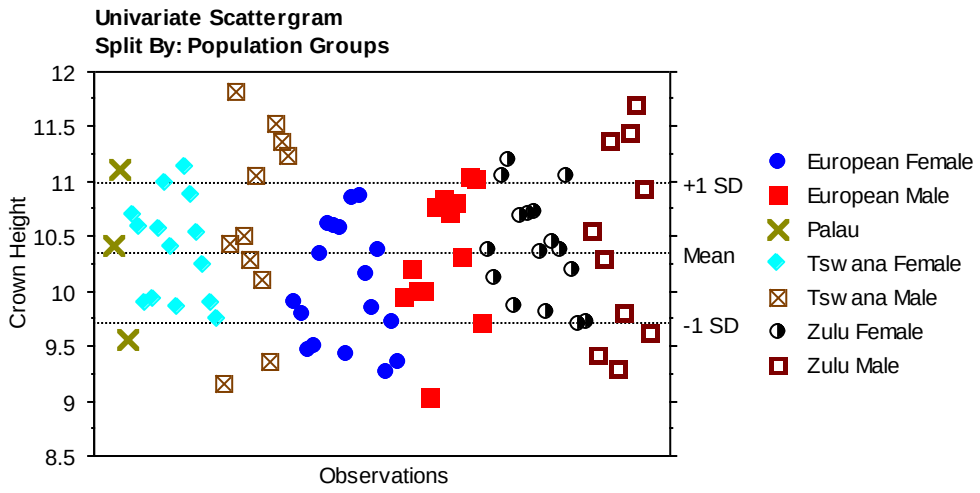

Figure 28: Univariate plot of the CH of the maxillary central incisors.

The crown height of the Palauns is equal to those of the modern human population groups. Some of the crown heights of the modern human populations, especially the Tswana and Zulu males

are larger than the crown heights of the Palau population. Tswana and Zulu males are comparable with each other; the same applies to the females of the same groups. The males and females of the European population group are slightly similar to each other, whereas the males and females of the two remaining modern human populations groups vary to a small degree, hence moderate sexual dimorphism.

Table 11: MD (cej) diameters of the maxillary central incisors

Population groups	**MD (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.02	0.92	4.90-7.00	5
Tswana males	6.85	0.66	5.90-7.95	16
Tswana females	6.55	0.53	5.61-7.54	14
Zulu males	6.7	0.62	5.70-7.85	12
Zulu females	6.57	0.40	5.84-7.40	20
European males	6.50	0.52	5.80-7.50	24
European females	6.41	0.48	5.70-7.18	18

Five Palauan maxillary central incisors were available for comparison with the modern human sample. No Khoisan population group was available for comparison. The mean of the MD (cej) diameters of the Palau population is the smallest of all the population groups measured. Tswana males have the highest mean of all the populations studied, whereas European females have the lowest. The means of the females of the modern humans measured are smaller than that of the males of their particular groups. The mean of the MD (cej) diameters of the European males is smaller than those of the Tswana and Zulu females, even though the difference is less than half a centimeter. The Palau population has the highest standard deviation of all, and the smaller standard deviations of the modern humans indicate clustering of the data along their individual population means.

The Palau population ranges from 4.90-7.00 mm. Tswana males have the highest mean, and range from 5.90-7.95 mm. European females have the lowest mean of the entire sample, ranging from 5.70-7.18 mm. These ranges show that the Palauans have MD (cej) diameters that fall below and within the normal range of modern human variation.

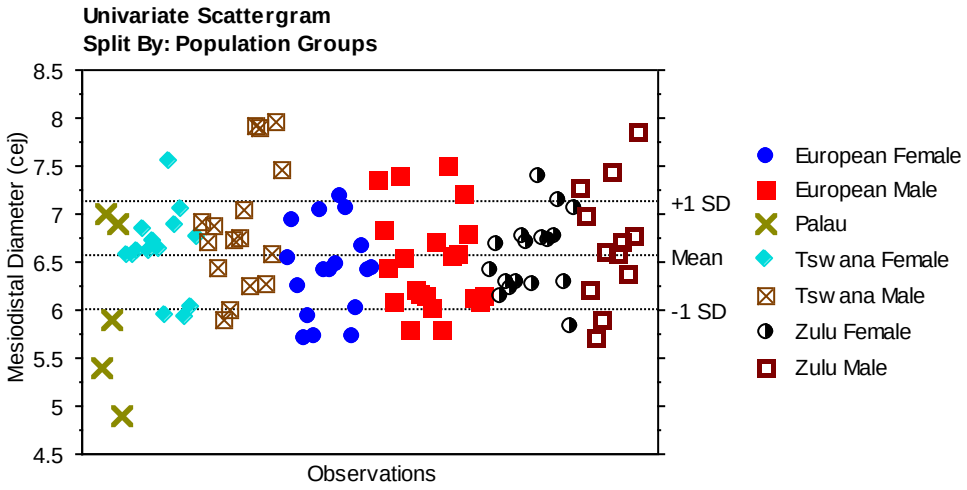

Figure 29: Univariate plot of the MD (cej) diameters of the maxillary central incisors.

The MD (cej) diameter of the Palau population is in some instance smaller and sometimes equal to some of the MD (cej) diameters of the modern human populations. Tswana and Zulu males have higher MD (cej) diameters compared to the rest of the groups measured, and they are also comparable with each other. The maximum values of the MD (cej) diameter of the European males are very similar to the maximum values of the females of the Tswana and the Zulu population groups. The minimum MD (cej) diameter of the maxillary central incisors recorded is for a Palauan. There is little difference between the females of the modern human samples.

Table 12: BL (cej) diameters of the maxillary central incisors

Population groups	**BL (cej) diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.48	0.37	6.10-7.00	5
Tswana males	7.22	0.38	6.53-7.95	16
Tswana females	7.16	0.47	6.43-7.87	14
Zulu males	7.24	0.49	6.36-8.02	12
Zulu females	7.16	0.35	6.61-7.86	20
European males	7.15	0.35	6.52-7.65	24
European females	7.04	0.30	6.59-7.51	18

Five Palauan maxillary central incisors were available for comparison with the modern human sample. No Khoisan sample was available for this comparison. The Mean of the BL (cej) diameter of the Palauans is smaller than the mean of all the populations measured. Zulu males have the highest mean of all the groups measured. The males of the modern human samples have means that are larger than the means of the females of their respective groups. European females have the lowest mean of all the populations studied. The standard deviations of all the groups measured are small, showing the clustering of the data around the means of the different groups. The Palauans range from 6.10-7.00 mm. Zulu males range from 6.36-8.02 mm, and European females from 6.59-7.51 mm. These ranges show that the BL (cej) diameter of the Palauans falls mostly below the normal range of modern human variation.

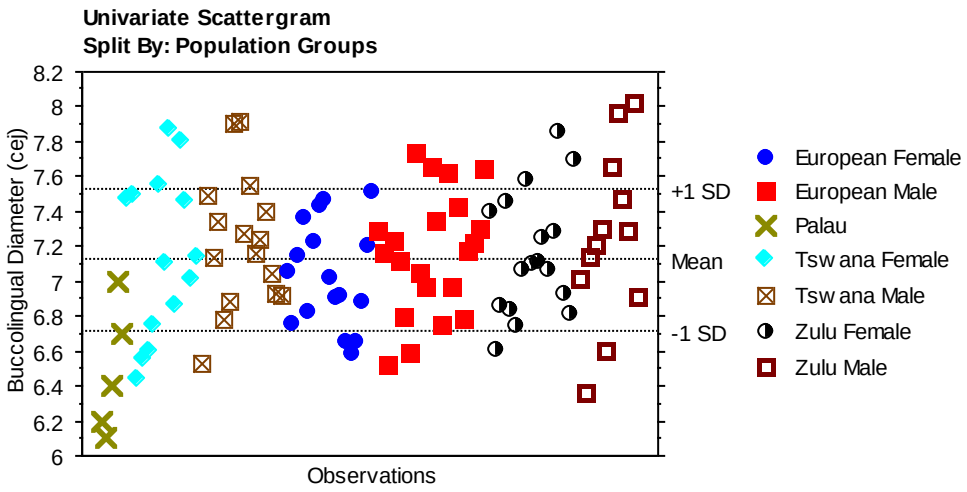

Figure 30: Univariate plot of the BL (cej) diameters of the maxillary central incisors.

Most of the BL (cej) diameters of the Palau populations are smaller than the BL (cej) diameters of all the modern humans studied. Tswana and the Zulu males are comparable. The same applies to the females of these groups. The Europeans are slightly smaller than the Tswana and the Zulu population groups. There is an even distribution of data for all groups from the lower to the upper end of the variation, with most of the data within the expected ranges.

Table 13: Total root length of the maxillary central incisors

Population groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	14.73	0.27	14.49-15.03	3
Tswana males	13.92	1.31	12.87-15.80	4
Tswana females	12.5	0.69	11.83-13.22	3
Zulu males	15.59	1.40	13.23-17.06	9

Three Palauan maxillary central incisors were available for comparison with the modern human sample. No measurements were obtained from the Khoisan and European population groups, as

well as Zulu females, because all of the available specimens had their teeth in their sockets. The mean of the total root length (TRL) of the Palau populations is larger than the mean of the Tswana population groups, but smaller than the mean of the Zulu males. The standard deviation of the Palau population is smaller than that of the modern human sample. This shows that there is less spread of the data from the mean of the population group. Zulu males, having the largest mean, range from 12.23-17.06 mm. Tswana females, with the lowest mean of all the groups measured, range from 11.83-13.22 mm. The total root lengths of the Palauans range from 14.49-15.03 mm. These ranges show that the TRL of the Palauans falls within the normal range of modern human variation.

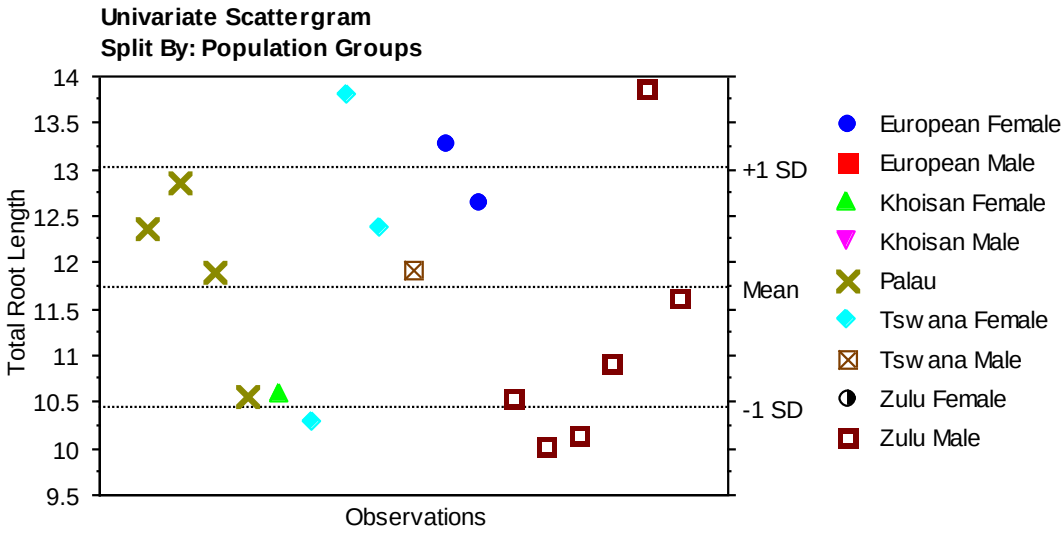

Figure 31: Univariate plot of the TRL of the maxillary central incisors.

The TRL of the Palau sample falls within the normal range of modern human variation. One Tswana female is at the lower end of the variation, whereas Zulu males cover a long range. The Zulu males have the widest range of variation.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the maxillary central incisors.

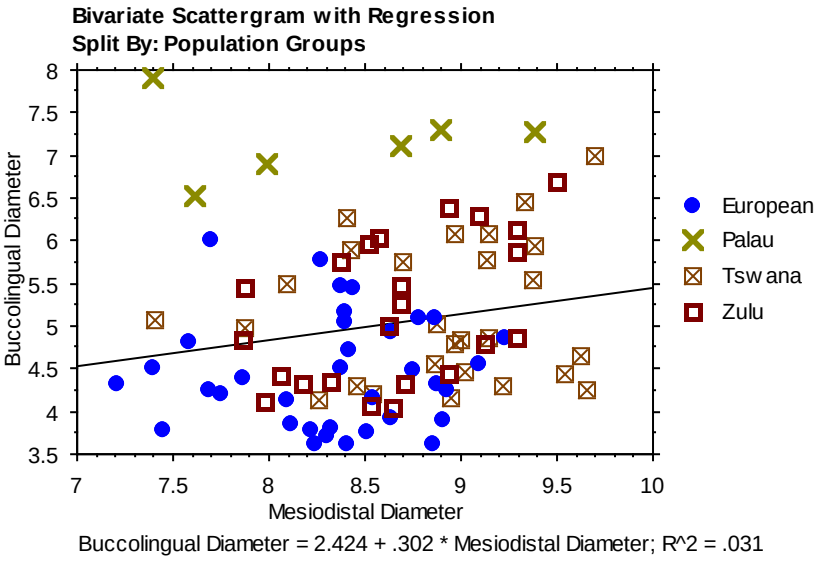

Figure 32: Bivariate plot of the MD and the BL diameters of the maxillary central incisors.

The MD diameter of the Palau population falls within the range of modern human variation, and it covers the same range. Most of the Europeans are at the lower end of the range of modern human variation, whereas the Tswana and Zulus are at the upper end. This makes the difference between the Palauans and Europeans the greatest.

The BL diameter of the maxillary central incisors of the Palau population falls above the range of modern human variation, and all are greater than those of the modern humans measured. The Tswana and Zulu populations are similar to each other, and are larger than the Europeans. The Europeans are clustered on the lower end of the range of modern human variation, thus making the difference between them and the Palau population the greatest. There is a low positive

correlation between the MD and BL diameter, (r= 0.18, n= 92, p= 0.0919, 95% CI -0.029-0.0368), however correlation between these two variables is not statistically significant.

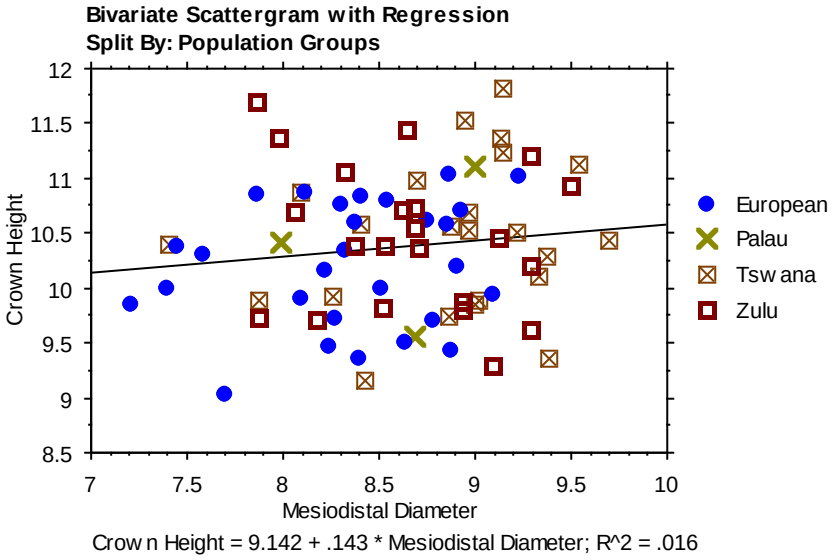

Figure 33: Bivariate plot of the MD diameter and the CH of the maxillary central incisors.

The MD diameter of the Palau population falls within the range of modern human variation. Two are at the upper end of the range of modern human variation, while one is at the lower end. The Tswana and Zulu populations are similar to each other, and are larger than most of the Europeans. The Europeans are clustered in the middle of the modern human range.

The Crown height of the Palau population falls within the range of modern human variation, with two plotting above the regression line and one below. There is little difference between the modern human populations, but the Tswanas and Zulus tend to shift to the upper end of modern human variation. The modern humans are evenly distributed along the expected slope of variation, with equal quantities on either side of the line. There is a low positive correlation

between the MD diameter and crown height, (r= 0.13, n= 77, p= 0.2794, 95% CI -0.102-0.340). The correlation between these two variables is not statistically significant.

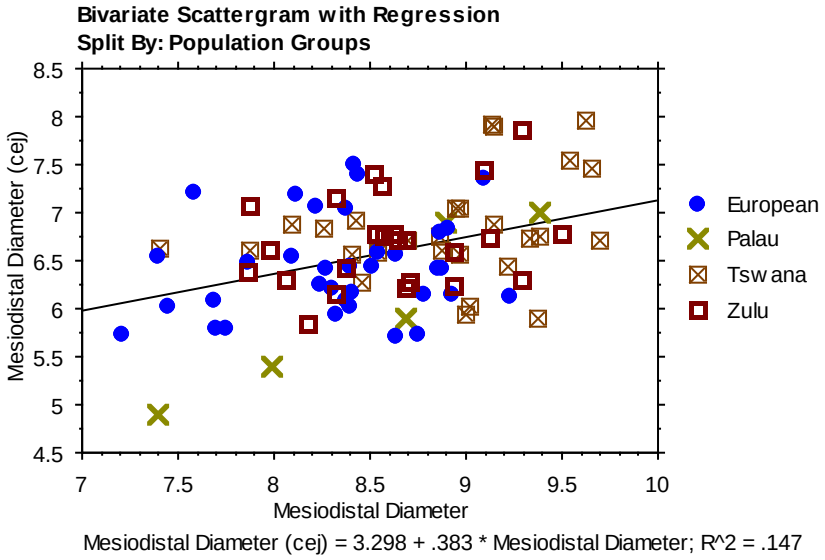

Figure 34: Bivariate plot of the MD and MD (cej) diameters of the maxillary central incisors.

The MD diameter of the Palau population falls within the range of modern human variation, and is distributed evenly along the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation, while the Europeans are on the lower end.

The MD (cej) diameter of the Palau population falls below and within the range of modern human variation. One is smaller than the rest of the modern human sample. There is little difference between the modern humans measured, as observed in the sample maximum of these three groups. There is a low positive correlation between the MD and MD (cej) diameters of the humans measured (r= 0.38, n= 92, p= 0.0001, 95% CI 0.193-0.545), and the correlation between these two variables is statistically significant.

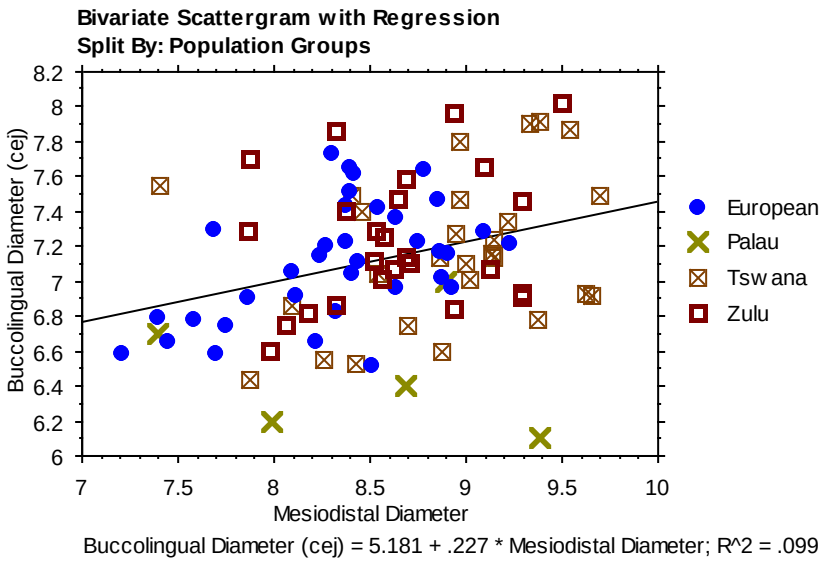

Figure 35: Bivariate plot of the MD and the BL (cej) diameters of the maxillary central incisors.

The MD diameter of the Palau populations falls within the range of modern human variation, and are evenly distributed along the range. The Tswana and Zulu populations are equal to each other, and are larger than the Europeans; who are clustered on the lower end of the range of modern human variation.

The BL (cej) diameter of the Palauan population falls at the lower end of the range of modern human variation, all plotting below the regression line. There is little difference between the three modern humans measured, but the sample maximum of the Tswanas and Zulus are greater than those of the Europeans. Therefore the difference between the Palau population and modern humans is smallest between the Palauans and the Europeans. There is a low positive correlation between the MD and BL (cej) diameters of the humans studied, (r= 0.32, n= 92, p= 0.021, 95& CI 0.118-0. 489) with a statistically significant correlation between these two variables.

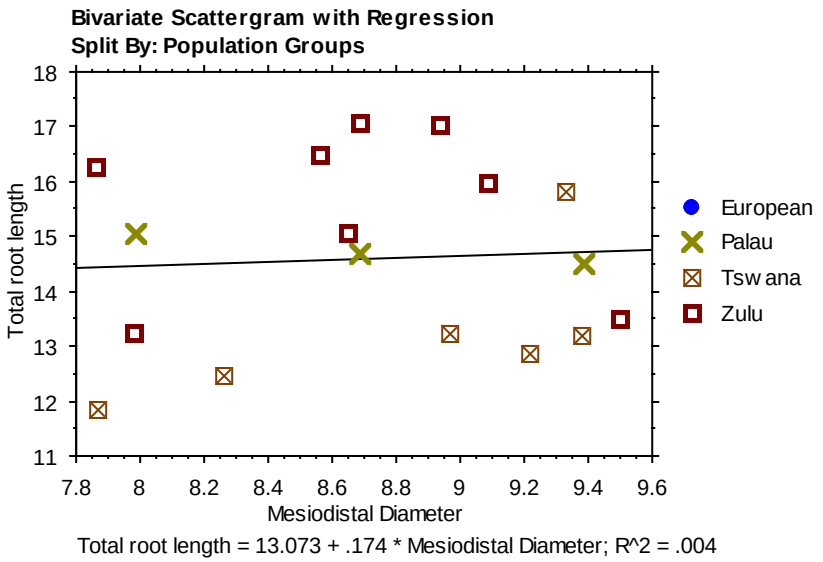

Figure 36: Bivariate plot of the MD diameters and the TRL of the maxillary central incisors.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those of the Tswana and Zulu populations. The Tswana and Zulu populations are similar to each other, therefore resulting in no difference between them and the Palauans.

The TRL of the Palau population falls within the range of modern human variation. The Tswana populations are at the lower end of the range, while the Zulus are at the upper end of the range. The difference between the Tswanas and the Palau population is the greatest since the Palauans are in the middle of the range. There is a high correlation between the MD diameter and TRL of the humans measured (r= 0.60, n= 17, p= 0.8235, 95% CI -0.432-0.525). Even though the correlation between these two variables is high, it is not statistically significant.

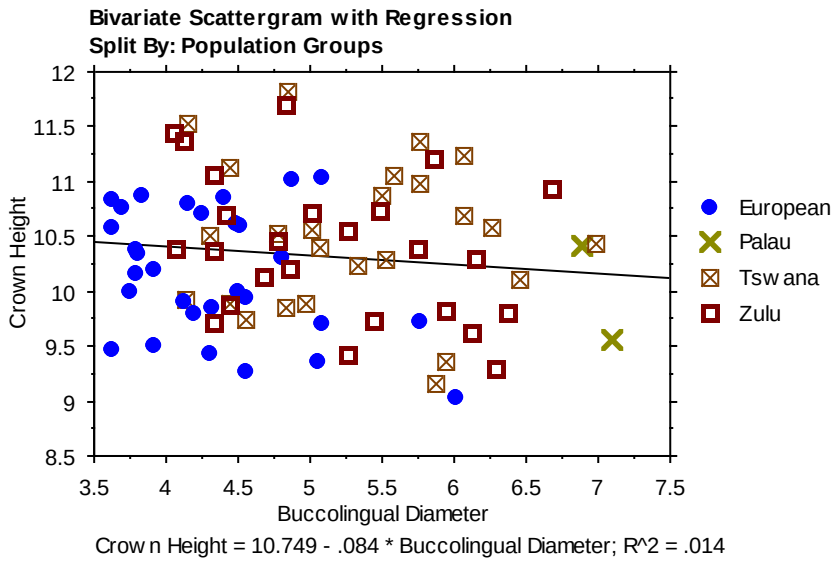

Figure 37: Bivariate plot of the BL diameters and CH of the maxillary central incisors.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. Europeans are clustered on the lower end, and this makes the difference between them and the Palau population the greatest.

The CH of the Palau population falls within the range of modern human variation. There is little difference between the modern humans, but the Tswana and Zulu populations tend to shift towards the upper end of the range of modern human variation. There is a low negative correlation between the BL diameter and crown height, (r= -0.12, n= 83, p= 0.2903, 95% CI -0.325-0.101). The correlation between these two variables is not statistically significant.

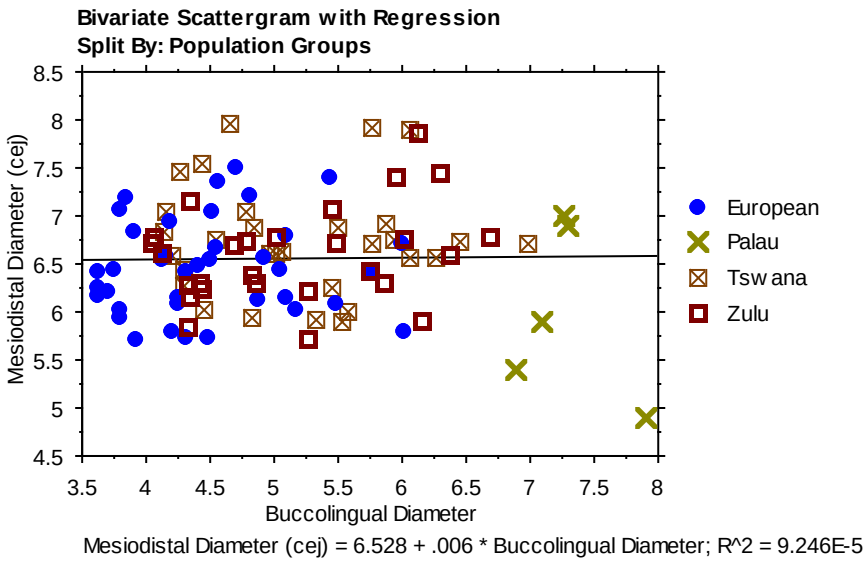

Figure 38: Bivariate plot of the BL and the MD (cej) diameters of the maxillary central incisors.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are larger than the European population. This makes the difference between the Palau population and Europeans the greatest.

The MD (cej) diameter of the Palau population falls below and within the range of modern human variation. One is smaller than those of the entire modern human sample. There is little difference between the modern humans measured, but the Europeans are clustered on the lower end of the range of modern human variation. There is a very low positive correlation (no correlation) between the BL and MD diameter of the humans studied, (r= 0.01, n= 100, p= 0.9245, 95% CI -0.187-0.206). The correlation between these two variables is not statistically significant.

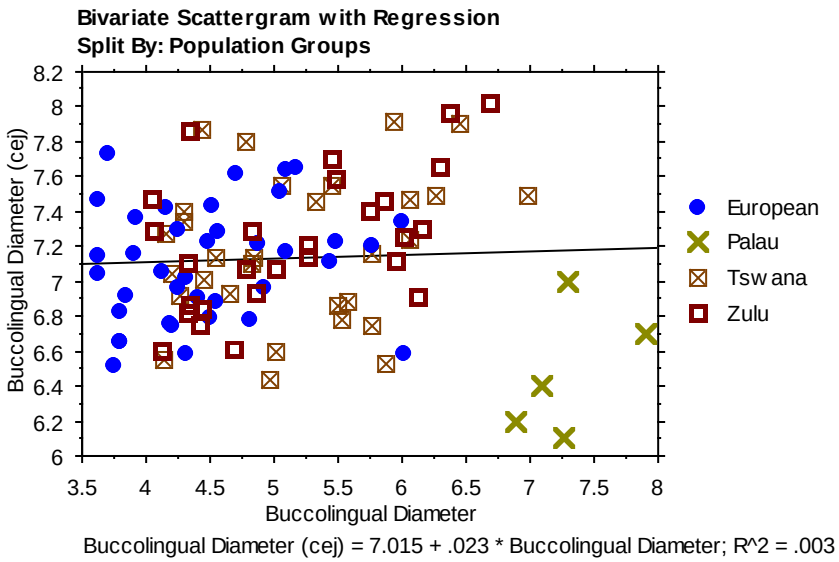

Figure 39: Bivariate of the BL and the BL (cej) diameters of the maxillary central incisors.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are larger than the Europeans. This makes the difference between the Palau population and Europeans the greatest.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. Three of the Palauan specimens are smaller than those of the entire modern human sample. There is little difference between the modern human BL (cej) diameters, however those of the Tswana and Zulu populations shift towards the upper end of the range of modern human variation. There is a very low positive correlation between the BL and BL (cej) diameter, (r= 0.05, n= 100, p= 0.5959, 95% CI -0.144-0.248). The correlation between these two variables is not statistically significant.

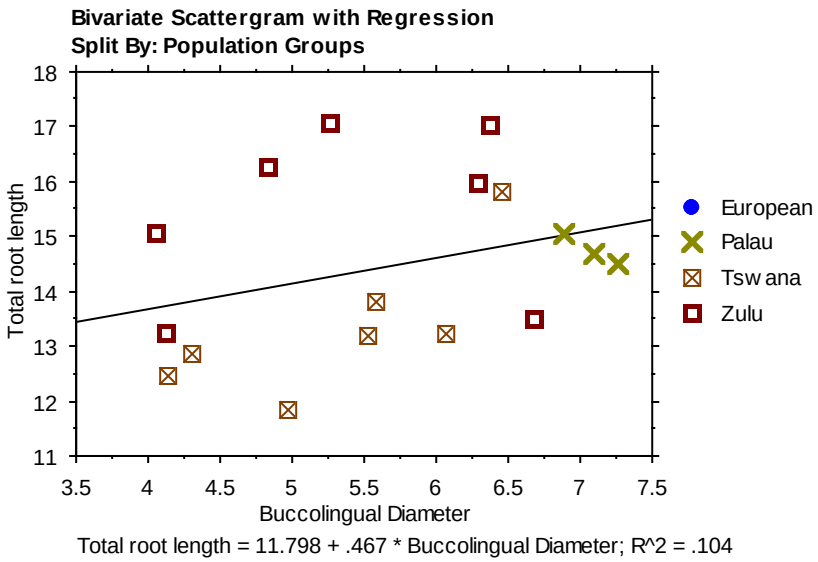

Figure 40: Bivariate plot of the BL diameters and TRL of the maxillary central incisors.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and Zulu populations are equal to each other, making the difference between them and the Palau population the same.

The TRL of the Palau population falls within the range of modern human variation, and are clustered in the middle of the range. The Zulu population has greater total root lengths compared to the Tswana and Palau populations. There is a low positive correlation between the BL diameter and total root length, (r= 0.32, n= 17, p= 0.2097, 95% CI -0.186-0.696). The correlation between these two variables is not statistically significant.

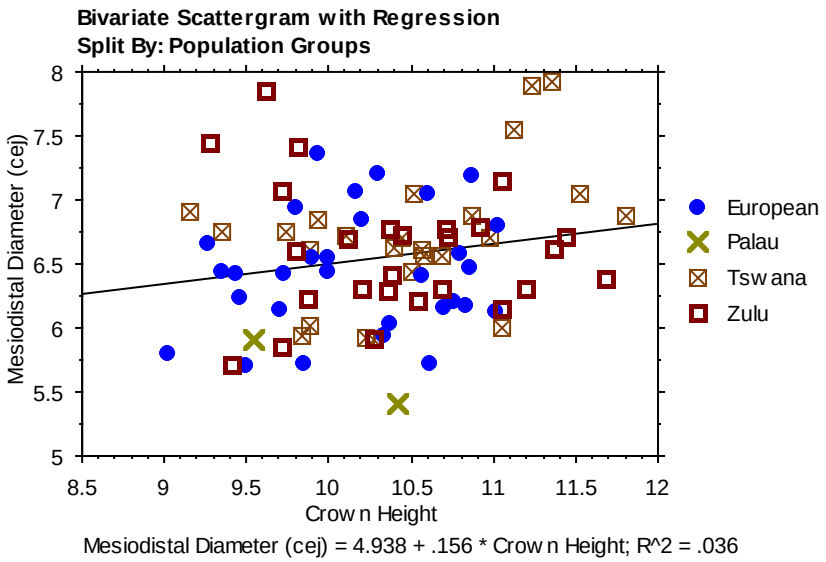

Figure 41: Bivariate plot of the CH and the MD (cej) diameters of the maxillary central incisors.

The CH of the Palau population falls within the range of modern human variation, and is equal to those on the lower end and in the middle of the range. There is little difference between the modern human populations, but the Tswana and Zulu shift towards the upper end of the range of modern human variation.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are larger than the Europeans. There is a low positive correlation between the crown height and MD (cej) diameter, (r= 0.19, n= 83, p= 0.0853, 95% CI -0.027-0.390). The correlation between these two variables is not statistically significant.

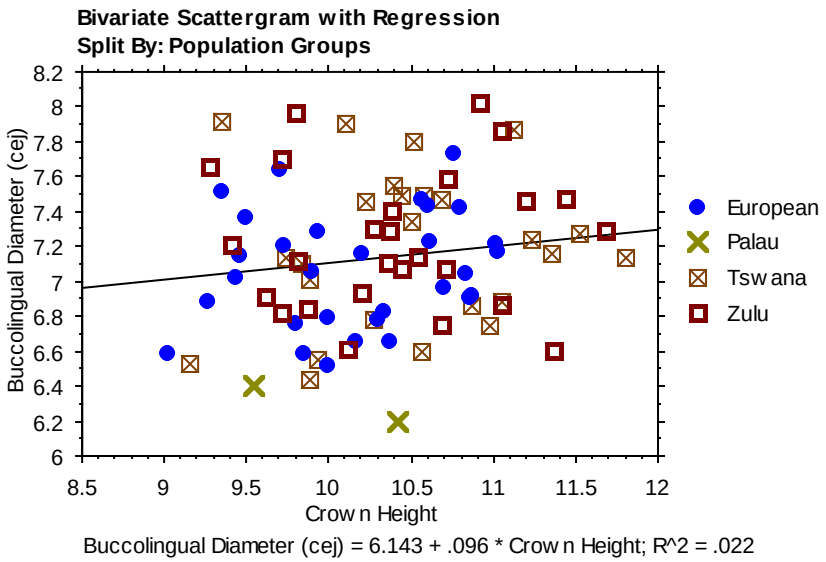

Figure 42: Bivariate plot of the CH and the BL (cej) diameters of the maxillary central incisors.

The CH of the Palau population falls within the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The Europeans are clustered in the middle and the lower end, and most are equal to the Palau population.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. There is little difference between the modern humans, but the Tswana and Zulu populations shift a little towards the upper end of the range. There is a low positive correlation between the crown height and BL (cej), (r= 0.15, n= 83, p=0.1795, 95% CI -0.069-0.353). The correlation between these variables is not statistically significant.

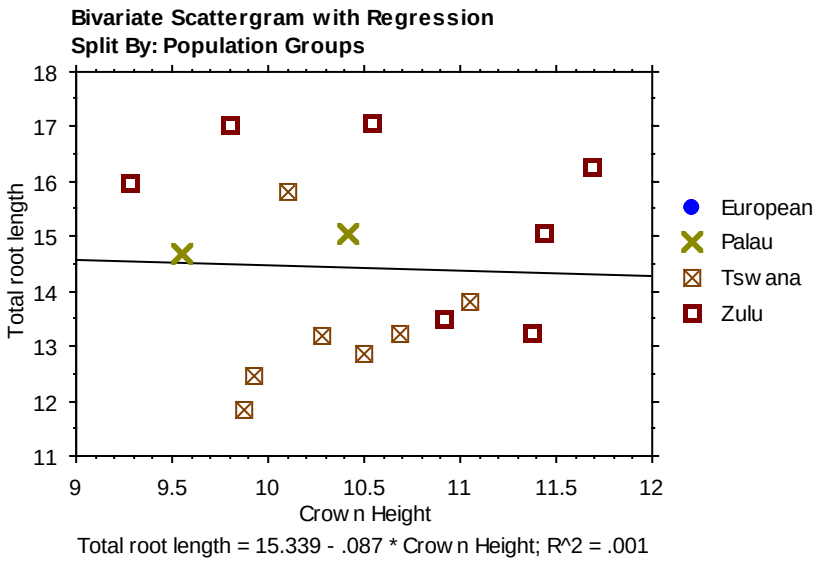

Figure 43: Bivariate plot of the CH and the TRL of the maxillary central incisors.

The CH of the Palau population falls within the range of modern human variation, and is equal to those on the lower end and in the middle of the range. There is little difference between the Tswana and Zulu populations, though the Tswana are clustered in the middle of the range.

The TRL of the Palau population falls within the range of modern human variation, and plots in the middle of the range. There is little difference between the modern human populations. The Tswana are clustered on the lower end of modern human variation, while Zulu are on the upper end. There is a low negative correlation between the crown height and total root length, (r= -0.04, n= 16, p= 0.8940, 95% CI -0.523-0.467). The correlation between these variables is not statistically significant.

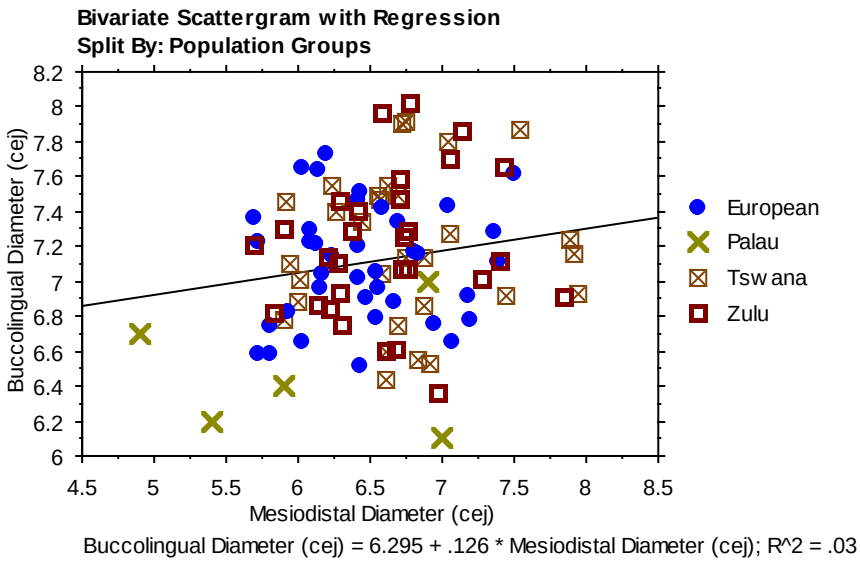

Figure 44: Bivariate plot of the MD (cej) and the BL (cej) diameters of the maxillary central incisors.

The MD (cej) diameter of the Palau population falls within and below the range of modern human variation. There is little difference between the modern human population groups. The sample minimum(s) of the three groups are similar whereas the sample maxima are a little different.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. There is little difference between the modern human population groups, as is noticeable on the sample maxima of the three groups represented. There is a low positive correlation between the MD and BL (cej) diameter, (r=0.17, n= 102, p= 0.0811, 95% CI -0.022-0.356). The correlation between these two variables is not statistically significant.

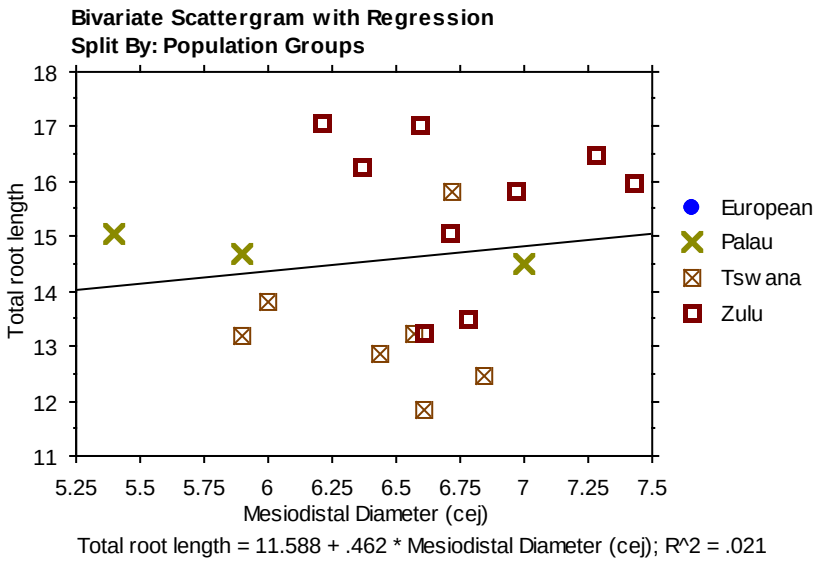

Figure 45: Bivariate plot of the MD (cej) diameters and the TRL of the maxillary central incisors.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Of the three individuals, one is at the upper end of the range. The Tswana and Zulu populations are similar to each other.

The total root length of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and Zulu populations are similar to each other, and are widely spread. There is a low positive correlation between the MD (cej) diameter and total root length, (r= 0.15, n=19, p= 0.5593, 95% CI -0.331-0.562). The correlation between these two variables is not statistically significant.

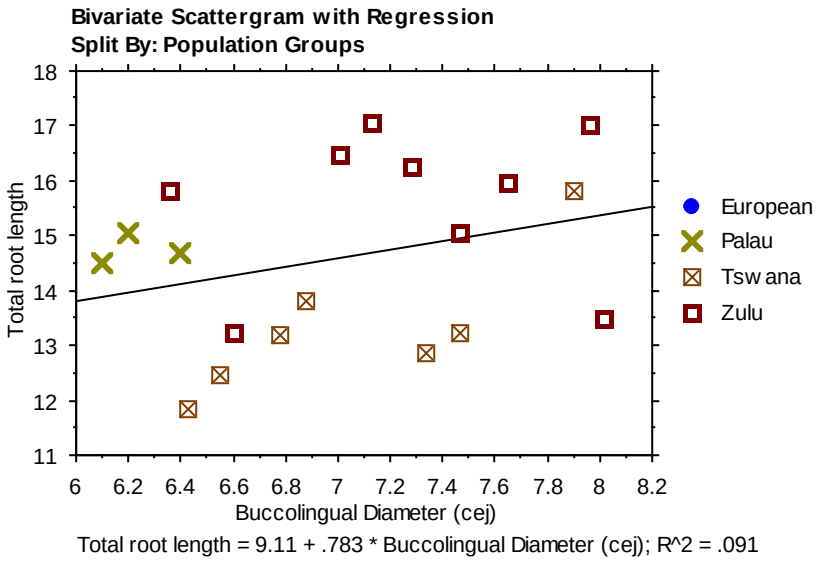

Figure 46: Bivariate plot of the BL (cej) diameters and the TRL of the maxillary central incisors.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are greater than most Palauans.

The TRL of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana are clustered on the lower end of the range of modern human variation, while the Zulu are on the upper end. There is a low positive correlation between the BL (cej) and TRL, (r= 0.30, n= 19, p= 0.2137, CI= -0.177-0.665). The correlation between these variables is not statistically significant.

Mandibular Lateral Incisors

The size of the mandibular lateral incisors was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample. In addition, the univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 14: MD diameters of the mandibular lateral incisors

Population Groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.03	0.35	5.81-6.55	4
Khoisan females	5.35	0.10	5.24-5.36	3
Tswana males	5.96	0.40	5.20-6.54	34
Tswana females	5.85	0.37	4.92-6.39	33
Zulu males	5.95	0.32	5.32-6.47	24
Zulu females	5.83	0.29	5.12-6.37	39
European males	5.73	0.27	5.14-6.15	43
European females	5.67	0.29	4.83-6.14	32

Four Palauan mandibular lateral incisors were available for comparison with the modern human sample. The Khoisan population was the least represented, with only three measurable individuals. The mean of the MD diameters of the Palauans is larger than the means of all the modern human population groups measured. The difference between the Palau sample and the modern human sample is smaller when compared to the Tswana and the Zulu population groups, but increases when compared to the European or Khoisan groups. The mean of the MD diameters of the Palauans is followed by the means of the MD diameters of the Tswana and Zulu males respectively. The mean of the MD diameters of the Tswana and the Zulu population

groups are very similar to each other, with a centimetre difference between the males and females. The mean of the MD diameters of the European population groups are smaller than those of the Tswana and Zulu population groups. Khoisan females have the lowest mean of all the human populations measured. The mandibular lateral incisors of modern human females are smaller than those of the males of their similar groups.

All of the human population groups measured have low standard deviations. These show that the primary data of the different groups are clustered around the means of the different populations. Tswana males have the highest mean of all the modern human population groups measured. They range from 5.20-6.54 mm. The MD diameter of the Palau population ranges from 5.81-6.55 mm. Khoisan females range from 5.24-5.36 mm. Even with the low sample size, it is possible that the measurements obtained on the Palauan sample represent the range of variation in the population.

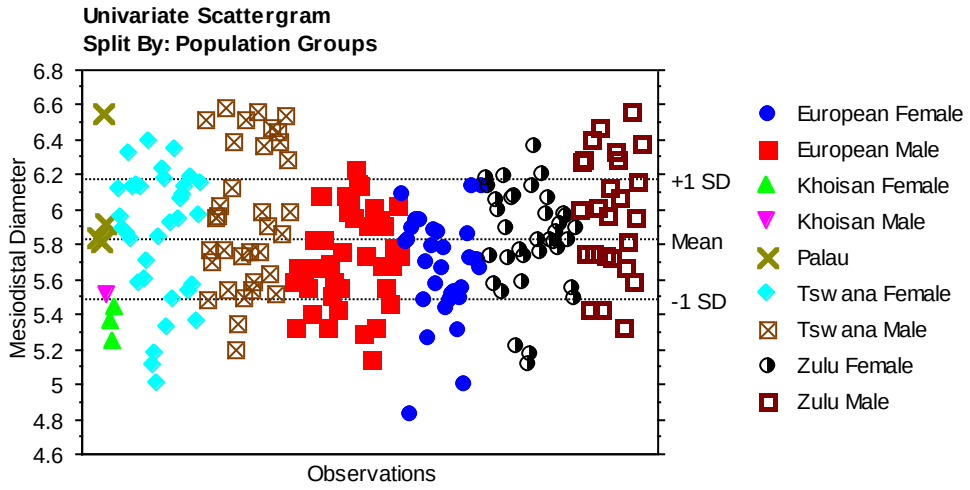

Figure 47: Univariate plot of the MD diameters of the mandibular lateral incisors.

Some of the MD diameters of the Palauans are equal to the MD diameters of modern human populations. There is little difference between the MD diameters of the modern human population groups. The males and females of different population groups are very similar to each other, but females are slightly smaller. The mean of the Zulu females is about 0.02 mm smaller than the ones of the Tswana females. They range from 5.12-6.37 mm and 4.92-6.39 mm respectively. Zulu and Tswana males are also very similar to each other. European population groups are equal to the smallest of the Tswana and Zulu population groups. The Khoisan females are clustered on the lower end of modern human variation.

Table 15: BL diameters of the mandibular lateral incisors

Population groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.31	0.26	6.08-6.64	4
Khoisan females	3.23	0.28	3.03-3.43	2
Tswana males	4.70	0.77	3.54-6.32	34
Tswana females	4.56	0.64	3.43-5.65	33
Zulu males	4.89	0.68	3.59-5.94	25
Zulu females	4.44	0.58	3.51-5.61	39
European males	3.51	0.47	2.56-4.36	43
European females	3.38	0.43	2.44-4.26	33

Four Palauan mandibular lateral incisors were available for comparison with the modern human sample. The Khoisan population was the least represented, with only two measurable individuals. The mean of the BL diameter of the Palau population is larger than the means of the BL diameters of the entire modern human sample measured. In some instances; as in the Khoisan and the European population groups, it is twice as large. The high mean BL diameter of the mandibular lateral incisors of Palauans is followed by the mean of the Zulu males. The means of the females of the groups measured are smaller than the means of the males of their respective

groups. The means of the European population groups are smaller than the means of the Palau, Tswana and Zulu population groups, but not Khoisan females, who have the smallest mean of all the populations measured.

The standard deviation of the Palau population is the lowest, showing clustering of primary data around the mean of the group. The Palauans range from 6.08-6.64 mm. The Zulu males have the highest mean of all modern human populations measured, whereas the Khoisan females have the lowest. They range from 3.59-5.94 mm and 3.03-3.43 mm respectively. These ranges show that the BL diameter of the Palauans falls above the normal range of modern human variation.

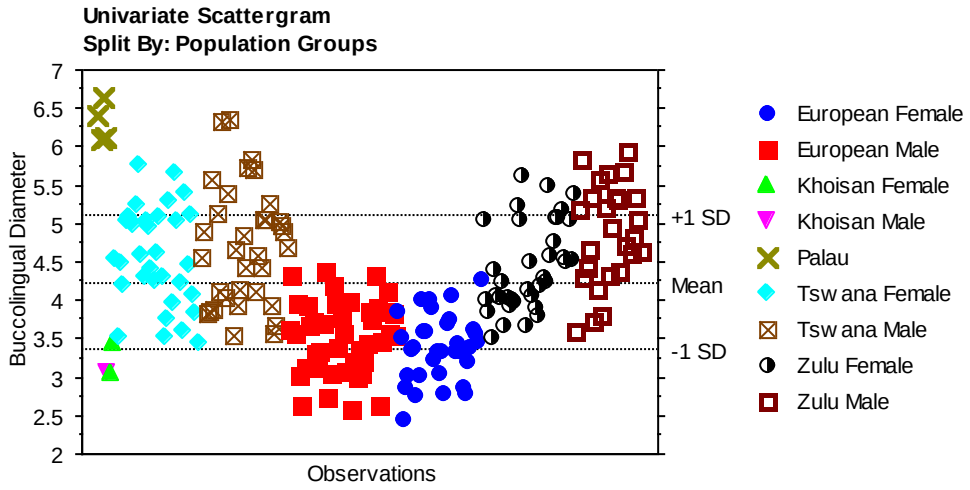

Figure 48: Univariate plot of the BL diameters of the mandibular lateral incisors.

The BL diameter of the Palau population is larger than the majority of the BL diameters of the modern human populations. The Tswana and the Zulu population groups are comparable with each other. This applies to both the males and females of these two groups. The Khoisan and the European populations are among some of the smallest human populations measured. They are clustered on the lower end of the range of variation. The European males are smaller than most

of the Tswana and Zulu females. The differences between the Palau population and the modern human sample are particularly marked when comparing them to Europeans and Khoisan.

Table 16: CH of the mandibular lateral incisors

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau	9.44	0.44	9.00-9.88	3
Khoisan females	7.74	0.10	7.62-7.82	3
Tswana males	8.92	0.96	7.71-10.34	24
Tswana females	8.7	0.82	7.02-10.16	32
Zulu males	8.75	0.82	7.30-10.00	26
Zulu females	8.54	0.80	7.09-9.86	39
European males	8.66	0.88	7.90-9.80	28
European females	8.54	0.67	6.90-9.84	33

Three Palauan mandibular lateral incisors were available for comparison with the modern human sample. The Khoisan population was the least represented, with one measurement obtained from the male sample. The mean of the crown height of the Palau population is larger than the crown height of the entire modern human sample measured. It is followed by the mean crown height of Tswana males. Khoisan females have the lowest mean of all. European population groups are smaller than the Palau, Tswana and Zulu population groups, but are larger than the Khoisan females. The females of the modern human sample have lower means than their male counterparts.

Khoisan females have the smallest standard deviations of all the populations measured. This indicates that the primary data are clustered around the mean of the group, but this might be influenced by the number of specimens available. The Palau population range from 9.00-9.88 mm. The Tswana males range from 7.71-10.34 mm, whereas the Khoisan females range from

7.62-7.82 mm. These ranges indicate that the crown height of the Palauans falls within the range of modern human variation.

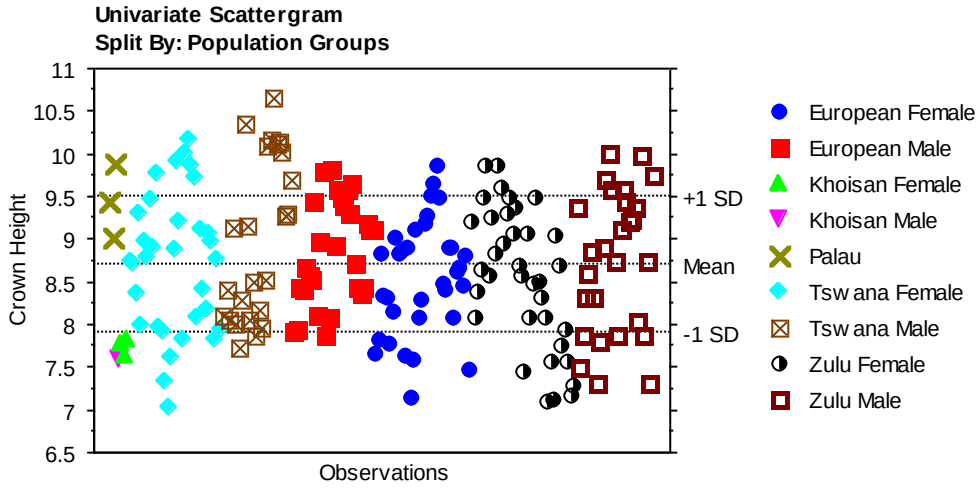

Figure 49: Univariate plot of the CH of the mandibular lateral incisors.

The crown height of the Palau population is equal to most of the crown height of the modern human population groups, mainly the ones on the upper end of the range of variation. The Khoisan population groups are among the smallest dimensions recorded for the modern human sample. The Tswana and Zulu females are comparable to each other, whereas the males of the similar groups are not. Tswana males have some of the highest values measured for this variable. Zulu and European males and females are very similar to each other. The Zulus range from 7.3-10 mm and 7.09-9.86 mm respectively.

Table 17: MD (cej) diameters of the mandibular lateral incisors

Population groups	**MD (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	3.93	0.17	3.70-4.10	4
Khoisan females	3.95	0.36	3.73-4.36	3
Tswana males	4.29	0.45	3.47-5.28	32
Tswana females	4.21	0.39	3.33-5.02	33
Zulu males	4.27	0.43	3.41-5.07	24
Zulu females	4.19	0.34	3.53-4.79	38
European males	4.17	0.28	3.61-4.59	41
European females	3.96	0.30	3.34-4.56	32

Four Palauan mandibular canines were available for comparison with the modern human sample. The mean of the MD (cej) diameter of the Palau population is smaller than the means of the modern human sample. It is even smaller than the mean of the Khoisan females who have particularly small teeth. Tswana males have the largest mean of all the populations studied, and are followed by Zulu males. The European population groups are smaller than the Tswana and the Zulu population groups, but larger than the Khoisan females. The Palauans have the smallest standard deviations of all the population groups measured, indicating the clustering of primary data around the mean of the group. In addition, of all the groups measured, Palauans have the lowest standard deviations.

The MD (cej) diameters of the Palau population range from 3.7-4.1 mm. Tswana males have the highest mean and they range from 3.47-5.28 mm. The Khoisan females; having the smallest mean of all the modern human populations measured, range from 3.73-4.36 mm. These ranges show that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

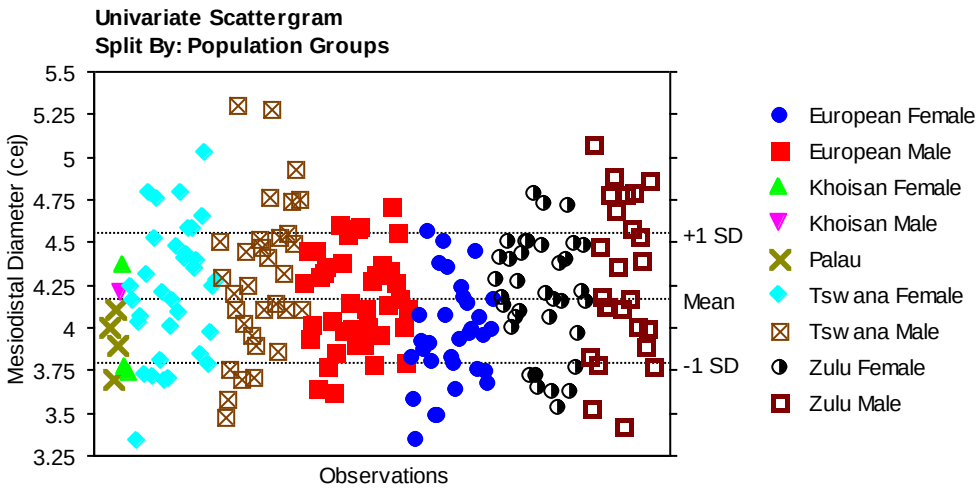

Figure 50: Univariate plot of the MD (cej) diameters of the mandibular lateral incisors.

The MD (cej) diameter of the Palau population is equal to some of the MD (cej) diameters of the modern human populations, but smaller than most. The European and Khoisan population groups are smaller than the Tswana and the Zulu population groups. The males and females of different groups are comparable with one another. For example, the Tswana males and females range from 3.25-5.28 mm and 3.33-5.31 mm, while the Europeans range from 3.45-4.7 mm and 3.34-4.56 mm respectively.

Table 18: BL (cej) diameters of the mandibular lateral incisors

Population Groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.10	0.5	5.40-6.60	4
Khoisan females	5.79	0.09	5.73-5.90	3
Tswana males	6.25	0.37	5.43-7.11	34
Tswana females	6.08	0.33	5.44-6.64	33
Zulu males	6.33	0.43	5.56-7.13	25
Zulu females	6.08	0.35	5.51-6.65	38
European males	6.03	0.33	5.30-6.55	43
European females	5.91	0.29	5.35-6.45	33

Four Palauan mandibular lateral incisors were available for comparison with the modern human sample. The Khoisan population group was the least represented. The mean of the BL (cej) diameter of the Palau population is smaller than the means of the Tswana and Zulu males, but larger than the means of the remaining modern population groups. Zulu males have the highest mean of all the population groups measured, whereas Khoisan females have the lowest. The males of the modern human sample have means that are higher than the females of their same groups. Tswana and Zulu females have means that are higher than the mean of European males. The difference between the males and females of the Tswana and Zulu population groups is very large, but not so for Europeans.

All the population groups measured have small standard deviations; an indication of the clustering of primary data around the means of the different groups. Khoisan females have the smallest standard deviations of all the populations measured. The Palau population ranges from 5.4-6.6 mm. The Khoisan females have the smallest mean and they range from 5.7-5.9 mm. Zulu males have the highest mean of all the populations measured, ranging from 5.56-7.13 mm. These ranges show that the BL (cej) diameter of the Palauans falls within the normal range of modern human variation.

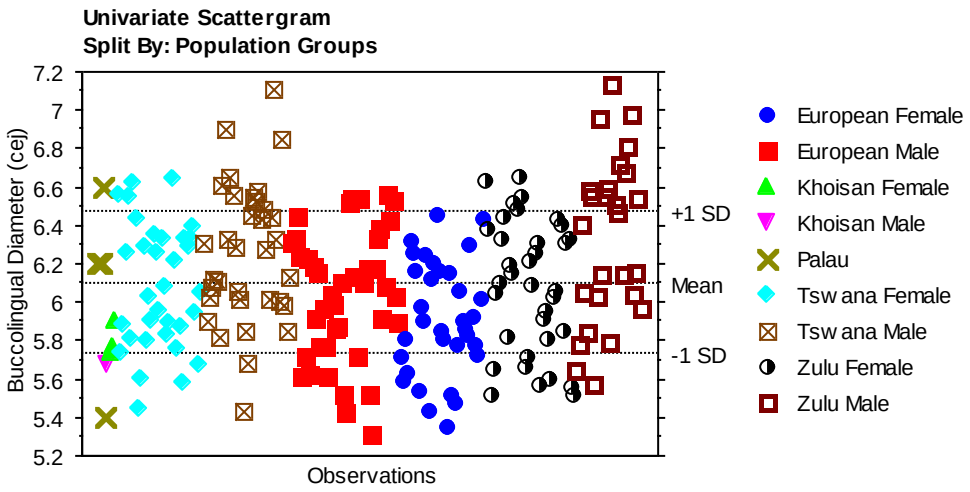

Figure 51: Univiate plot of the BL (cej) diameters of the mandibular lateral incisors.

The BL (cej) diameter of the Palau population is equal to the majority of the modern human population groups. The Khoisan population groups are among the smallest of the modern humans measured. The males and females of the Tswana and Zulu population groups are comparable with one another. The Khoisan population groups are among the smallest of the modern humans recorded. The difference between the males and females of the Tswana and Zulu population groups is quite marked. Tswana males range from 5.43-7.11 mm, whereas the Tswana females range from 5.44-6.64 mm. The BL (cej) diameters of the Palauans are spread evenly along those of the modern humans. There are few at the lower as well as upper end of modern human variation.

Table 19: Total root length of the mandibular lateral incisors

Population groups	**Total Root Lengths**			
	Mean	***Std dev***	***Range***	***N***
Palau	13.4	0.91	12.57-14.37	3
Tswana males	13.3	1.70	11.22-15.38	4
Tswana females	12.89	1.46	11.34-15.51	10
Zulu males	12.70	0.88	11.25-13.78	11
European females	12.73	1.41	10.42-14.54	7

Three Palauan mandibular lateral incisors were available for comparison with the human populations. No measurements were available for the Khoisan population, Zulu females and European males. The mean of the total root length of the Palau population is large compared to those of the entire human sample. It is followed by those of the Tswana males. Zulu males have the lowest mean of all the groups represented, which is very close to the mean of European females.

Zulu males have the lowest standard deviation of all the populations measured. Other groups have higher standard deviations, showing that the primary data are extremely dispersed from the means of the different groups. The Palau population ranges from 12.57-14.37 mm. The Zulu males having the smallest mean range from 11.25-13.78 mm, whereas the Tswana males having the highest mean of the entire modern human sample, range from 11.22-15.38 mm. These ranges indicate that the total root length of the Palauans is normal compared to those of modern humans.

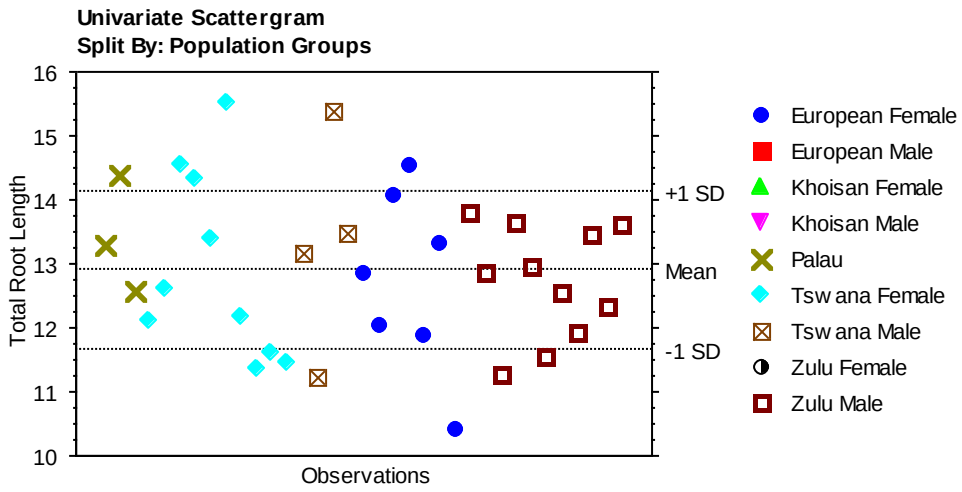

Figure 52: Univariate plot of the TRL of the mandibular lateral incisors.

The Palau population has a comparable root length to modern humans. There is little difference between the total root lengths of the modern human populations, but most of the total root lengths of Zulu males are clustered on the lower end of modern human variation.

Bivariate analysis

The first variables compared were the crown measurements, the MD and BL of the mandibular lateral incisors.

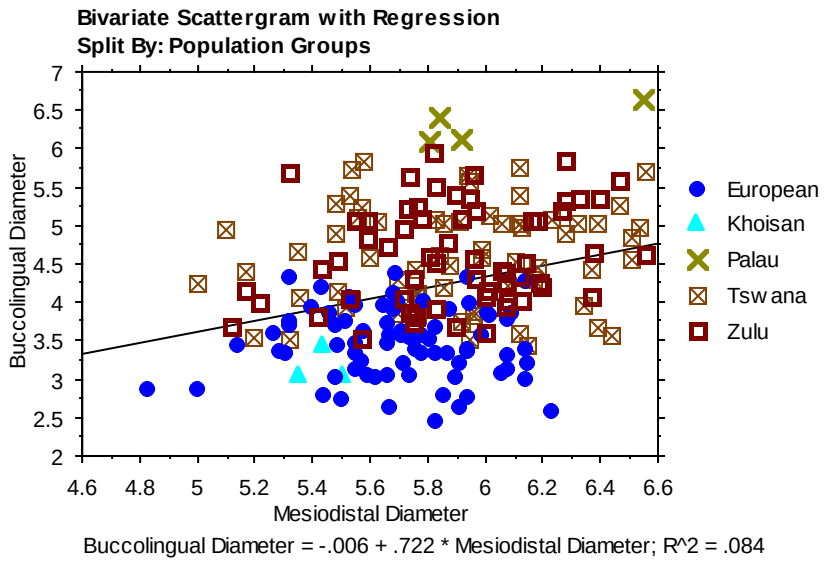

Figure 53: Bivariate plot of the MD and BL diameters of the mandibular lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. It is at the upper end and in the middle of the range. The Tswana and Zulu populations are similar to each other, and they are larger than the European and Khoisan. Europeans are clustered from the middle to the lower end of the range. The Khoisan are among the smallest of the modern humans measured, making the difference between them and the Palauans the greatest.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the European and Khoisan. The Europeans and all Khoisan are at the lower end of the range of modern human variation, thus making the difference between them and the Palauans the greatest. There is a low positive correlation between the MD and BL diameter, ($r = 0.29$, $n = 207$, $p < 0.0001$, 95% CI 0.159-0.410). The correlation between these two variables is statistically significant.

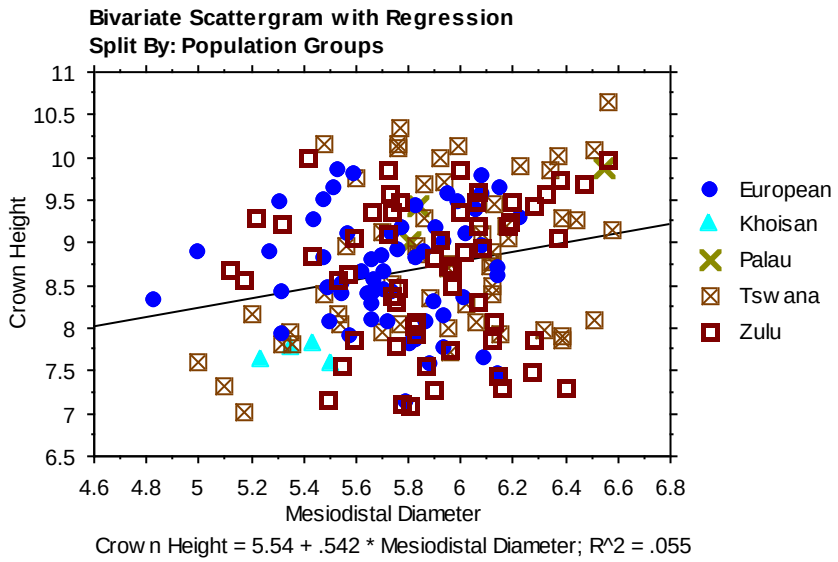

Figure 54: Bivariate plot of the MD diameters and the CH of the mandibular lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are larger than the Europeans and Khoisan. The difference is noticeable on the sample maximum(s) of these four different groups. The Khoisan are among the smallest of the modern humans measured, making the difference between them and the Palauans the greatest.

The crown height of the Palau population falls within the range of modern human variation. There is little difference between the Tswana, Zulu and European populations. The crown height of the Tswana and Zulu populations are widely spread. The Khoisan are clustered at the lower end of the range of modern human variation, making the difference between them and the Palauans the greatest. There is a low positive correlation between the MD diameter and CH of the humans measured, (r= 0.23, n= 184, p= 0.0013, 95% CI 0.093-0.366). The correlation between these two variables is statistically significant.

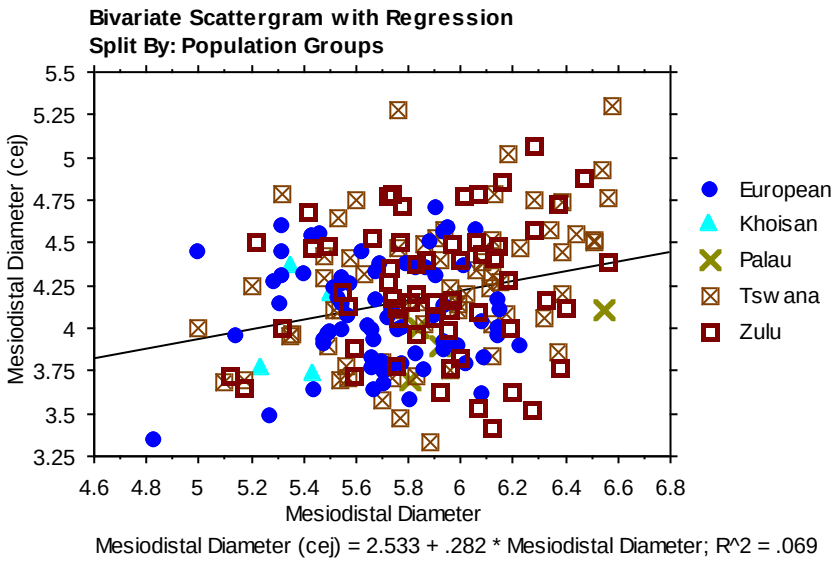

Figure 55: Bivariate plot of the MD and MD (cej) diameters of the mandibular lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. One is at the upper end of the range. The Tswana and the Zulu populations are equal to each other, and are larger than the European and Khoisan. The European and the Khoisan populations are clustered at the lower end of the range, and this makes the difference between them and the Palauans the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and plots at the lower end of the range. There is little difference between the modern human populations measured. Most of the Tswana and the Zulu populations are at the upper end of the range of modern human variation, whereas most of the European and the Khoisan are at the lower end. There is a low positive correlation between the MD and MD (cej) diameter, (r= 0.26, n= 203, p= 0.0001, 95% CI 0.130-0.386). The correlation between these two variables is statistically significant.

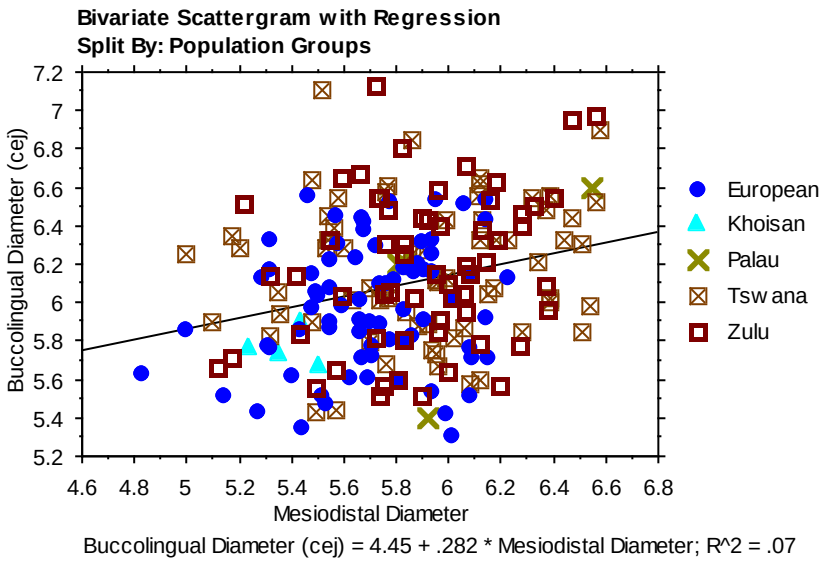

Figure 56: Bivariate plot of the MD and BL (cej) diameters of the mandibular lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. Only two are present, and one is at the upper end of the range while the other is in the middle. The Tswana and Zulu populations are similar to each other, and their sample maximums are larger than those of the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation. The Khoisan are among the smallest of the modern humans measured, and this makes the difference between them and the Palauans the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. One is at the upper end of the range, while the other is at the lower end. The Tswana and Zulu populations are similar to each other; and their sample maximums are larger than those of the European, while the sample minimums are similar. The Khoisan population is at the lower end of the range of modern human variation. There is a low positive correlation between the MD and BL (cej) diameter, ($r= 0.27$, $n= 209$, $p< 0.0001$, 95% CI 0.135-0.387). The correlation between these two variables is statistically significant.

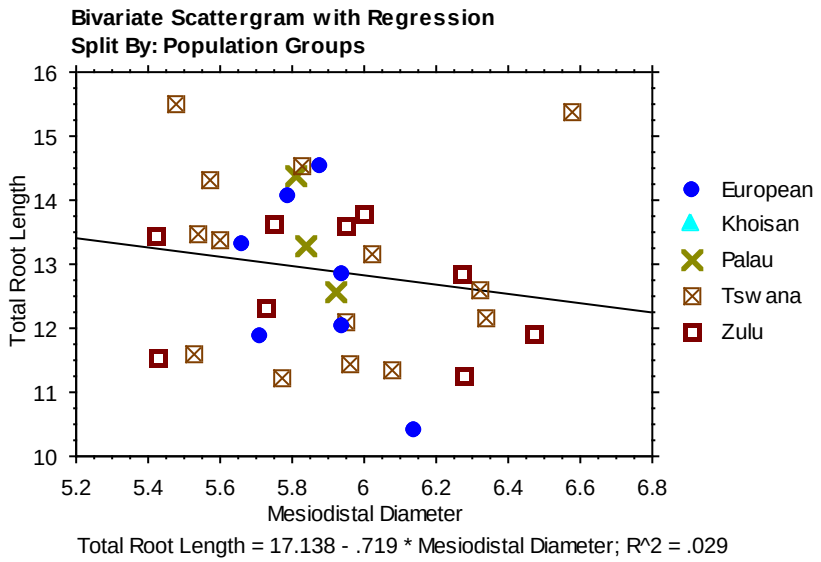

Figure 57: Bivariate plot of the MD diameters and the TRL of the mandibular lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation, and are equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, and a few are larger than the Palauans and the Europeans. The Europeans are in the middle of the range.

The total root length (TRL) of the Palau population falls within the range of modern human variation. It is equal to those in the middle of the range. There is little difference between the total root lengths of modern humans, but the Tswanas shift towards the upper end of the range. There is a low negative correlation between the MD diameter and total root length, (r= -0.17, n= 33, p= 0.3488, 95% CI -0.485-0.185). The correlation between these two variables is not statistically significant.

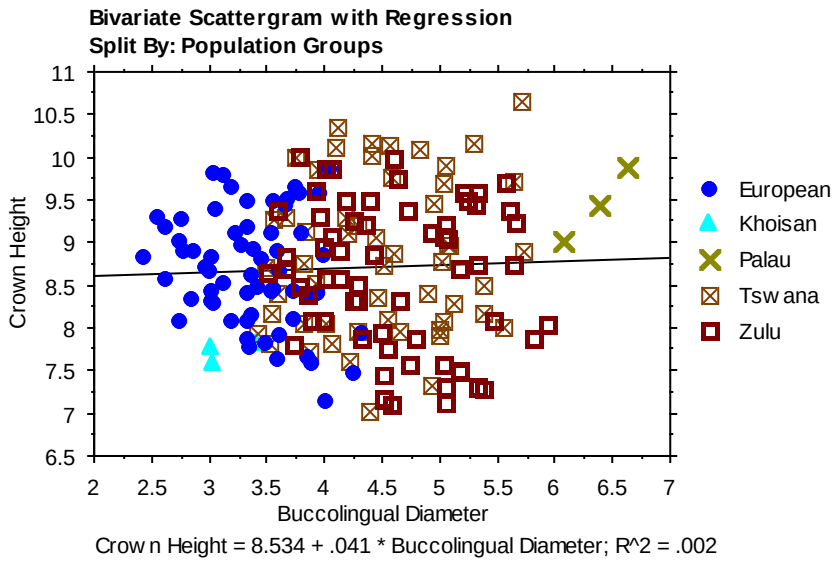

Figure 58: Bivariate plot of the BL diameter and the CH of the mandibular lateral incisors.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. Europeans are clustered on the lower end of the range, with the two available Khoisan; thus making the difference between them and the Palau population the greatest.

The crown height of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. There is little difference between the Tswana, Zulu and the European populations. The Tswana and the Zulu populations are widely spread. The Khoisan are clustered on the lower end of the range of modern human variation, making the difference between them and the Palauans the greatest. There is a low positive correlation between the BL diameter and the crown height, (r= 0.04, n= 183, p=0.5600, 95% CI -0.102-0.187). The correlation between these two variables is statistically significant.

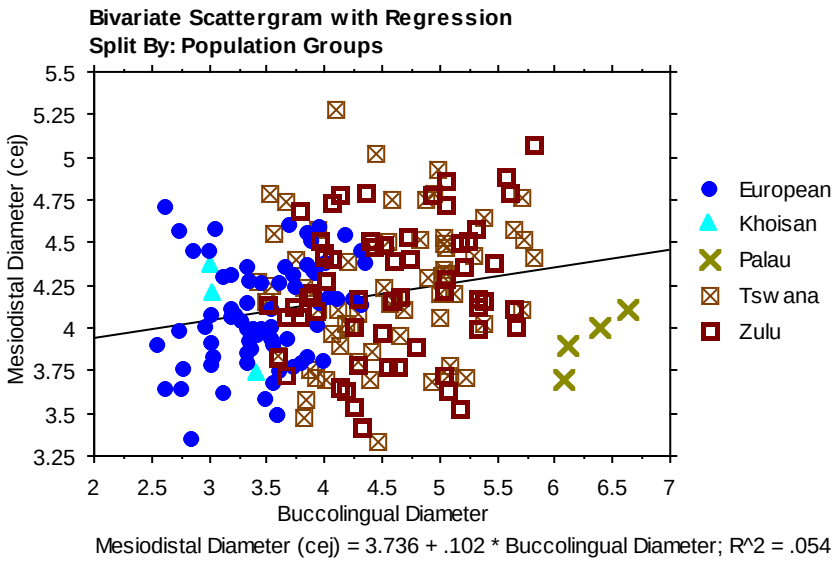

Figure 59: Bivariate plot of the BL and the MD (cej) diameters of the mandibular lateral incisors.

The BL diameter of the Palau population falls above the range of modern human variation, and is greater than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan populations are clustered on the lower end of the range, and this makes the difference between them and the Palauans the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and all are below the regression line. It is equal to those modern human populations that are at the lower end of the range. There is little difference between the modern humans measured. The sample maximums of the Tswana and the Zulu populations are larger than those of the European and Khoisan. There is a low positive correlation between the BL and MD (cej) diameter, (r= 0.23, n= 202, p= 0.0007, 95% CI 0.097-0.358). The correlation between these variables is statistically significant.

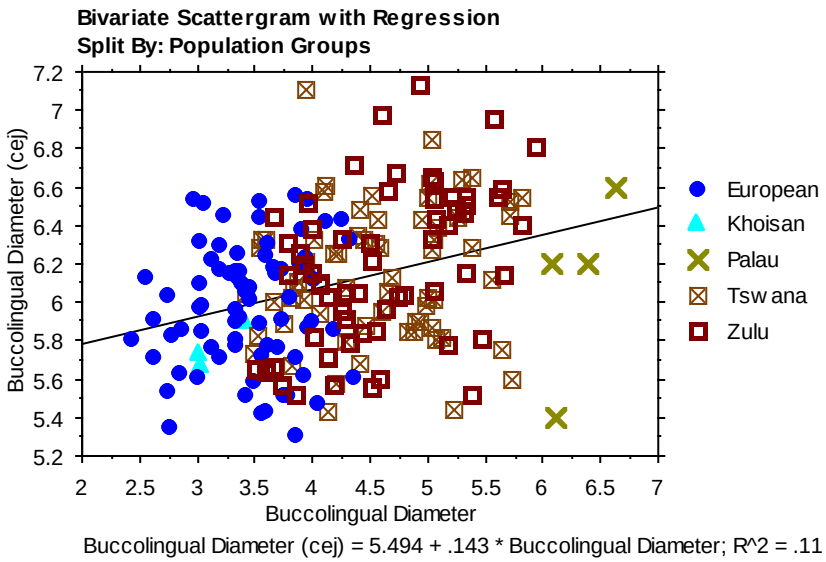

Figure 60: Bivariate plot of the BL and BL (cej) diameters of the mandibular lateral incisors.

The BL diameter of the Palau population falls above the range of modern human variation, and is greater than the BL diameters of the modern humans sampled. The Tswana and the Zulu populations are similar to each other. They are clustered on the upper end of the range of modern human variation, whereas the European and the Khoisan are clustered on the lower end. This makes the difference between the Palauans and the Europeans and Khoisan the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the Europeans and the Khoisan. The Khoisan are among the smallest of the modern humans measured. There is a low positive correlation between the BL and BL (cej) diameter of the humans measured, ($r = 0.33$, $n = 208$, $p < 0.0001$, 95% CI 0.205-0.448). The correlation between these two variables is statistically significant.

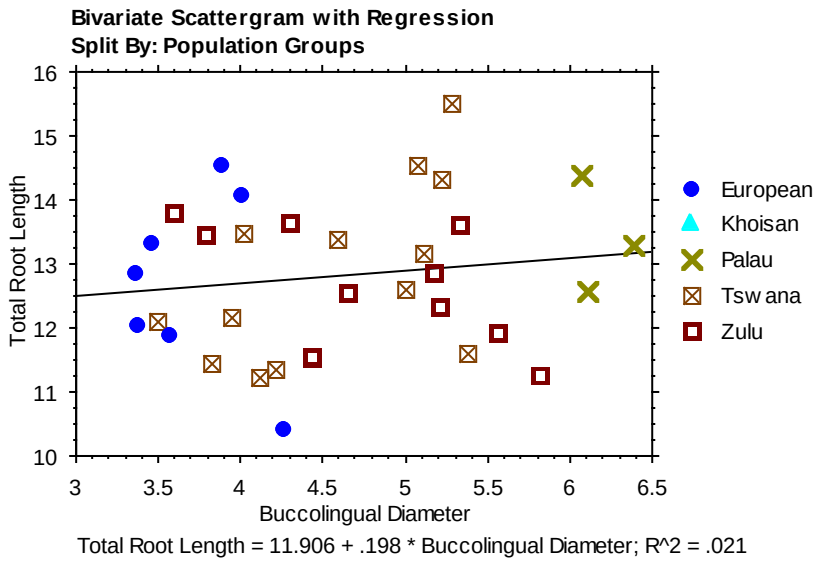

Figure 61: Bivariate plot of the BL diameters and the TRL of the mandibular lateral incisors.

The BL diameter of the Palau population falls above the range of modern human variation, and is greater than the modern humans sampled. The Tswana and the Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The Europeans are clustered on the lower end of the range, and this makes the difference between them and the Palau population the greatest.

The total root length of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. There is little difference between the modern human populations sampled. This makes the difference between the Palau population and the modern humans negligible. There is a low positive correlation between the BL diameter and the TRL of the humans measured, (r= 0.15, n= 33, p= 0.4204, 95% CI -0.208-0.466). The correlation between these variables is not statistically significant.

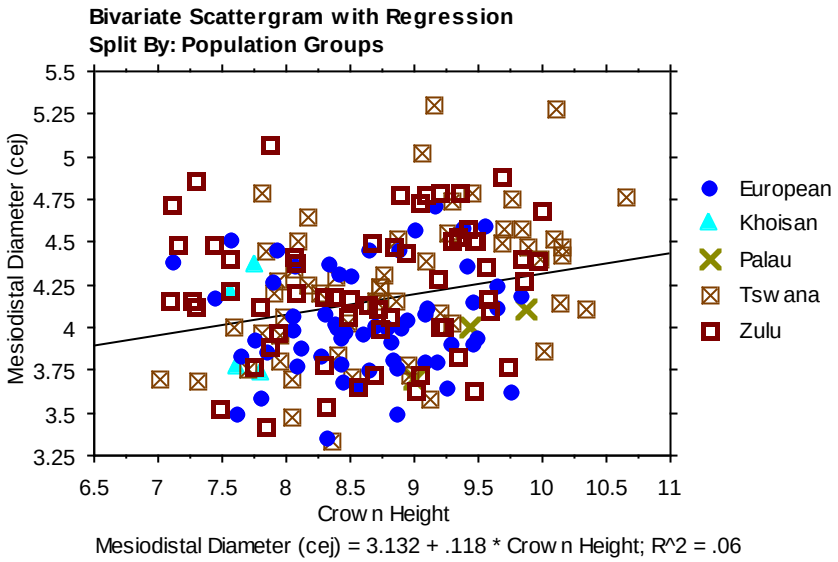

Figure 62: Bivariate plot of the MD (cej) diameters and the CH of the mandibular lateral incisors.

The crown height of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. There is little difference between the modern humans, but the Tswanas and Zulus tend to shift towards the upper end of the range. The Khoisan are among the smallest of the modern humans measured.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those on the lower end of the range. The Tswana and Zulu populations are equal to each other, and are clustered on the upper end of the range. The Europeans are clustered on the lower end of the range. There is a low positive correlation between the crown height and MD (cej) diameter, (r= 0.25, n= 180, p= 0.0009, 95% CI 0.103-0.378). The correlation between these two variables is statistically significant.

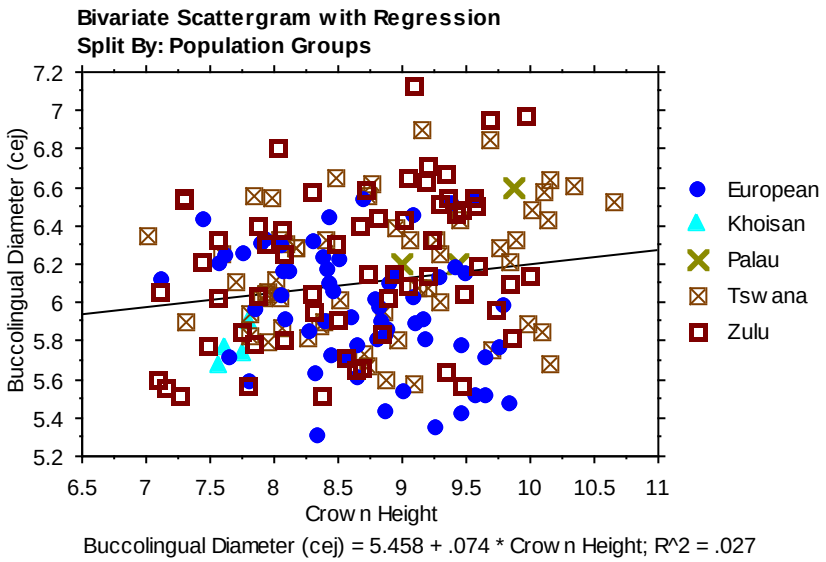

Figure 63: Bivariate plot of the BL (cej) diameter and the CH of the mandibular lateral incisors.

The crown height of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. There is little difference between the Tswana, Zulu and European populations. The sample maximums of the two aforementioned groups are greater than those of the European. The Khoisan population is clustered on the lower end of the range of modern human variation.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and the upper end of the range. The Tswana and Zulu populations are similar to each other, and are larger than the European and Khoisan. The European and Khoisan populations are clustered on the lower end of the range of modern human variation, thus making the difference between them and the Palauans the greatest. There is a low positive correlation between the BL (cej) and the crown height, (r= 0.16, n= 185, p=0.0259, 95% CI 0.020-0.301). The correlation between these two variables is statistically significant.

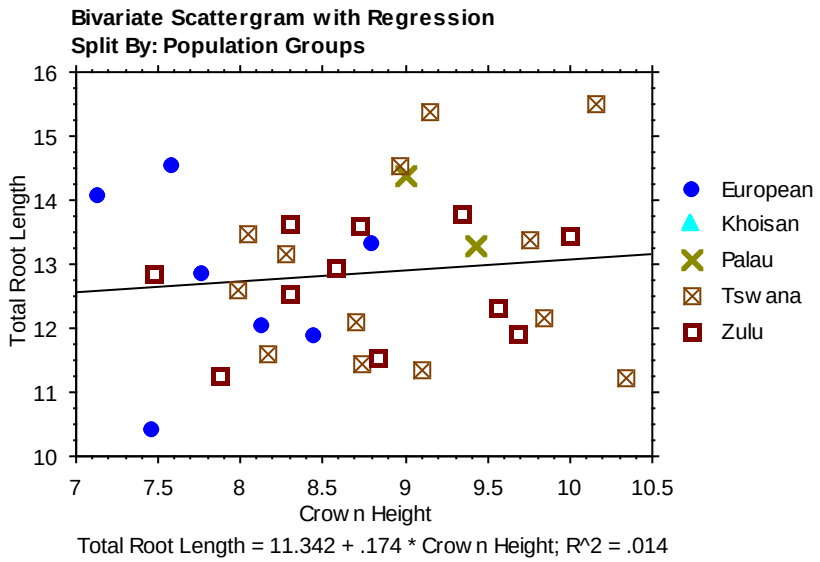

Figure 64: Bivariate plot of the TRL and the CH of the mandibular lateral incisors.

The crown height of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. The Tswana and Zulu populations are similar to each other, and are clustered in the middle and towards the upper end of the range of modern human variation. The Europeans are clustered on the lower end of the range, making the difference between them and the Palauans the greatest.

The total root length falls within the range of modern human variation, and is equal to those in the middle of the range. There is little difference between the three available groups of the modern humans. There is a low positive correlation between the crown height and the total root length, (r= 0.12, n= 33, p= 0.5172, 95% CI -0.235-0.443). The correlation between these two variables is statistically significant.

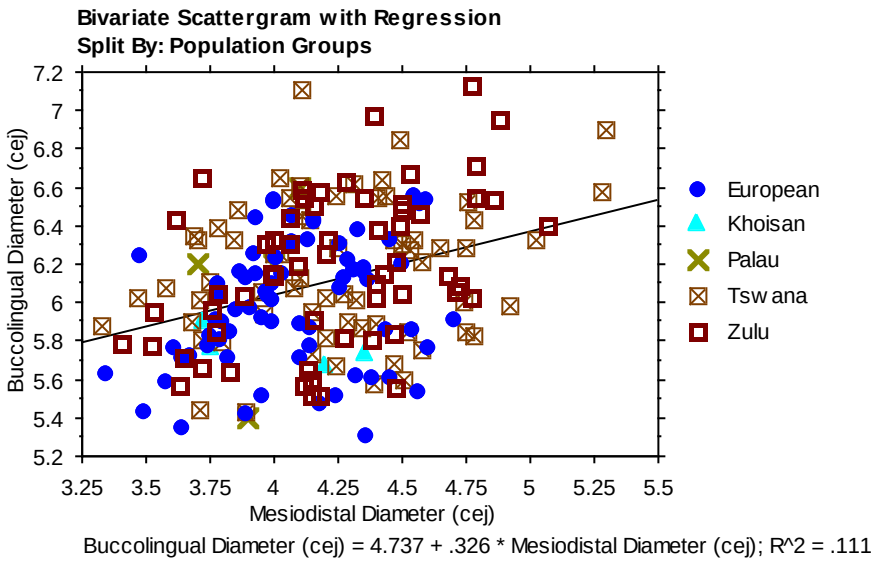

Figure 65: Bivariate plot of the MD (cej) diameter and the BL (cej) diameter of the mandibular lateral incisors.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are larger than the European and Khoisan. The European and Khoisan populations are clustered in the middle and on the lower end of the range of modern human variation, and are equal to the Palauans.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the lower end of the range. There is little difference between the Tswana, Zulu and European populations, but the Tswana and Zulu shift towards the upper end of the range of modern human variation. The Khoisan are clustered on the lower end of the range. There is a low positive correlation between the MD (cej) and BL (cej) diameter, ($r = 0.33$, $n = 205$, $p < 0.0001$, 95% CI 0.205-0.449). The correlation between these two variables is statistically significant.

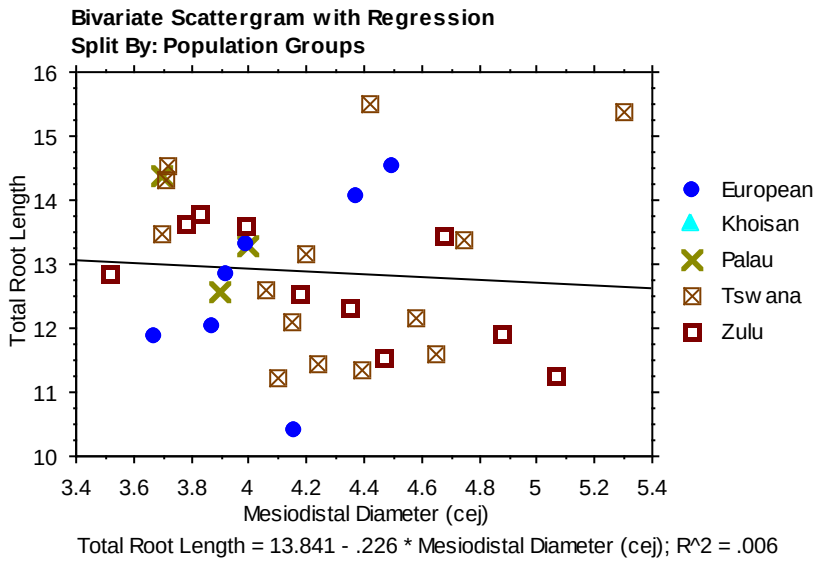

Figure 66: Bivariate plot of the MD (cej) diameter and the TRL of the mandibular lateral incisors.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range. The Europeans are clustered in the middle and on the lower end of the range of modern human variation, and are equal to the Palauans.

The total root length of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. There is little difference between the modern humans measured, therefore making the difference them and the Palauans small. There is a low negative correlation between the MD (cej) diameter and TRL, (r= -0.08, n= 34, p= 0.6641, 95% CI -0.405-0.267). The correlation between these two variables is not statistically significant.

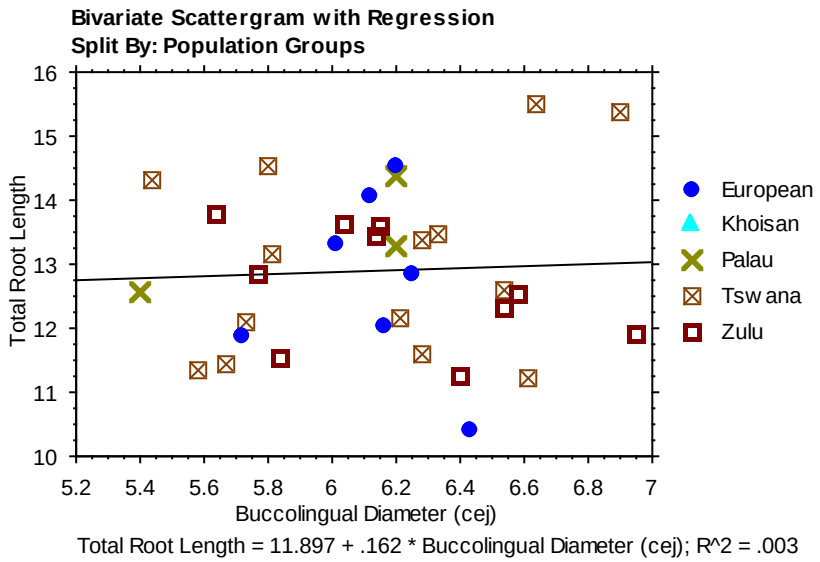

Figure 67: Bivariate plot of the BL (cej) diameter and the TRL of the mandibular lateral incisors.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the lower end of the range. The Tswana and Zulu populations are similar to each other, and their sample maximums are larger than those of the Europeans.

The total root length of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the upper end of the range. There is little difference between the total root lengths of the modern humans, and the majority of them are equal to the Palauans. There is a low positive correlation between the BL (cej) diameter and the total root length, (r= 0.051, n= 34, p= 0.7759, 95% CI -0.292-0.383). The correlation between these two variables is not statistically significant.

Maxillary Lateral Incisors

The same format for the mandibular lateral incisors was followed for the maxillary lateral incisors. The size of maxillary lateral incisors was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of maxillary lateral incisors. In addition the univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 20: MD diameters of the maxillary lateral incisors

Population Groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.04	0.65	6.39-7.76	7
Tswana males	7.01	0.43	6.51-7.98	22
Tswana females	6.73	0.49	5.89-7.55	19
Zulu males	6.91	0.47	6.24-7.97	20
Zulu females	6.79	0.45	5.83-7.79	28
European males	6.50	0.40	5.77-7.27	18
European females	6.41	0.37	5.80-6.93	16

Seven Palauan maxillary lateral incisors were available for comparison with the modern human sample. No Khoisan were available for this comparison. The mean of the MD diameter of the Palau population is higher than the mean of all the modern human population groups. It is followed by those of the Tswana males. The means of the males of the modern human samples are larger than the means of the females of their groups. The Tswana and the Zulu population groups are larger than the Europeans. All groups measured have small standard deviations, showing clustering of data around the means. The Palau population ranges from 6.39-7.76 mm.

The Tswana males have the highest mean of all the modern humans studied; ranging from 6.51-7.98 mm. The European females have the lowest mean and they range from 5.80-7.22 mm. These ranges show that the MD diameter of the Palau population is equal to some of the MD diameter of the modern human populations, mostly those on the upper end of human variation.

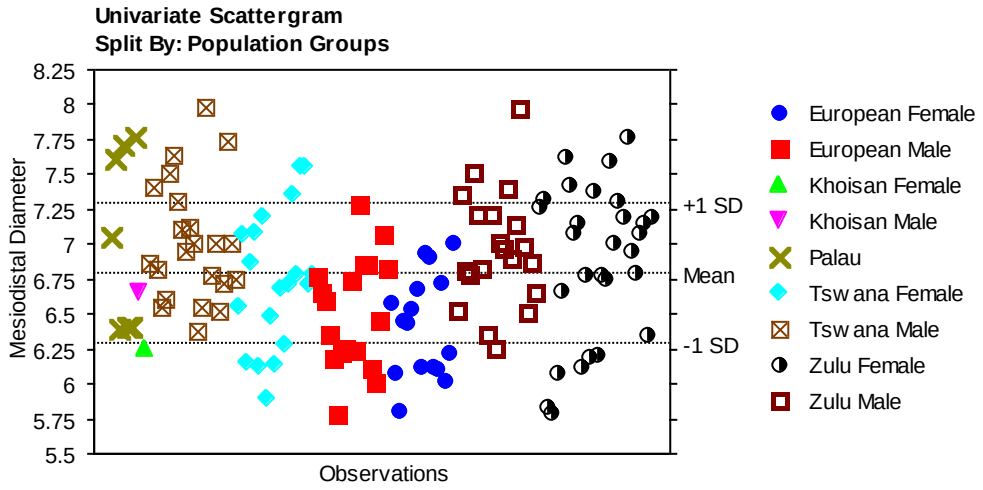

Figure 68: Univariate plot of the MD diameters of the maxillary lateral incisors.

The MD diameter of the Palau population is equal to most of those of the modern human populations. The Tswana and Zulu males each have an individual larger than the Palauans. The MD diameter of the modern human population groups does not vary that much. The males and females are comparable. The Tswana males and females range from 6.51-7.98 mm and 5.89-7.55 mm respectively. This shows a small degree of sexual dimorphism in this particular measurement. The modern human population groups are slightly different from one another. The Tswana and the Zulu populations are larger than the European populations. The Zulu populations range from 5.83-7.97 mm while the European populations range from 5.77-7.27 mm respectively. The difference is greater at the upper end of modern human variation.

Table 21: BL diameters of the maxillary lateral incisors

Population Groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.51	0.69	6.39-7.76	7
Khoisan males	3.85	0.22	3.69-4.00	2
Tswana males	5.03	0.61	4.12-6.29	24
Tswana females	4.88	0.60	3.81-5.78	20
Zulu males	5.35	0.69	4.14-6.55	20
Zulu females	4.56	0.47	3.91-5.38	28
European males	4.24	0.39	3.47-4.78	19
European females	4.02	0.40	3.49-4.73	16

Seven Palauan maxillary lateral incisors were available for comparison with the modern human sample. The Khoisan population was the least represented; with only three individuals. The mean of the MD diameters of the Palau population is greater than that of the entire modern human sample. It is followed by the Zulu males. Khoisan males have the lowest mean of all the groups measured. The means of the males of the modern human samples are larger than those of the females of their similar groups. The males and females of the Tswana population groups are similar to each other. Contrary to this, the Zulu males and females are quite different from each other, with a difference of 0.79 mm. The European population groups have means smaller than all the groups measured, except for the Khoisan males.

The Khoisan males have the lowest standard deviations of all the populations measured. The Tswana, Zulu and Palau population groups have higher standard deviations, showing the scattering of primary data around the means of these individual groups.

The Palau population ranges 5.60-7.67 mm. The Zulu males have the highest mean of the modern human sample, and it ranges from 4.14-6.55 mm. The Khoisan males range from 3.69-4.00 mm. They have the smallest mean of the groups measured. These ranges indicate that the BL diameter of the Palauans falls above the normal range of modern human variation.

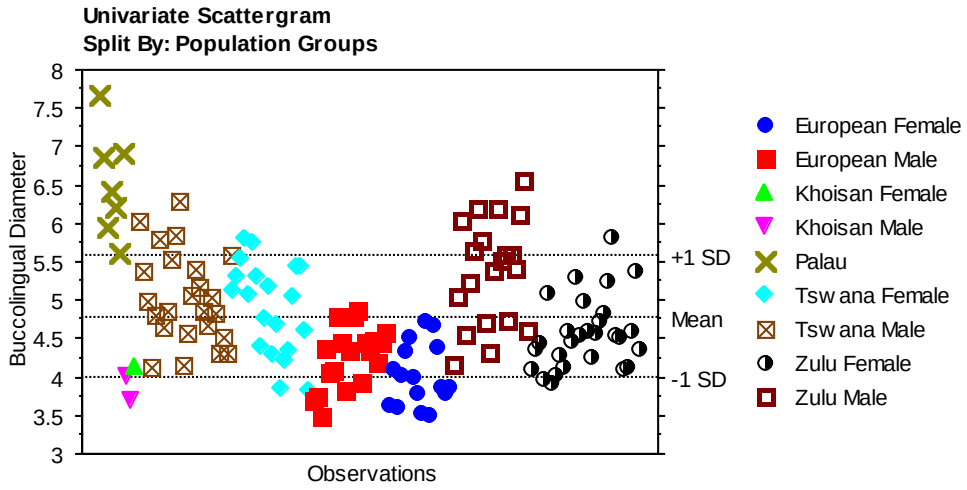

Figure 69: Univariate plot of the BL diameters of the maxillary lateral incisors.

The Palau population has the largest BL diameters when compared with the modern human populations measured. The Europeans are clustered on the lower end, but still fall within the normal range of modern human variation. The Tswana and Zulu males are comparable with each other, and are close to the Palau population. The Tswana and Zulu females are very similar to each other as well. There is less difference between males and females of similar groups, except for the Zulu population group. European males and females range from 3.47-4.78 mm and 3.49-4.73 mm respectively, whereas the Zulus range from 4.14-6.55 mm and 3.91-5.38 mm respectively.

Table 22: CH of the maxillary lateral incisors

Population Groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau	10.41	1.29	9.43-11.88	3
Khoisan males	7.23	0.71	6.73-7.73	2
Khoisan females	7.17	0.30	6.95-7.38	2
Tswana males	9.58	0.84	7.64-10.56	18
Tswana females	9.35	0.75	7.61-10.39	20
Zulu males	9.48	0.98	7.74-10.49	19
Zulu females	9.33	0.71	7.77-10.22	28
European males	9.31	0.69	7.76-10.01	14
European females	9.26	0.70	7.61-10.00	16

Three Palauan maxillary lateral incisors were available for comparison with the modern human sample. Of all the populations measured, the Khoisan population group was the least represented. The mean of the crown height of the Palau population is higher than those of the entire modern human sample. The Khoisan population groups have the lowest means of all the populations measured. Tswana males have the highest mean of all the modern human populations; which makes the difference between them and the Palauans smaller when compared to the other groups. It is followed by the mean of the Zulu males. The means of the crown height of the males of modern humans are larger than the females of their similar groups. The means of the crown height of the Tswana and Zulu females are very close to each other, as well as to the mean of the European males.

The standard deviation of the Khoisan females is smaller than the rest of the groups measured. The Palauans have the highest standard deviations. The Palau population ranges from 9.43-11.88 cm. Tswana males have the highest mean of all the modern human populations, and they range from 7.64-10.56 mm. Khoisan females have the lowest mean and they range from 6.95-7.38 mm.

These ranges show that the crown height of the Palau population falls within the normal range of modern human variation.

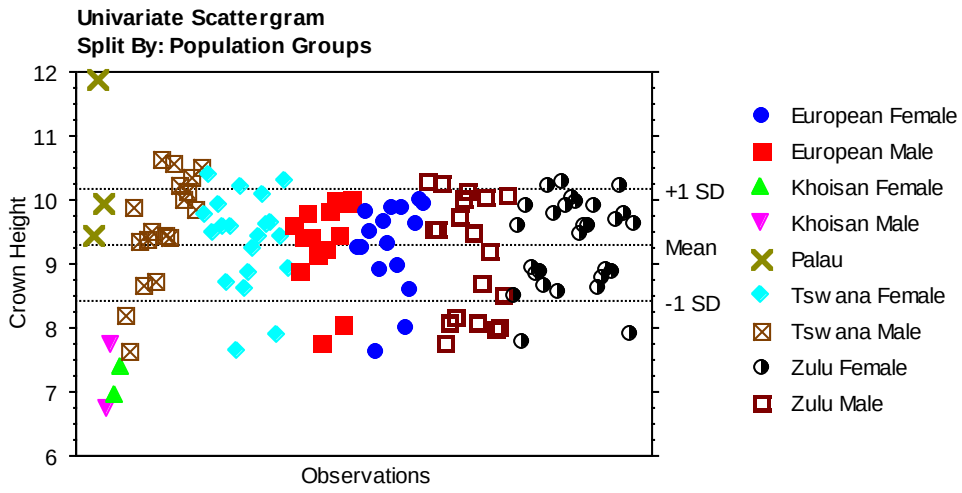

Figure 70: Univariate plot of the CH of the maxillary lateral incisors.

The Palauans have crown heights that are equal to most of the modern human populations, but one is exceptionally large compared to the modern human sample. The crown heights of modern humans are comparable, especially the Tswana and the Zulu population groups. The Khoisan population groups are among the smallest of the modern human sample. The males and females of similar groups are slightly different from each other.

Table 23: MD (cej) diameters of the maxillary lateral incisors

Population Groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	5.3	0.51	4.60-5.90	6
Khoisan males	4.59	0.58	4.18-5.00	2
Khoisan females	4.36	0.09	4.29-4.42	2
Tswana males	5.44	0.29	5.03-6.15	24
Tswana females	5.08	0.40	4.45-5.75	20
Zulu males	5.33	0.52	4.45-6.33	18
Zulu females	5.08	0.43	4.27-5.83	15
European males	5.00	0.34	4.30-5.64	24
European females	4.95	0.34	4.32-5.61	28

Six Palauan maxillary lateral incisors were available for comparison with the modern human sample. The Khoisan population was the least represented, with only four individuals. The mean of the MD (cej) diameters of the Palau population is smaller than the mean of the Tswana and Zulu males, but larger than the ones of the remaining modern human groups. The mean of the females of the measured samples are smaller than the means of the males of similar groups. The difference between the Palau population and the modern human populations is not very big. In fact the majority of the MD (cej) diameters of the Palauans are equal to most of the MD (cej) diameters of modern humans. Khoisan females have the lowest mean of all the populations measured. The Tswana and the Zulu females have means that are equal to each other. The Palauan standard deviation is similar to most of those of the modern human population groups. The Khoisan females have the lowest standard deviation, whereas the Khoisan males have the highest. All the groups measured have low standard deviations, showing the clustering of primary data around the means of individual groups.

The Palau population ranges from 4.60-5.7 mm. Tswana males have the highest mean of all the populations measured, they range from 5.03-6.15 mm. The Khoisan females, having the lowest mean range from 4.29-4.42 mm. These ranges show that the MD (cej) diameters of the Palau population fall within the normal range of modern human variation.

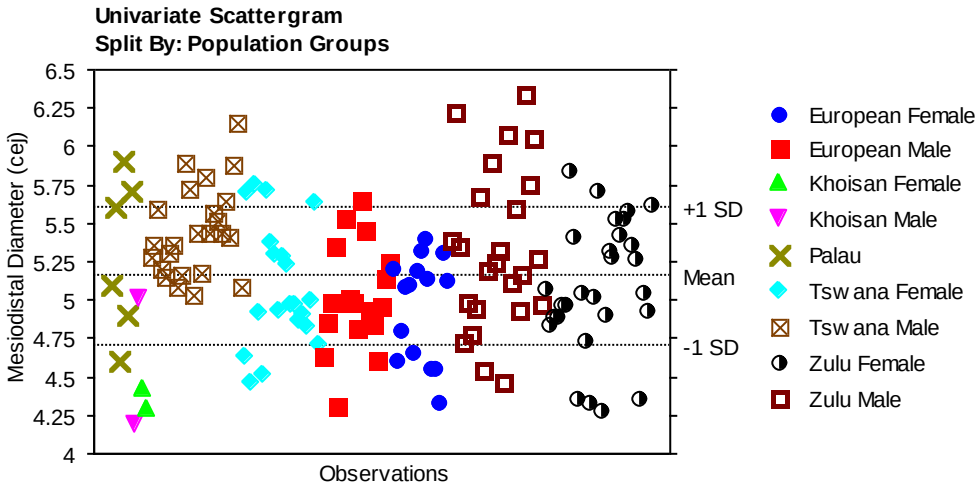

Figure 71: Univariate plot of the MD (cej) diameters of the maxillary lateral incisors.

The MD (cej) diameters of the Palau population are equal to the MD (cej) diameters of the entire sample of humans. Some of the MD (cej) diameter of the human populations are large than those of the Palau population. The MD (cej) diameters of the modern humans do not show much difference amongst them. There is less difference between the population groups and within the groups as well.

Table 24: BL (cej) diameters of the maxillary lateral incisor

Population Groups	BL (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	6.33	0.66	5.20-7.30	7
Khoisan males	5.59	0.04	5.56-5.62	2
Khoisan females	6.07	0.13	5.97-6.16	2
Tswana males	6.44	0.53	5.49-7.42	25
Tswana females	6.38	0.49	5.53-7.09	20
Zulu males	6.47	0.5	5.54-7.49	23
Zulu females	6.39	0.32	5.79-6.90	28
European males	6.17	0.33	5.52-6.58	19
European females	6.05	0.32	5.51-6.30	16

Seven Palauan maxillary lateral incisors were available for comparison with the modern human sample. The Khoisan population was the least represented of all the groups measured. The mean of the BL (cej) diameters of the Palau population is similar to those of the other human population groups. It is smaller than those of the Tswana and the Zulu populations, but larger than those of the European and Khoisan. Zulu males have the highest mean of all the populations measured. European and Khoisan females have the smallest and equal means of all the populations measured. The males of all the groups measured have means that are greater than those of their female counterparts. Khoisan females have the lowest standard deviation which might be due to the low number of specimens (n.2) measured from this group.

The BL (cej) diameter of the Palau population ranges from 6.00-7.30 mm. Zulu males have the highest mean range from 5.54-7.49 mm while the European and Khoisan females have the lowest mean range from 5.51-6.6 mm and 5.97-6.16 mm respectively. These ranges indicate that the Palau population has a BL (cej) diameter that falls within the normal range of modern human variation.

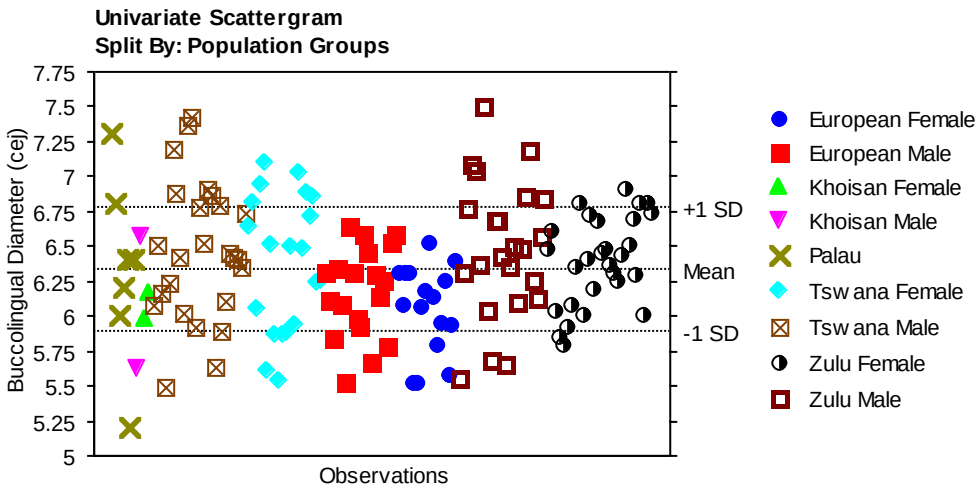

Figure 72: Univariate plot of the BL (cej) diameters of the maxillary lateral incisors.

The BL (cej) diameter of the Palau population is equal to those of the modern humans measured. The BL (cej) diameters of the Tswana and Zulu males are very similar to each other. The European population groups are clustered on the lower end of human variation.

Table 25: Total root length of the maxillary lateral incisors

Population Groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	13.98	1.68	12.20-15.93	5
Tswana males	14.18	1.27	12.32-15.21	4
Tswana females	13.15	1.28	11.42-15.06	9
Zulu males	13.55	0.98	12.45-15.83	13
European females	13.82	0.45	13.50-14.13	2

Five Palauan maxillary lateral incisors were available for comparison with the modern human sample. The Khoisan population, Zulu females and European males were not available for comparison. The mean of the total root length of the Palau population is equal in comparison to those of the entire modern human sample. There is not much difference between the modern

human population groups. Tswana males have the highest mean of all the populations measured, whereas the Tswana females have the lowest. They range from 12.32-15.21 mm and 11.42-15.06 mm respectively. The total root length of the Palau population ranges from 12.20-15.93 mm. These ranges indicate that the Palauans have total root lengths that fall within the normal range of modern human variation.

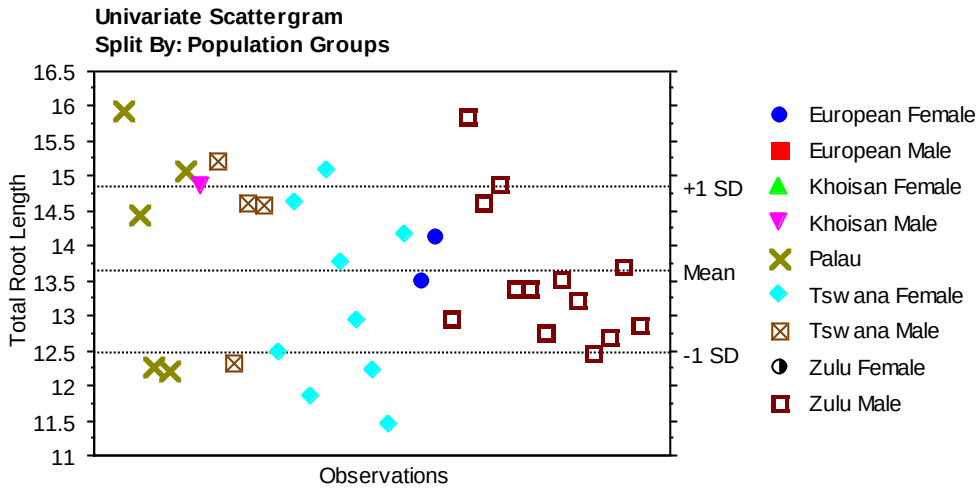

Figure 73: Univariate plot of the TRL of the maxillary lateral incisors.

The total root length of the Palau population is equal to those of the modern human populations. There is less little difference between the modern human population groups. The Tswana and Zulu males are very similar to each other. Tswana females are similar to many of the Zulu males. European females fall in the middle of the range of modern human variation.

Bivariate analysis

The first variables compared were the crown measurements, the MD and BL of the maxillary lateral incisors.

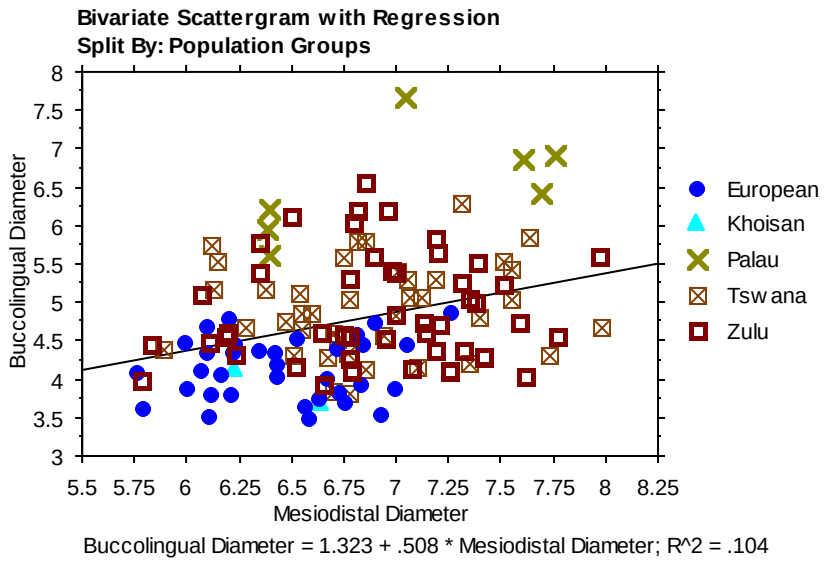

Figure 74: Bivariate plot of the MD and BL diameters of the maxillary lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. The Tswana and Zulu populations are similar to each other, and their sample maximums are greater than those of the European and Khoisan. The Europeans and Khoisan are clustered at the lower end of the range of modern human variation. The difference between the Palau population and the Khoisan is the greatest.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. One is greater than the entire modern human sample. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan populations are clustered on the lower end of the range, making the difference between them and the Palau population greater than those of the Tswana and the Zulu. There is a low positive correlation between the MD and BL diameters, (r= 0.32, n= 131, p= 0.0002, 95% CI 0.159-0.468). The correlation between these two variables is statistically significant.

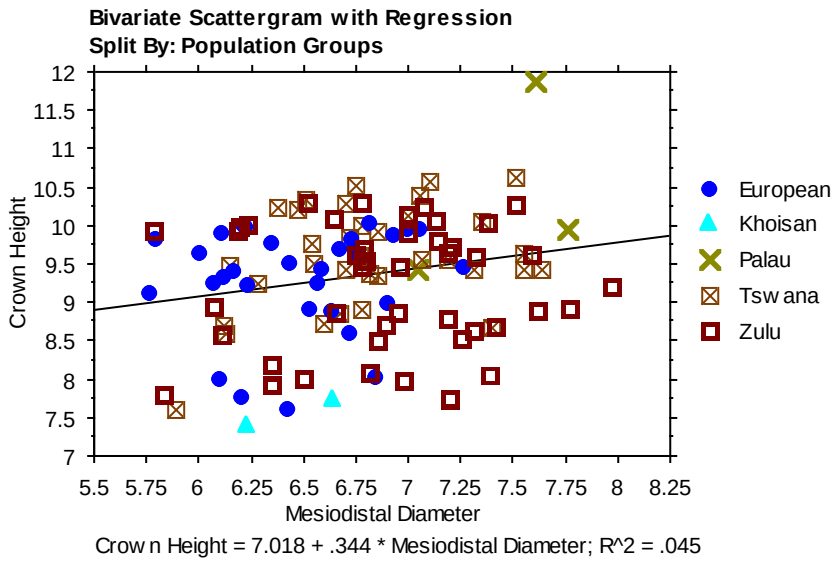

Figure 75: Bivariate plot of the MD diameters and the CH of the maxillary lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan populations are in the middle and on the lower end of the range, thus making the difference between them and the Palau population the greatest.

The crown height of the Palau population falls within the range of modern human variation. One is greater than the entire modern human sample, while two are equal to those on the upper end of the range. There is a little difference between the Tswana, Zulu and European populations, but the sample maximums of the Tswana and Zulu are greater than those of the Europeans. The Khoisan population is clustered among the smallest of the modern humans measured, therefore making the difference between them and the Palau population the greatest. There is a low positive correlation between the MD diameter and the crown height, (r= 0.21, n= 116, p= 0.0217, 95% CI 0.032-0.380). The correlation between these two variables is statistically significant.

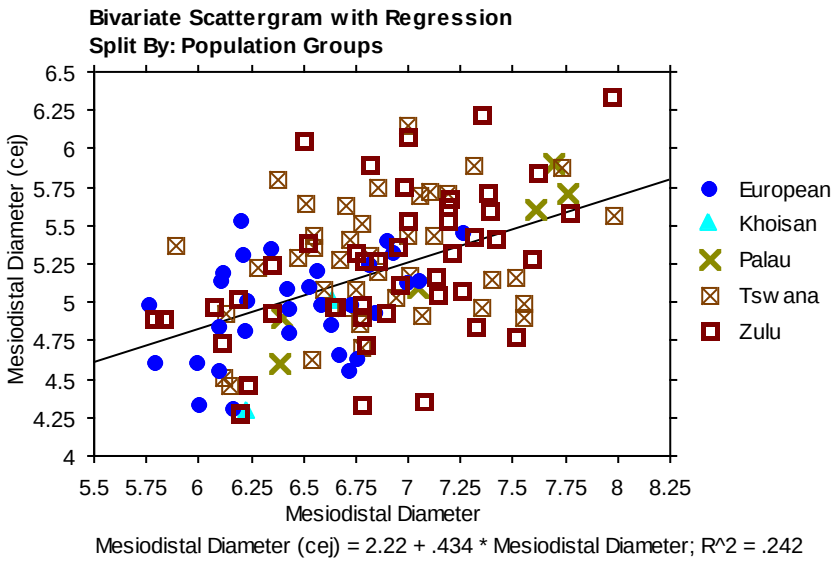

Figure 76: Bivariate plot of the MD and MD (cej) diameters of the maxillary lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. Two are at the lower end of the range, and two are at the upper end. The Tswana and the Zulu populations are similar to each other, and are greater than the European and the Khoisan; who are clustered in the middle and at the lower end of the range. This makes the difference between them and the Palau population greater than those of the Tswana and the Zulu populations.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the European and the Khoisan. The European and the Khoisan population are at the lower end of the range of modern human variation. There is little difference between the modern humans and the Palau population because the Palauans are distributed along the range of modern human variation. There is a low positive correlation between the MD and MD (cej) diameter of the humans measured, ($r= 0.49$, $n= 128$, $p<0.0001$, 95% CI 0.348-0.613). The correlation between these two variables is statistically significant.

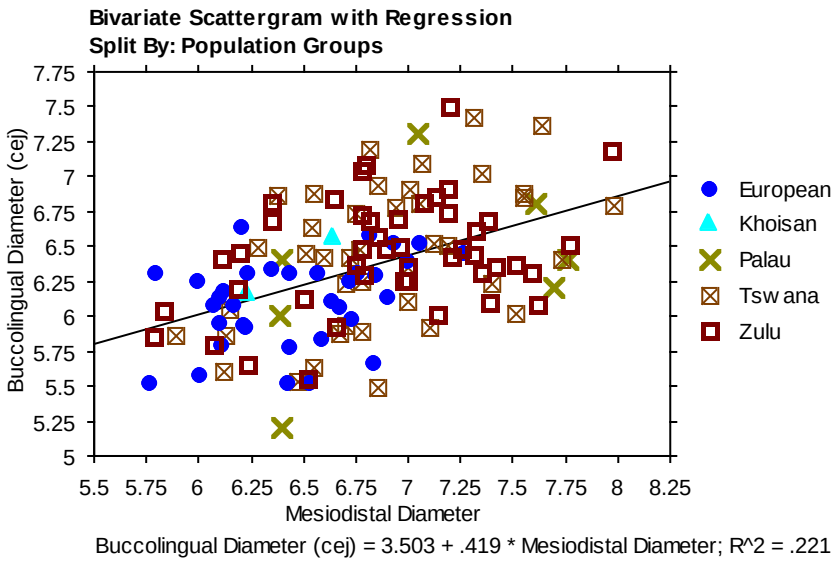

Figure 77: Bivariate plot of the MD and BL (cej) diameters of the maxillary lateral incisors.

The MD diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan populations are clustered on the lower end and in the middle of the range. There is little difference between the modern humans and the Palau population because the Palauans are distributed evenly along the range of modern human variation.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan populations are in the middle and lower end of the range. There is a low positive correlation between the MD and the BL (cej) diameter, ($r= 0.47$, $n= 132$, $p< 0.0001$, 95% CI 0.325-0.593). The correlation between these two variables is statistically significant.

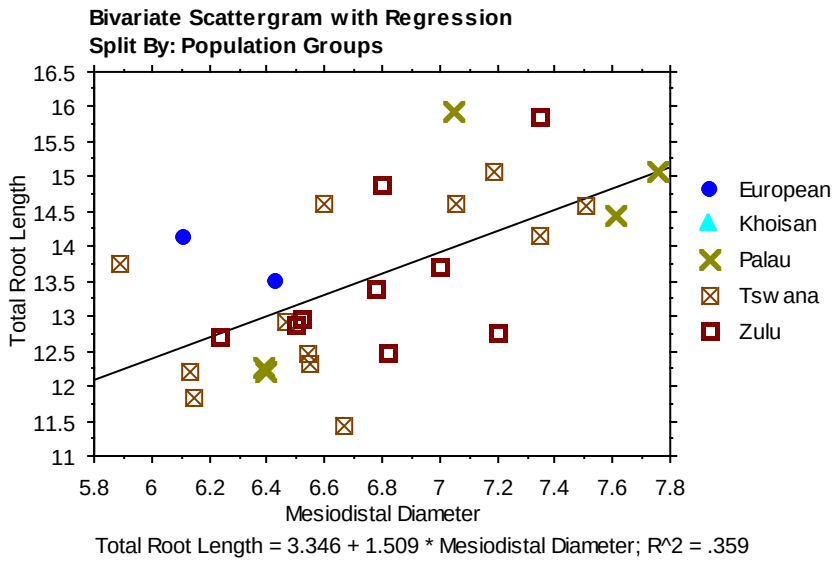

Figure 78: Bivariate plot of the MD diameters and the TRL of the maxillary lateral incisors.

The MD diameter of the Palau population falls at the lower and upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the European. The two available Europeans are at the lower end of the range. There is little difference between the Palau population and the modern humans sampled.

The total root length of the Palau population falls at the lower and upper end of the range of modern human variation. There is little difference between the total root lengths of the modern humans. The Tswana and Zulu populations are similar to each other, and their sample maximums are greater than those of the European. There is a moderate correlation between the MD diameter and the total root length, (r= 0.60, n= 28, p= 0.0005, 95% CI 0.292-0.795). The correlation between these two variables is statistically significant.

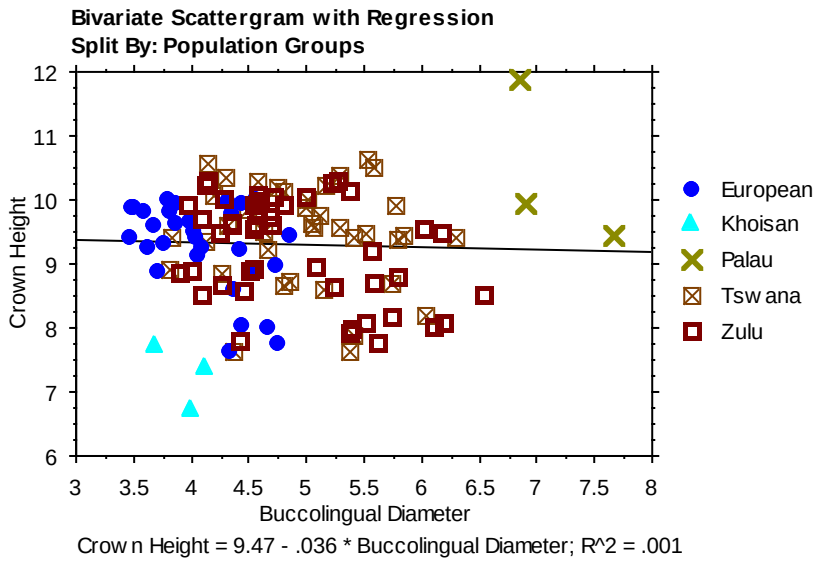

Figure 79: Bivariate plot of the BL diameters and the CH of the maxillary lateral incisors.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the European and Khoisan populations. The European and the Khoisan populations are clustered at the lower end of the range of modern human variation, therefore making the difference between them and the Palauans greater than those of the remaining modern human populations.

The crown height of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are equal to each other, and their sample maximums are greater than that of the Europeans. The Khoisan population is among the smallest of the modern human populations measured. There is a low negative correlation between the BL diameter and the crown height, (r= -0.34, n= 121, p= 0.7114, 95% CI -0.211-0.145). The correlation between these two variables is not statistically significant.

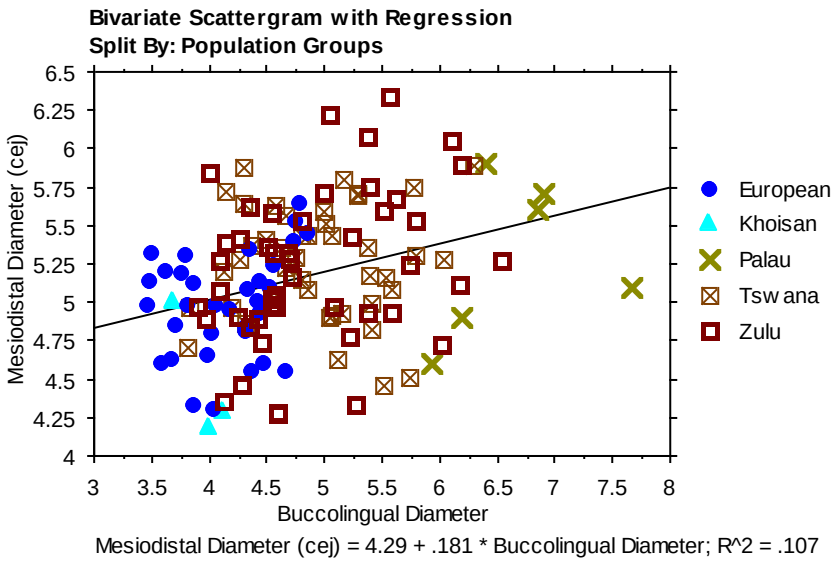

Figure 80: Bivariate plot of the BL and MD (cej) diameters of the maxillary lateral incisors.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. Three are greater than the entire modern human sample. The Tswana and the Zulu populations are equal to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan populations are clustered on the lower end of the range, and this makes the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Equal quantities are on either side of the regression line, being equal to the modern humans at the upper and the lower end of the range. The sample minimums of the modern humans are similar to each other, but the sample maximums of the Tswana and the Zulu populations are larger than those of the other two modern human groups. There is a low correlation between the BL and MD (cej) diameter, (r= 0.33, n= 133, p= 0.0001, 95% CI 0.166-0.471). The correlation between these two variables is statistically significant.

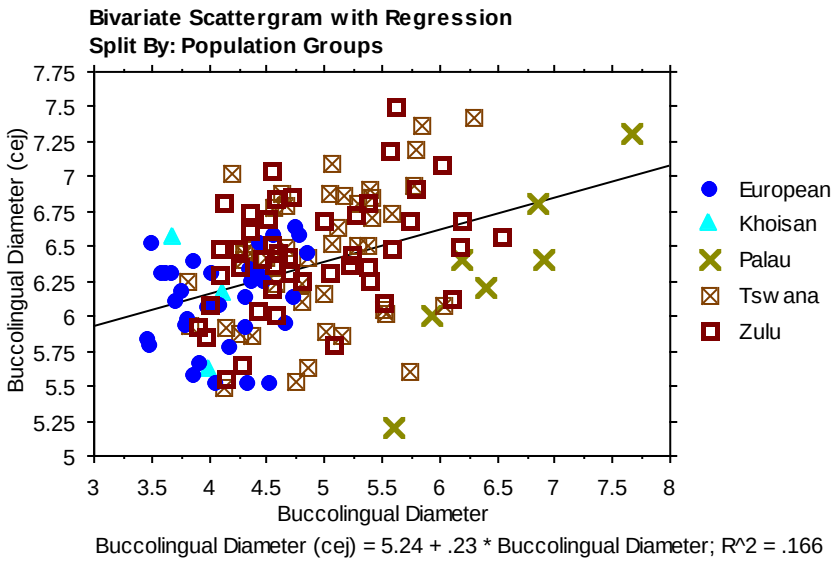

Figure 81: Bivariate plot of the BL and BL (cej) diameters of the maxillary lateral incisors.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are equal to each other, and are larger than the European and Khoisan population. The European and Khoisan populations are clustered on the lower end of the range of modern human variation, making the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are equal to each other and are greater than the European and Khoisan populations. The European and Khoisan populations are clustered at the lower end of the range. There is no difference between the modern humans and the Palau population because the Palauans are evenly distributed along the range of modern human variation. There is a low positive correlation between the BL and BL (cej) diameter of the humans measured, ($r = 0.41$, $n = 137$, $p<0.0001$, 95% CI 0.257-0.539). The correlation between these two variables is statistically significant.

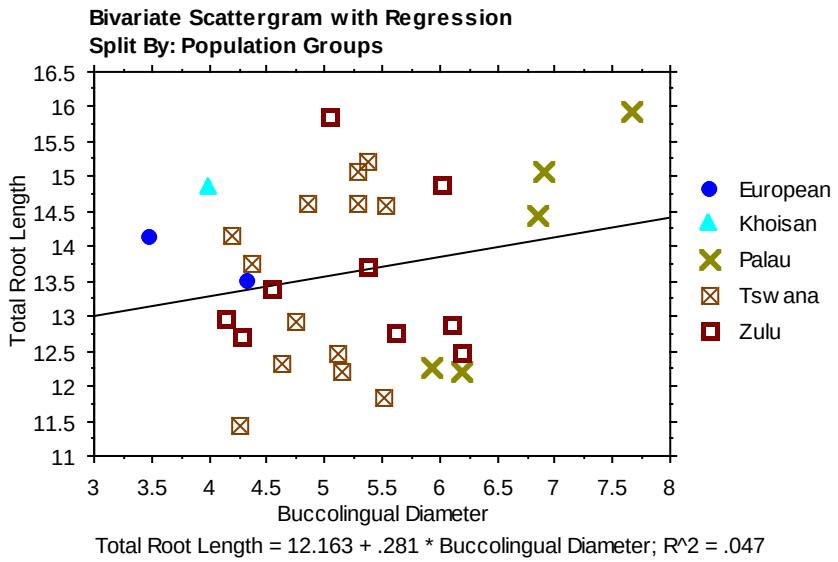

Figure 82: Bivariate plot of the BL diameters and the TRL of the maxillary lateral incisors.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The BL diameters of the Tswana and the Zulu populations are equal to each other, and are greater than those of the European and the Khoisan populations. The latter two populations are at the lower end of the range of modern human variation, and this makes the difference between them and the Palau population the greatest.

The total root length of the Palau population falls within the range of modern human variation. Three are equal to those on the upper end of the range, while two are equal to those on the lower end. There is little difference between the total root lengths of the modern human populations, with the only available Khoisan on the upper end of the range of modern human variation. There is a low positive correlation between the BL and the total root length, (r= 0.22, n=30, p= 0.2548, 95% CI -0.157-0.534). The correlation between these two variables is not statistically significant.

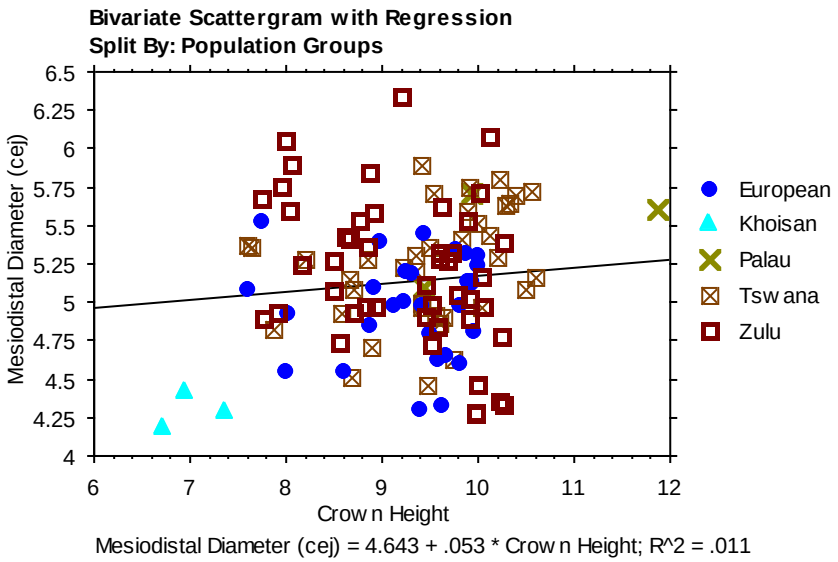

Figure 83: Bivariate plot of the CH and the MD (cej) diameter of the maxillary lateral incisors.

The crown height of the Palau population falls within the range of modern human variation. One is greater than the entire modern human sample. There is little difference between the crown heights of the Tswana, Zulu and European populations, but the sample maximums of the Tswana and the Zulu are greater than that of the Europeans. The Khoisan population is among the smallest of the modern human populations measured.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those of modern humans in the middle of the range. There is little difference between the MD (cej) diameters of the Tswana, Zulu, and European populations, but the sample maximums of the Tswana and the Zulu are greater than those of the Europeans. The Khoisan are clustered on the lower end of the range of modern human variation. There is a low positive correlation between the crown height and the MD (cej) diameter, (r= 0.12, n= 119, p= 0.2507, 95% CI -0.075-0.281). The correlation between these two variables is not statistically significant.

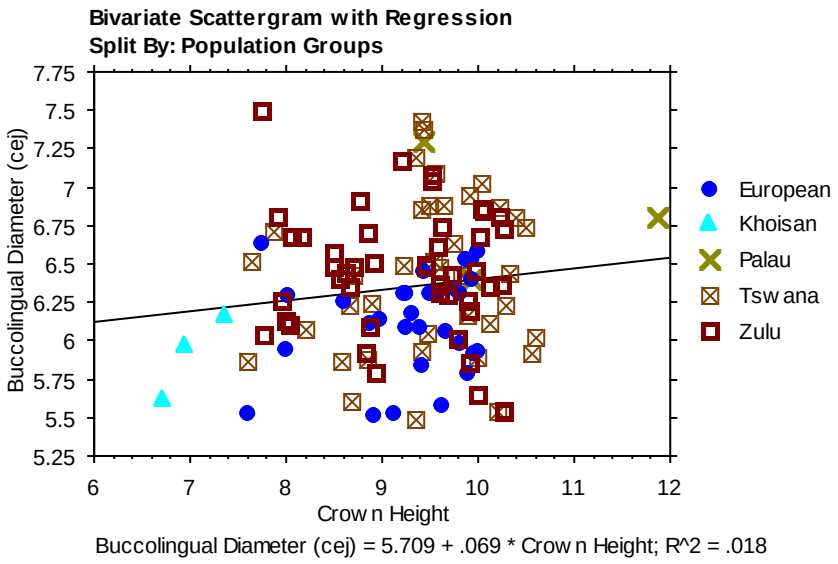

Figure 84: Bivariate plot of the CH and the BL (cej) diameters of the maxillary lateral incisors.

The crown height of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. There is little difference between the Tswana, Zulu and the European populations, but the Tswana and Zulu shifts lightly towards the upper end of the range. The Khoisan are clustered on the lower end of the range, and this makes the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. The Tswana and the Zulu populations are equal to each other, and are larger than the European and the Khoisan. The latter two modern human populations are clustered on the lower end of the range, and this makes the difference between them and the Palauans the greatest. There is a low positive correlation between the crown height and the BL (cej) diameter, (r= 0.13, n= 121, p= 0.1432, 95% CI -0.046-0.305). The correlation between these two variables is not statistically significant.

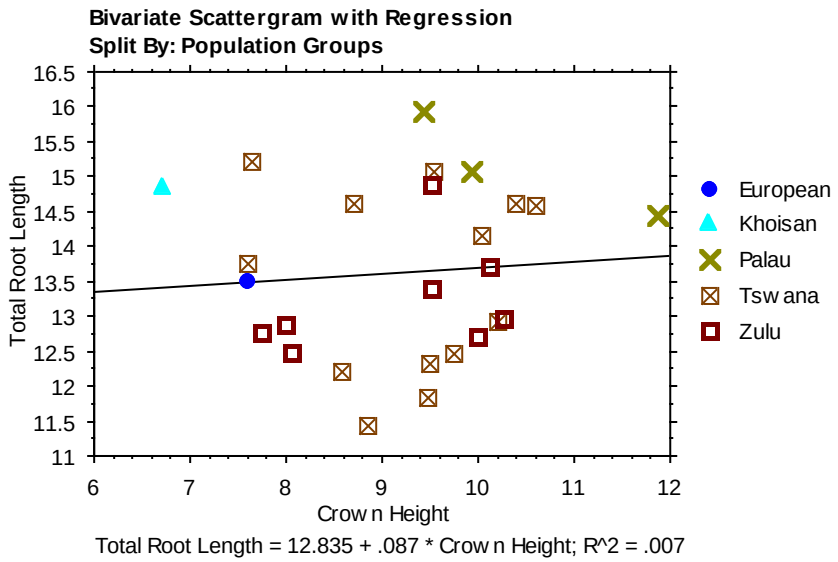

Figure 85: Bivariate plot of the CH and the TRL of the maxillary lateral incisors.

The crown height of the Palau population falls within the range of modern human variation. One is greater than the entire modern human sample. The crown heights of the Tswana and the Zulu populations are similar to each other, and are larger than the European and the Khoisan. The European and the Khoisan populations are on the lower end of the range of modern human variation.

The total root length of the Palau population falls at the upper end of the range of modern human variation. There is little difference between the total root lengths of the modern humans. The European and the Khoisan are in the middle of the range of modern human variation. There is a very low positive correlation between the crown height and the total root length, (r= 0.09, n= 26, p= 0.6807, 95% CI -0.312-0.458). The correlation between these two variables is statistically significant.

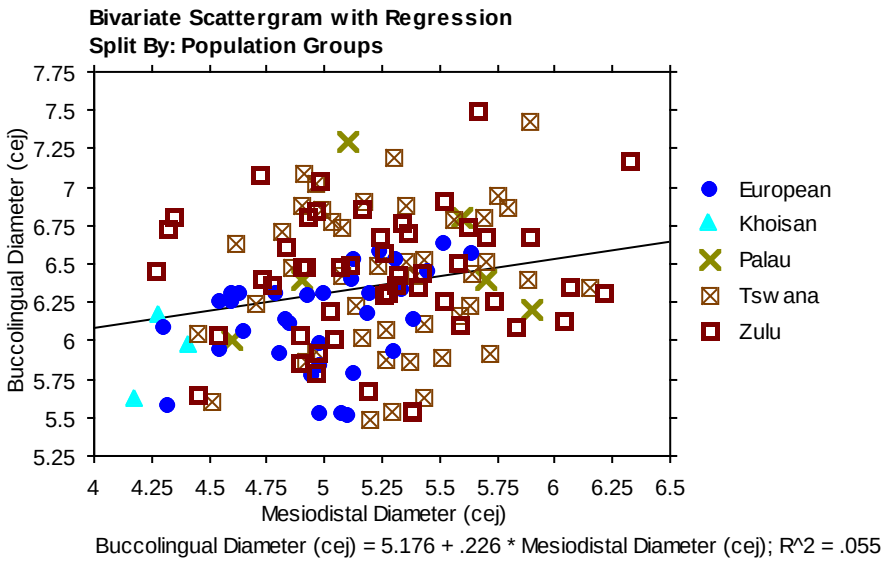

Figure 86: Bivariate plot of the MD (cej) and the BL (cej) diameters of the maxillary lateral incisors.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the European and Khoisan. The Khoisan populations are at the lower end of modern human variation. There is no difference between the Palau population and the modern humans because the Palauans are distributed evenly along the range of modern human variation.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. It is equal to those of the modern human populations at the upper and lower end of the range. The Tswana and the Zulu populations are equal to each other and are greater than the European and the Khoisan. The European and Khoisan populations are clustered at the lower end of the range of modern human variation. There is little difference between the Palau population and the modern humans. There is a low positive correlation between the MD (cej) and the BL (cej)

diameter, (r= 0.24, n= 137, p= 0.0056, 95% CI 0.070-0.387). The correlation between these two variables is statistically significant.

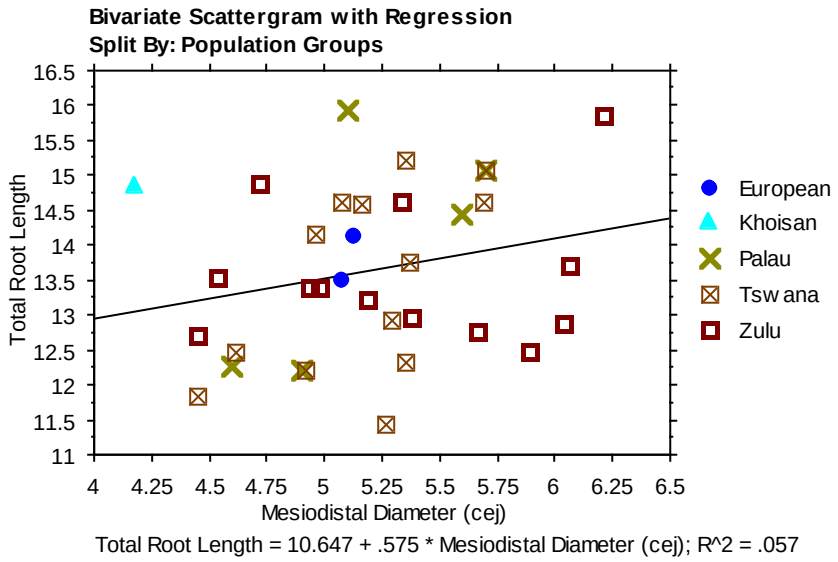

Figure 87: Bivariate plot of the MD (cej) diameters and the TRL of the maxillary lateral incisors.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the lower end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the European and Khoisan. The European is in the middle of the range, while the Khoisan is on the lower end.

The total root length of the Palau population falls within the range of modern human variation. Three are equal to those on the upper end of the range, while two are equal to those on the lower end. The Tswana and the Zulu populations are similar to each other. The European and Khoisan are in the middle of the range of modern human variation. There is a low positive correlation between the MD (cej) diameter and the total root length, (r= 0.24, n= 34, p= 0.1734, 95% CI -0.107-0.535). The correlation between these two variables is not statistically significant.

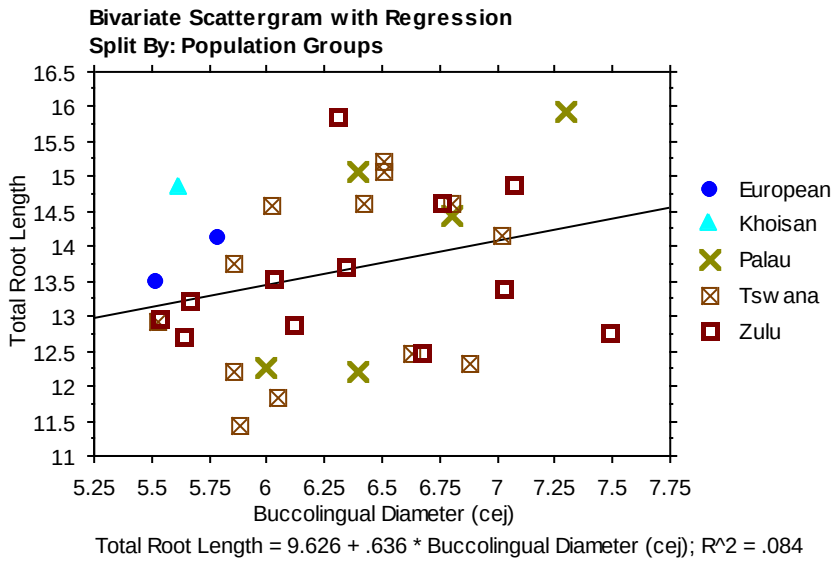

Figure 88: Bivariate plot of the BL (cej) diameters and the TRL of the maxillary lateral incisors.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. There is little difference between the BL (cej) diameters of the modern human populations, but the European and the Khoisan populations are at the lower end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the European and the Khoisan.

The total root length of the Palau population falls within the range of modern human variation. Three are equal to those in the middle of the range, while two are equal to those on the lower end of the range. The Tswana and the Zulu populations are similar to each other. The European and the Khoisan populations are in the middle of the range of modern human variation. There is a low positive correlation between the BL (cej) diameter and the total root length, (r= 0.29, n= 33, p= 0.1019, 95% CI -0.059-0.576). The correlation between these variables is not statistically significant.

Mandibular Canines

The size of mandibular canines was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of mandibular canines. In addition the univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 26: MD diameters of the mandibular canines

Population Groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.89	0.57	7.20-8.51	4
Khoisan females	6.43	0.20	6.17-6.62	4
Tswana males	7.27	0.54	6.25-8.32	45
Tswana females	6.82	0.44	5.70-7.54	48
Zulu males	7.21	0.56	5.97-8.08	45
Zulu females	6.81	0.38	5.73-7.52	56
European males	6.72	0.34	5.94-7.24	49
European females	6.44	0.35	5.84-7.04	44

Four Palauan mandibular canines were available for comparison with the modern human sample. The Khoisan population group was the least represented, with only four individuals. The mean of the MD diameters of the Palau population is greater than those of the modern human populations. It is followed by the means of the Tswana and Zulu males respectively. The means of the MD diameters of the European and Khoisan populations groups are smaller than those of the Tswana and the Zulu population groups. The Khoisan females have the lowest mean of all the groups measured. The means of the MD diameters of the females of the entire modern human

sample are smaller than those of the males of their similar groups. The difference between the Palau population and the modern human populations increases from the Tswana to Zulu, then European and finally Khoisan population groups.

Khoisan females have the smallest standard deviations of all the populations measured. In addition, the standard deviations of all the groups measured are small, indicating the clustering of the data around the means of the different groups. The Palauans range from 7.20-8.51 mm. Tswana males have the highest mean of all the modern human populations studied and they range from 6.25-8.32 mm. Khoisan females have the smallest mean, ranging from 6.17-6.62 mm. These ranges show that the MD diameter of the Palau population falls towards the upper end of, and exceeds the range of modern human variation.

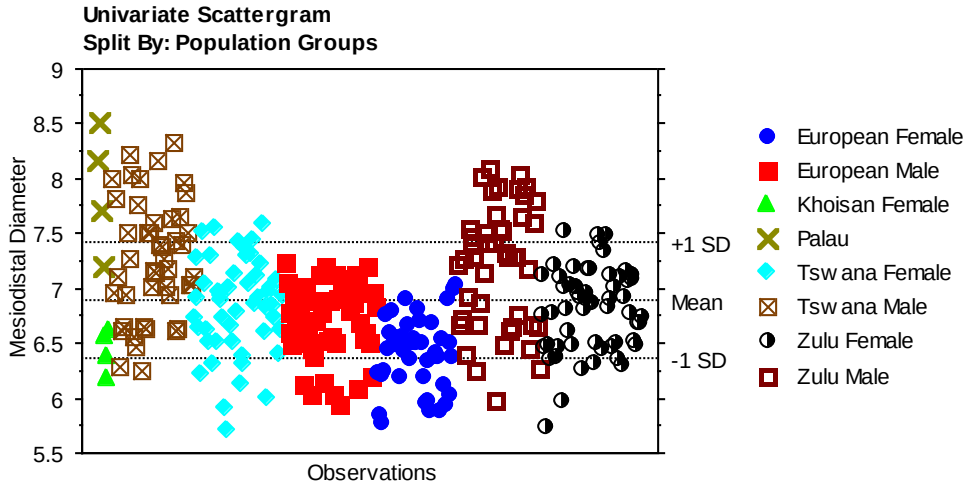

Figure 89: Univariate plot of the MD diameters of the mandibular canines.

The MD diameters of the Palau population are equal to most of the MD diameters of the modern human population groups. One of the measurements is greater than the entire sample of modern human populations. The MD diameters of the Tswana and Zulu males are very close to each

other and to those of the Palau population. European males are equal to the Tswana and the Zulu females. European females are slightly smaller than the European males, and are comparable with the Khoisan females. They range from 5.84-7.04 mm and 6.17-6.62 mm respectively. There is an extensive amount of sexual dimorphism between the males and females of the same groups for the entire modern human sample. The Tswana males and females range from 6.25-8.32 mm and 5.73-7.54 mm respectively.

Table 27: BL diameters of the mandibular canines

Population Groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.87	0.37	7.20-8.51	4
Khoisan females	5.12	0.54	4.53-5.59	5
Tswana males	6.52	0.58	5.61-7.84	46
Tswana females	6.29	0.50	5.16-7.09	48
Zulu males	6.67	0.65	5.48-7.76	46
Zulu females	6.27	0.56	5.39-7.26	56
European males	5.53	0.48	4.55-6.52	50
European females	5.29	0.56	4.45-6.40	43

Four Palauan mandibular canines were available for comparison with the modern human sample. No Khoisan males were available for this comparison, and the Khoisan females were the least represented. The mean of the BL diameters of the Palau population is greater than those of the modern human population groups. The mean of the Palau population is followed by the mean of the Zulu and Tswana males respectively. Khoisan females have the smallest mean of all the populations measured, making the difference between them and the Palauans the greatest.

The Palau population has the lowest standard deviations of all the population groups studied. This indicates the clustering of the primary data around the mean of the group. The remaining groups also have considerably small standard deviations, still indicating the clustering of primary

data around the means of the different groups. The Palau population ranges from 7.20-8.51 mm. Zulu males have the largest mean of all the modern human populations measured, ranging from 5.48-7.76 mm. Khoisan females have the lowest mean and they range from 4.53-5.59 mm. These ranges show that the Palauans have the BL diameter that falls above the normal range of modern human variation.

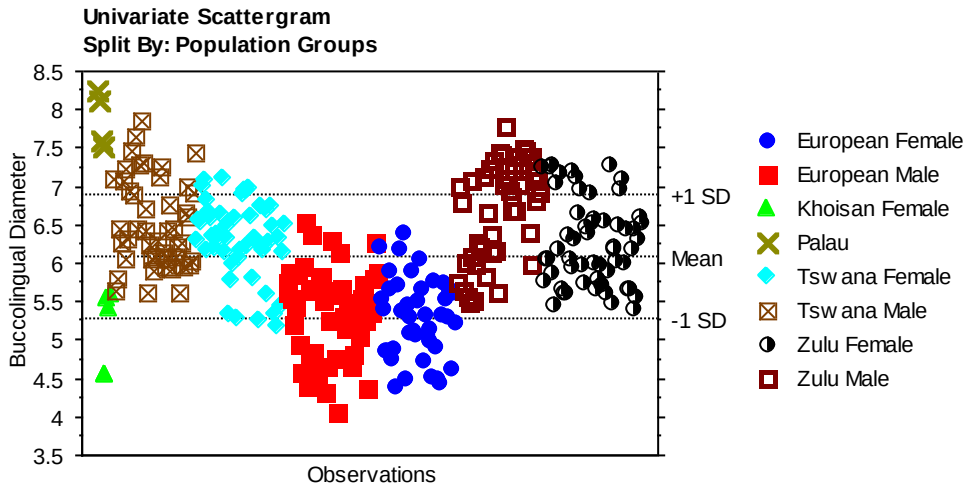

Figure 90: Univariate plot of the BL diameters of the mandibular canines.

The BL diameters of the mandibular canines of the Palau population are larger than most of the BL diameters of the modern human populations. They are followed by those of the Zulu and the Tswana males. The females of the Tswana and the Zulu population groups are smaller than the males of their male counterparts, but larger than the European population groups. The Khoisan females are equal to most of the European population groups, and are clustered on the lower end of the range of modern human variation. Sexual dimorphism is moderate between the males and females of the European populations, whereas slightly high between the Tswana and Zulu population groups. The Zulu males and females range from 5.48-7.76 mm and 5.39-7.26 mm respectively.

Table 28: CH of the mandibular canines

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan females	9.17	0.78	8.50-10.36	5
Tswana males	10.71	0.78	9.21-11.77	33
Tswana females	10.34	0.60	8.98-11.43	48
Zulu males	10.67	0.72	9.06-11.76	46
Zulu females	10.24	0.79	8.88-11.41	56
European males	10.19	0.86	8.54-11.34	39
European females	9.82	0.72	8.41-11.27	45

No Palauans and Khoisan males were available for comparison with the modern human populations. Khoisan females were the least represented of the entire modern human sample. Tswana males have the greatest mean of the crown height of all the groups measured, followed by those of Zulu males. The mean of the crown height of the females of the modern humans are smaller than the means of their male counterparts. This trait indicates the degree of sexual dimorphism displayed by the canines. The Khoisan females have the smallest mean of all the populations measured.

The Tswana females have the smallest standard deviation when compared to the other groups, but the difference between them and the remaining groups is small. The Tswana males range from 9.21-11.77 mm, whereas the Khoisan females range from 8.50-10.36 mm. Although small, Khoisan females fall within the normal range of modern human variation.

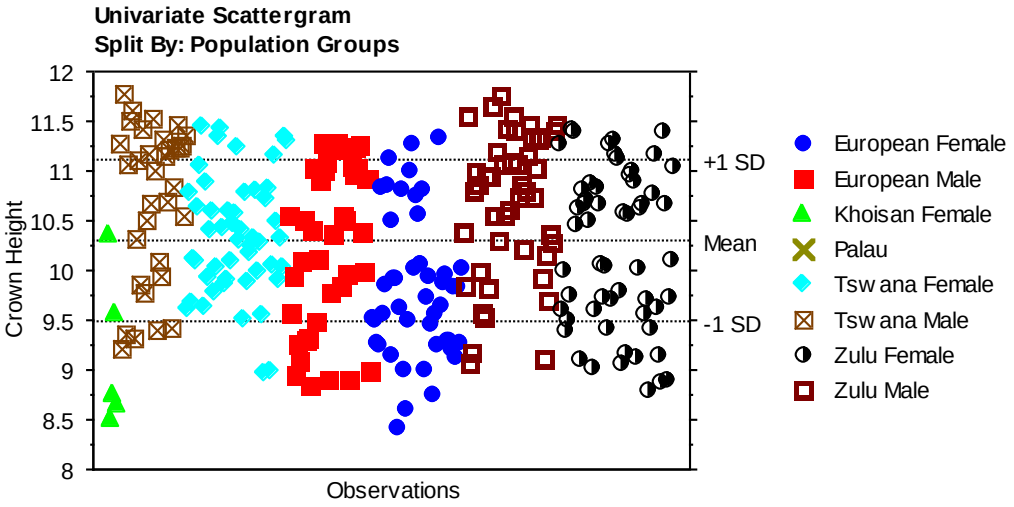

Figure 91: Univariate plot of the CH of the mandibular canines.

No Palauan specimens were available for comparison with the modern human sample. There is little difference between the modern human population groups. The Tswana and Zulu males are similar to each other. The same applies to the females of these two groups. The European females are equal to the European males. The Khoisan females are on the lower end of modern human variation. This variable displays less sexual dimorphism than the other measurements obtained from the mandibular canines.

Table 29: MD (cej) diameters of the mandibular canines

Population Groups	**MD (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.18	0.31	5.90-6.60	4
Khoisan females	5.04	0.28	4.64-5.28	5
Tswana males	6.02	0.52	5.23-7.09	44
Tswana females	5.63	0.35	4.88-6.23	48
Zulu males	5.92	0.52	5.01-7.13	47
Zulu females	5.61	0.34	4.72-6.24	56
European males	5.55	0.37	4.93-6.19	49
European females	5.32	0.36	4.64-6.15	42

Four Palauan mandibular canines were available for comparison with the modern human sample. The Khoisan population was the least represented, with no males and only five females. The mean of the MD (cej) diameters of the Palau population is greater than the mean of the modern human population groups. It is followed by those of the Tswana and Zulu males respectively. The females of the different groups have the means that are smaller than those of the males of their similar population groups. Khoisan females have the smallest mean and standard deviation of all the populations measured.

The remaining groups also have smaller standard deviations, indicating the clustering of primary data around the means of different groups. The MD (cej) diameter of the Palau population ranges from 5.90-6.60 mm. The Tswana males range from 5.23-7.09 mm, while small Khoisan females range from 4.64-5.28 mm. These ranges indicate that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

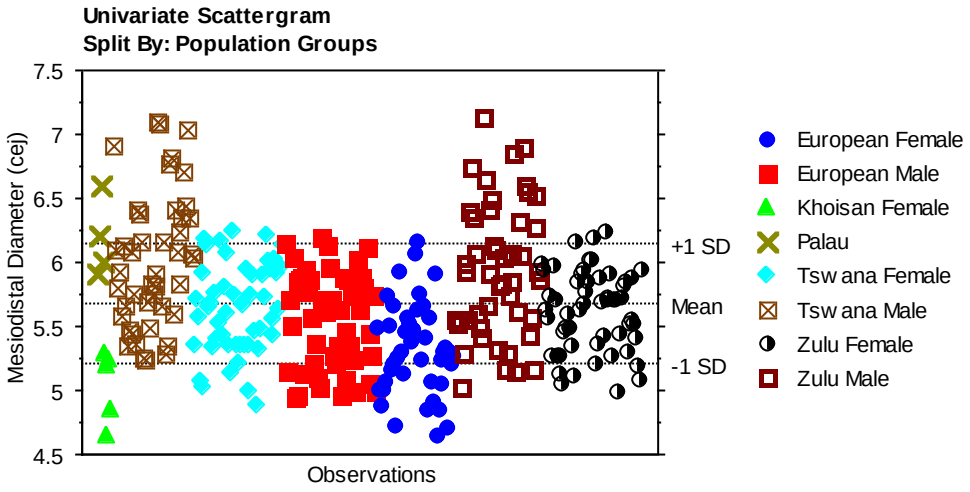

Figure 92: Univariate plot of the MD (cej) diameters of the mandibular canines.

The MD (cej) diameters of the Palau population are equal to most of the MD (cej) diameters of the modern human population groups. They are mostly equal to the European population groups and the females of the three remaining groups. Some of the MD (cej) diameters of the Tswana and the Zulu males are larger than the MD (cej) diameters of the Palau population, and are comparable with each another. The females of these two groups are also similar, and are slightly similar to the European males. The Khoisan females are clustered on the lower end of the range of modern human variation, and are similar to most of the Europeans population groups. The Tswana and Zulu population groups display a great degree of sexual dimorphism compared to the European population. The Tswanas range from 4.88-7.09 mm and Zulus from 4.72-7.13 mm, while the Europeans range from 4.64-6.19 mm.

Table 30: BL (cej) diameters of the mandibular canines

Population Groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.95	0.26	7.60-8.20	4
Khoisan females	7.04	0.20	6.75-6.97	8
Tswana males	7.87	0.52	6.82-9.17	46
Tswana females	7.52	0.46	6.73-8.54	48
Zulu males	7.93	0.61	6.72-9.19	47
Zulu females	7.54	0.42	6.61-8.30	56
European males	7.51	0.52	6.23-8.19	50
European females	7.26	0.42	6.20-8.14	43

Four Palauan mandibular canines were available for comparison with the modern human sample. The Khoisan population group was the least represented, with no males and only eight females. The mean of the BL (cej) diameter of the Palau population is larger than those of the modern human population groups. It is followed by the mean of the BL (cej) diameter of the Tswana males. The mean of the BL (cej) diameter of the Khoisan females is the smallest of all the

groups measured. The mean of the BL (cej) diameter of the European males is very close to the means of the Tswana and Zulu females. The males of the modern humans have means that are larger than the females of their groups. The difference between the males and females is quite noticeable, indicating the greater degree of sexual dimorphism displayed by this character.

Khoisan females and Palauans have the smallest standard deviations of all the populations measured. This indicates the clustering of primary data around the means of the groups. The Palau population ranges from 7.60-8.20 mm. Zulu males have the highest mean of the modern human sample ranging from 6.72-9.19 mm. Khoisan females have the lowest mean of all the populations measured ranging from 6.75-6.97 mm. These ranges indicate that the BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

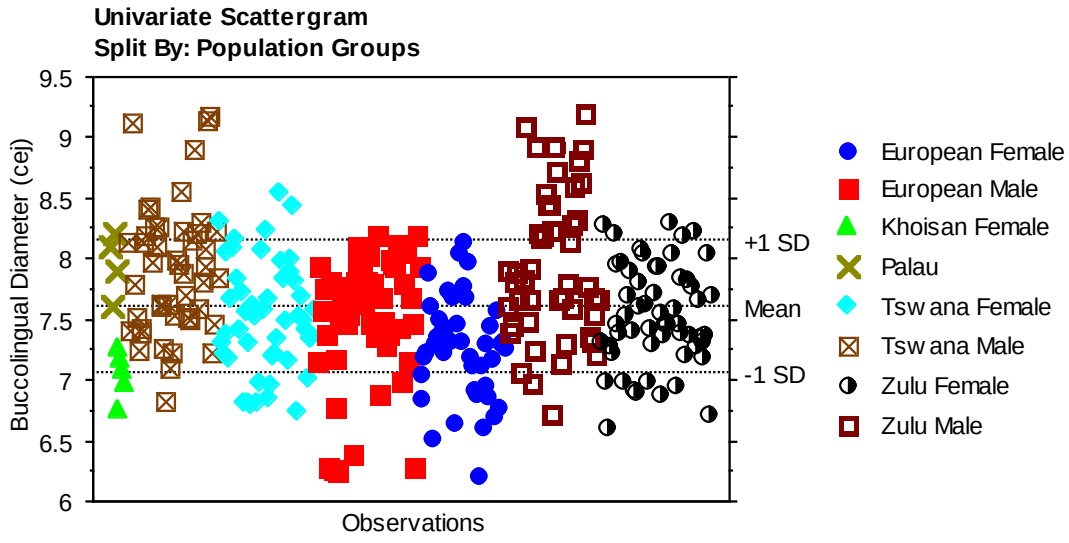

Figure 93: Univariate plot of the BL (cej) diameters of the mandibular canines.

The BL (cej) diameters of the Palau population are equal to most of the BL (cej) diameters of the modern human populations. A few of the Tswana and the Zulu males have larger BL (cej) diameters than the palauans. The Tswana and Zulu females are also similar to each other.

Khoisan females are among the smallest of the modern human populations measured. They are clustered on the lower end of modern human variation with majority of the European population groups. There is extensive sexual dimorphism within the Tswana and Zulu population groups, as opposed to the Europeans, who record similar measurements in both sexes.

Table 31: Total root length of the mandibular canines

Population Groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	17.45	2.33	14.82-19.80	4
Tswana males	14.09	1.56	12.32-16.77	8
Tswana females	14.03	2.05	11.24-16.74	11
Zulu males	13.57	1.46	11.61-16.83	26
Zulu females	13.52	1.32	12.58-14.45	2
European females	12.44	1.92	10.27-14.39	6

Four Palauan mandibular canines were available for comparison with the modern human sample. No Khoisan and European males were available for comparison. The mean of the total root length of the Palau population is greater than those of the modern human population groups. It is followed by the mean of the Tswana males. European females have the lowest mean of all the groups measured. The females of the modern human populations groups have means that are smaller than the means of their male counterparts, but the mean of the total root length of the Tswana females is greater than that of Zulu males.

The standard deviations of all the population groups studied are very large; indicating that the primary data are widespread in the different population groups. Palauans range from 14.82-19.80 mm. Tswana males range from 12.32-16.77 mm, whereas the European females range from 10.27-14.39 mm. These ranges indicate that the Palauans have total root length that fall within and slightly above the range of modern human variation, hence normal total root length.

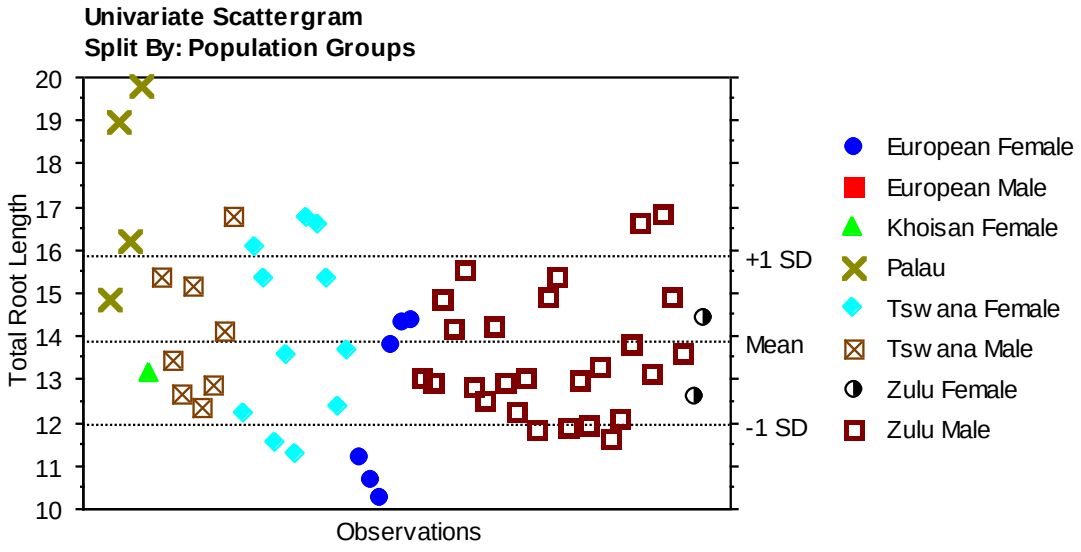

Figure 94: Univariate plot of the total root length of the mandibular canines.

The Palau populations have total root lengths that are equal to those of modern human populations. Only two are notably larger than the modern humans. There is little difference between the total root lengths of the modern human populations. The total root lengths of the males and females of the represented groups are comparable with each other.

Bivariate analysis

The first variables compared were the crown measurements, the MD and BL of the mandibular canines.

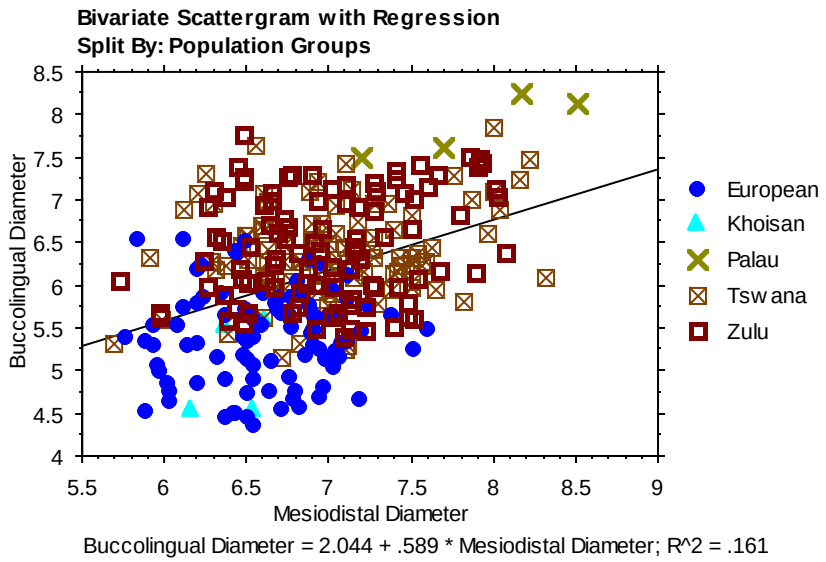

Figure 95: Bivariate plot of the MD and BL diameters of the mandibular canines.

The MD diameter of the Palau population falls within and above the range of modern human variation. It is greater than most of the MD diameters of the modern humans; but some are equal to those on the upper end of modern human variation. The majority of the Tswana and the Zulu population groups are larger than the European and the Khoisan populations. Most Europeans are at the lower end of the range of modern human variation. This makes the difference between the Palauans and the Europeans and Khoisan greater than the difference between the Palauans and the remaining two modern human population groups.

The BL diameter of the Palau population falls above the normal range of modern human variation. Tswana and Zulu populations are larger than most of the Europeans and Khoisan, and are close to a few of the Palauans. The difference between the Palau population and the modern human populations is smaller in relation to the Tswana and the Zulu populations; but greater when they are compared with the European and the Khoisan population groups. There is a low

positive correlation between the MD and BL diameter, (r= 0.40, n= 294, p<0.0001, 95% CI 0.301-0.493). The correlation between these two variables is statistically significant.

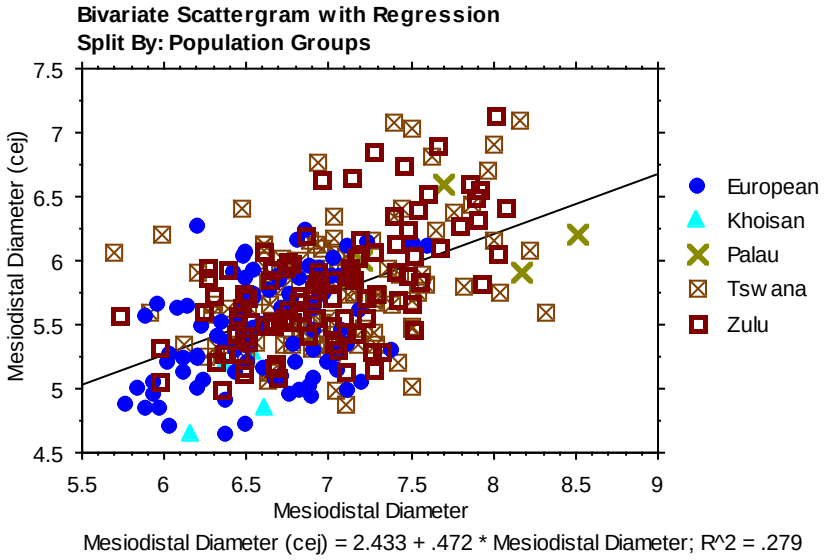

Figure 96: Bivariate plot of the MD and the MD (cej) diameters of the mandibular canines.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. Most of the Tswana and the Zulu populations are larger than the European and the Khoisan populations. The difference between the Palauans and the modern humans increases from the Tswana and the Zulu all the way to the European and the Khoisan populations.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. It is equal to those of modern humans on the higher end of the range (Tswanas and Zulus). European and Khoisan are smaller than most of the groups measured. There is a moderate positive correlation between the MD and MD (cej) diameters of the populations measured (r= 0.53, n= 291, p<0.0001, 95% CI 0.440-0.607). The correlation between these two variables is statistically significant.

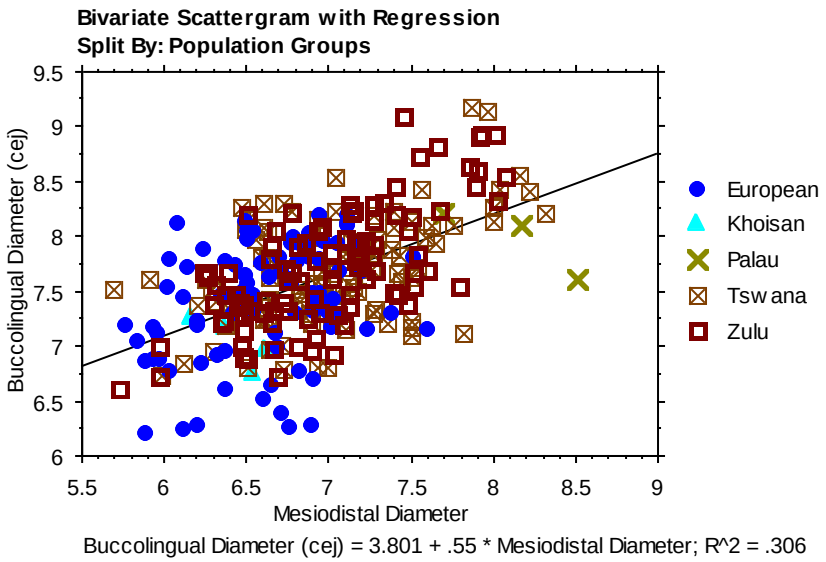

Figure 97: Bivariate plot of the MD and the BL (cej) diameters of the mandibular canines.

The MD diameter of the Palau population falls within and above the range of modern human variation. It is greater than the majority of the modern humans measured. A few are equal to those on the upper end of the range of modern human variation. Tswana and Zulu populations are equal to Palauans (with one exception), but larger than the European and the Khoisan. The Europeans and the Khoisan are at the lower end of the range of modern human variation. This makes the difference between them and the Palauans the greatest.

The BL (cej) diameter of the Palau populations falls within the range of modern human variation. It is at the upper end of the range, but is smaller than a few of the Tswana and Zulu. European and Khoisan populations are smaller than most of the Tswanas and the Zulus, and are clustered mostly on the lower end of the range of modern human variation. There is a moderate positive correlation between the MD and BL (cej) diameters, ($r= 0.55$, $n= 294$, $p<0.0001$, 95% CI 0.468-0.628). The correlation between these two variables is statistically significant.

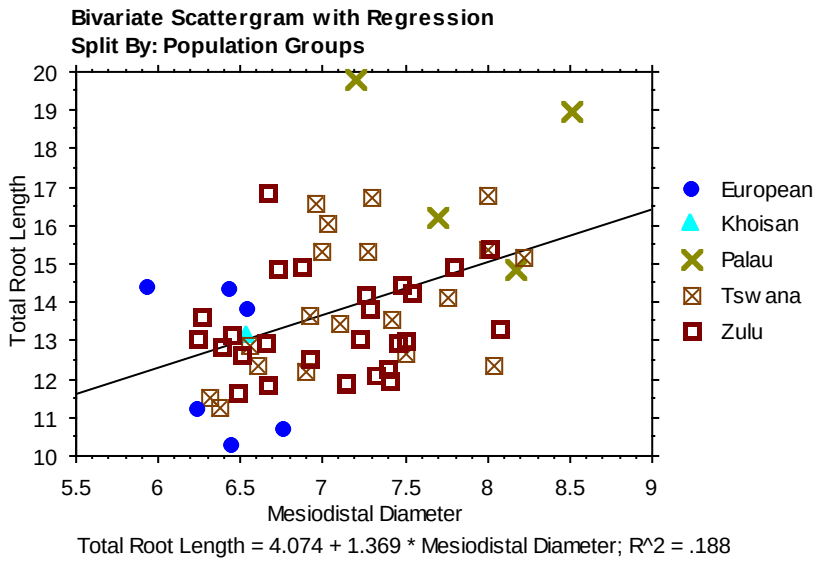

Figure 98: Bivariate plot of the MD diameters and the TRL of the mandibular canines.

The MD diameter of the Palau population falls above and within the range of modern human variation. It is equal to most of the modern humans at the higher end of the modern human range. Some of the Tswana and the Zulus are equal to the Palauans, and are larger than the European and Khoisan. Europeans and Khoisan are equal to the smallest of the Tswanas and Zulus recorded.

The total root length (TRL) of the Palau population falls above and within the range of modern human variation. Two are equal to some of the Tswanas and Zulus. The TRL of the Tswanas and Zulus are greater than those of the Europeans and Khoisan, which happen to be clustered on the lowest end of the range of modern human variation. There is a low positive correlation between the MD diameter and the TRL, ($r= 0.43$, $n=56$, $P<0.0007$, 95% CI 0.192-0.625). The correlation between these two variables is statistically significant.

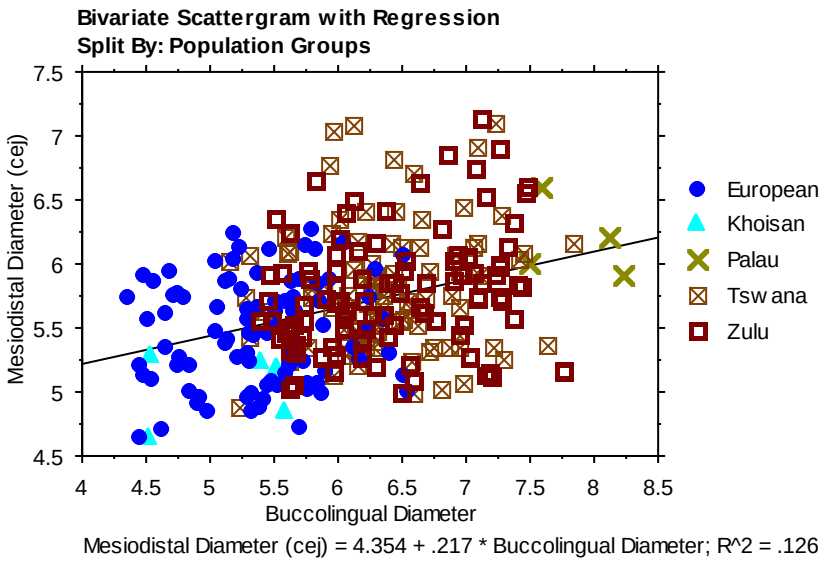

Figure 99: Bivariate plot of the BL and the MD (cej) diameters of the mandibular canines.

The BL diameter of the Palau population falls above the range of modern human variation. Two of the Palauans are larger than the entire sample of the modern humans. The Tswana and the Zulu populations are larger than the European and the Khoisan, which happen to be on the lower end of the range of modern human variation. This makes the difference between the Palauans and the European and Khoisan populations the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. It is equal to a few of the Tswana and the Zulu population groups. The majority of the Tswana and the Zulu populations are equal to the European population, but a few are larger. The Khoisan population is among the smallest of the modern human populations measured. There is low positive correlation between the BL and MD (cej) diameter of the humans measured ($r= 0.35$, $n= 293$, $p<0.0001$, 95% CI 0.250-0.451). The correlation is statistically significant.

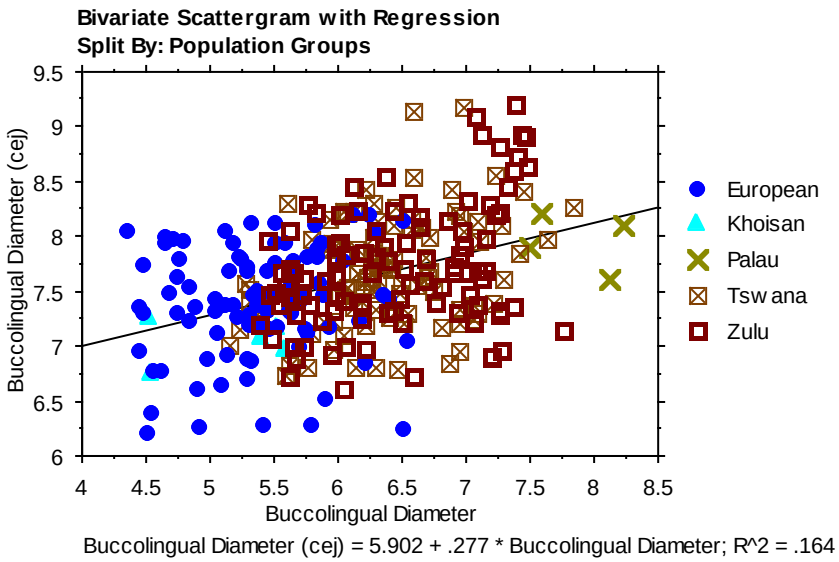

Figure 100: Bivariate plot of the BL and the BL (cej) diameters of the mandibular canines.

The BL diameter of the Palau population falls above the range of modern human variation. Two are equal to the Tswanas and Zulus on the upper end of the range of modern human variation. The BL diameters of the Tswana and the Zulu populations are equal to each other and are greater than those of the European and the Khoisan. The difference between the Palauans and the modern humans is greaterr when comparing them to the Tswanas and Zulus, as opposed to the comparison between them and the Europeans and Khoisan.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. It is equal to those modern humans that are on the expected slope of variation. A few of the Tswanas and Zulus are larger than the Palauans, Europeans and Khoisan. Most of the European population and Khoisan are on the lower end of the range of modern human variation, making the difference between them and the Palauans the greatest. There is a low positive correlation between the BL and BL (cej) diameters of the humans measured ($r= 0.41$, $n= 300$, $p< 0.0001$, 95% CI 0.305-0.495). The correlation between these two variables is statistically significant.

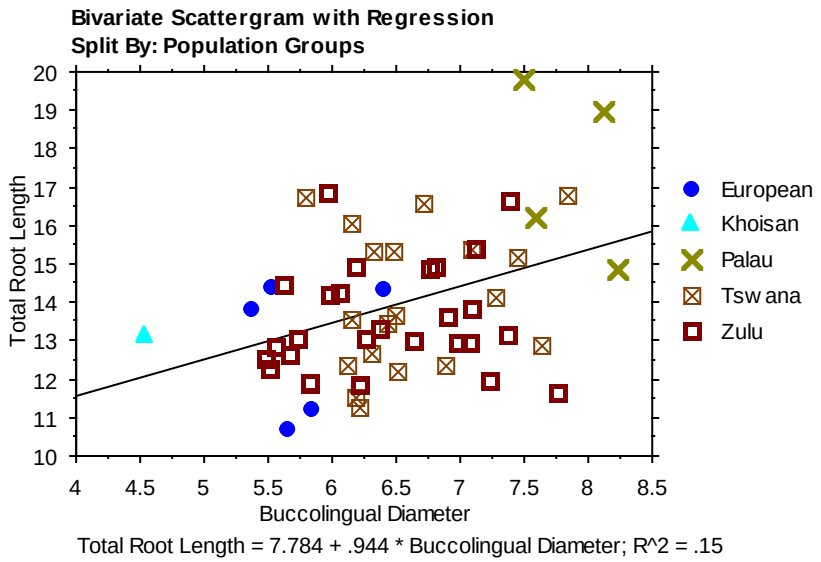

Figure 101: Bivariate plot of the BL diameters and the TRL of the mandibular canines.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are at the upper end of the range of modern human variation, with a few European and Khoisan at the lower end. The difference between the Palauans and Europeans and Khoisan is greater when compared to the other two groups.

The total root length of the Palau population falls above the range of modern human variation. There is little difference between the total root lengths of the modern human populations, but the Tswana and Zulus are evenly distributed along the regression line, while Europeans are clustered on the lower end of the range of modern human variation. There is a low positive correlation between the BL diameter and TRL of the humans studied (r= 0.39, n= 55, p= 0.0033, 95% CI 0.135-0.591). The correlation between these two variables is statistically significant.

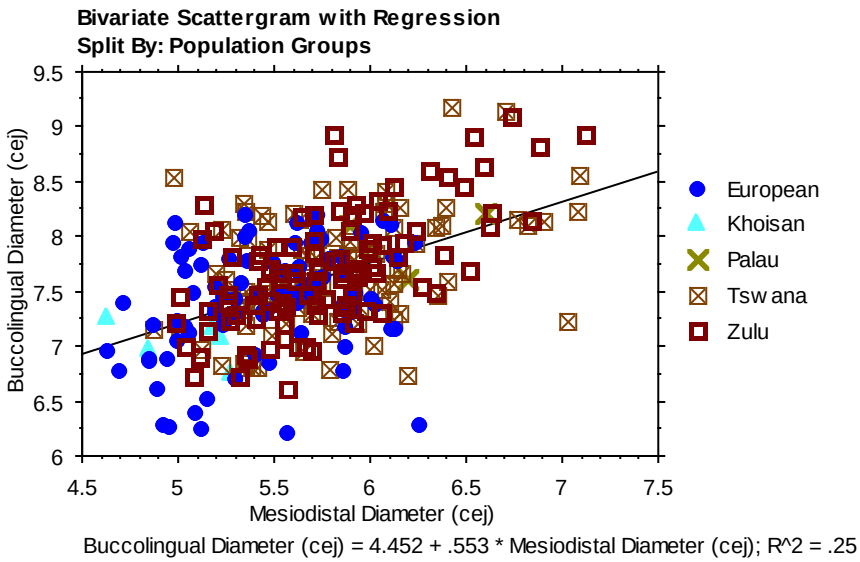

Figure 102: Bivariate plot of the MD (cej) and the BL (cej) diameter of the mandibular canines.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to modern humans in the middle and upper end of the range. The Tswana and Zulu population groups are equal to each other, and are larger than the European and Khoisan. The Khoisan are among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. Most of the Tswana and the Zulu populations are larger than the European and the Khoisan, with the majority being equal to the Europeans. The Khoisan are clustered among the smallest of the modern humans measured. There is a moderate positive correlation between the MD (cej) and BL (cej) diameter of the humans studied ($r= 0.50$, $n= 294$, $p< 0.0001$, 95% CI 0.409-0.581). The correlation between these variables is statistically significant.

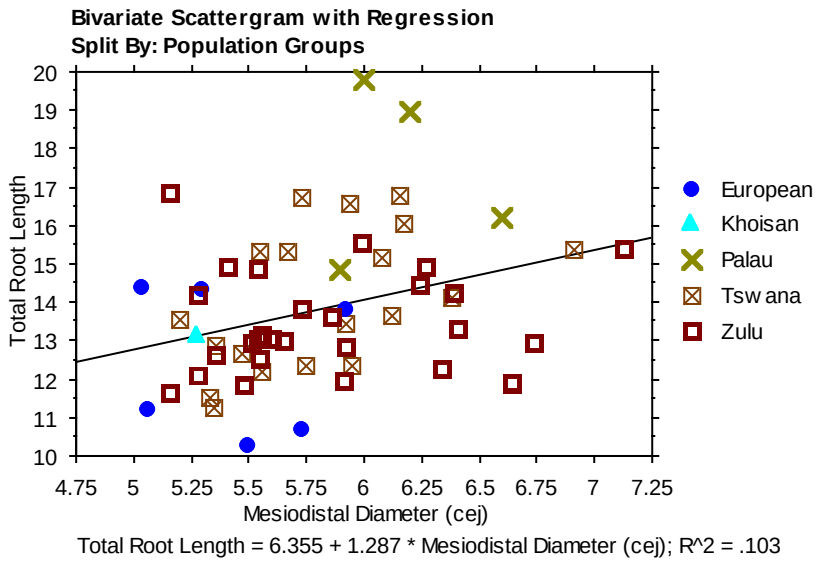

Figure 103: Bivariate plot of the MD (cej) diameters and the TRL of the mandibular canines.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. It is equal to most of the Tswana and Zulu populations, which are in turn comparable with each other. The European and Khoisan population are at the lower end of the range of modern human variation, making the difference between them and the Palauans the greatest.

The total root length of the Palau population falls at the upper end of the range of modern human variation. The total root lengths of the Tswana and Zulu populations are equal to each other, and are greater than the European and Khoisan. The latter two modern human populations are mainly plotted below the regression line of modern human variation. There is a low positive correlation between the MD (cej) diameter and the TRL of the humans measured (r= 0.32, n= 57, p= 0.0145, 95% CI 0.066-0.537). The correlation between these two variables is statistically significant.

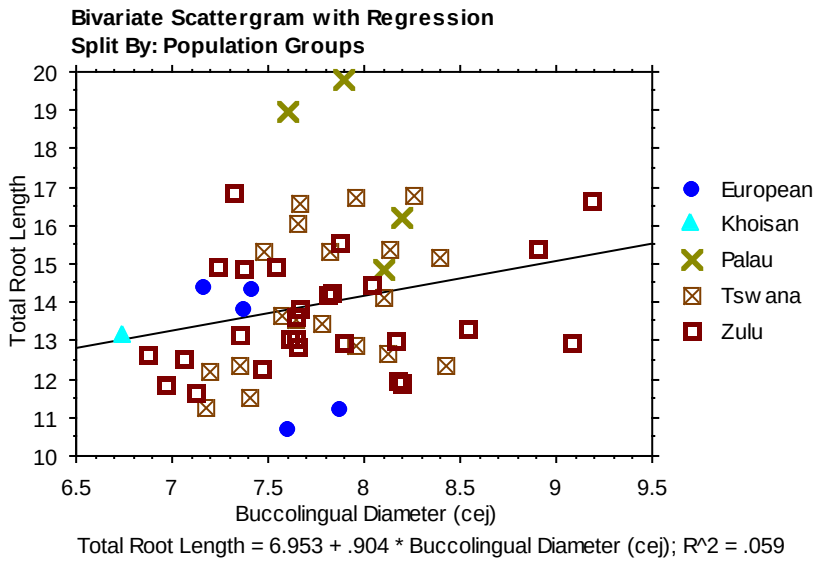

Figure 104: Bivariate plot of the BL (cej) diameters and the TRL of the mandibular canines.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to mainly the Tswana and Zulu populations. The BL (cej) diameter of the Tswana and Zulus are equal to each other, and are greater than the European and Khoisan. The Khoisan population is at the lower end of the range of modern human variation.

The total root length of the Palau population falls at the upper end of the range of modern human variation. Tswana and Zulu populations are equal to each other, and are larger than the European and Khoisan. There is a low positive correlation between the BL diameter and the TRL of the humans measured (r= 0.24, n= 56, p= 0.0717, 95% CI -0.022-0.475). The correlation is not statistically significant.

Maxillary canines

The size of maxillary canines was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of maxillary canines. In addition the univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 32: MD diameters of the maxillary canine

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.39	0.60	7.47-9.40	8
Khoisan males	6.46	0.46	5.95-6.90	4
Khoisan females	6.23	0.37	5.98-6.51	2
Tswana males	7.78	0.38	7.28-8.62	39
Tswana females	7.41	0.51	6.52-8.30	41
Zulu males	7.79	0.48	6.61-8.68	54
Zulu females	7.43	0.45	6.62-8.34	51
European males	7.37	0.41	6.45-8.13	37
European females	7.25	0.49	6.42-8.00	22

Eight Palauan maxillary canines were available for comparison with the modern human sample. Out of 400 modern human samples measured, the Khoisan population was the least represented, with only six individuals. The mean of the Palau population is greater than the mean of all the population groups measured. It is followed by the mean of the Zulu males. Khoisan females have the lowest mean of all the groups. The mean of the males of the modern human populations are greater than the mean of the females of their respective groups.

Khoisan females have the smallest standard deviations of all the populations measured. This indicates the clustering of primary data around the mean. In addition, the remaining groups still have small standard deviations, with the Palauans having the highest. The Palauans range from 7.47-9.40 mm. Khoisan females have the lowest range of all the groups measured, ranging from 5.98-6.51 mm. Zulu males have the highest range of the modern human populations measured, ranging from 6.61-8.68 mm. These ranges indicate that the MD diameters of the Palauans fall within and above the normal range of modern human variation.

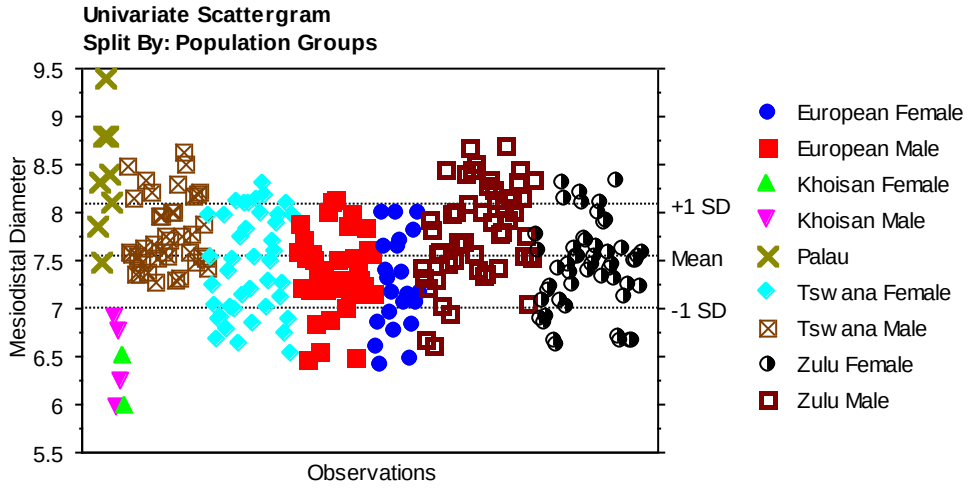

Figure 105: Univariate plot of the MD diameters of the maxillary canines.

The MD diameter of the Palau population is larger than those of the modern human populations. Most of them are equal to the MD diameters of the modern human populations on the upper end of modern human variation. Tswana and Zulu population groups are very similar to each other, and are larger than the European and Khoisan population groups. The Khoisan are clustered on the lower end of the range of modern human variation. There is a noticeable difference between the males and females of the Tswana and Zulu population groups, as compared to those of the European and Khoisan. This indicates that sexual dimorphism is prominent in the

aforementioned population groups as compared to the latter. The difference between the Palauans and the Khoisan population groups is the greatest.

Table 33: BL diameters of the maxillary canines

Population groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.52	1.00	7.17-10.00	7
Khoisan males	5.97	0.45	5.55-6.59	4
Khoisan females	5.47	0.16	5.35-5.58	2
Tswana males	7.52	0.72	6.41-8.97	36
Tswana females	7.39	0.69	5.74-8.45	41
Zulu males	7.76	0.81	5.87-8.65	54
Zulu females	7.17	0.60	5.95-8.40	53
European males	6.33	0.59	5.38-7.57	37
European females	6.26	0.61	5.33-7.38	21

Seven Palauan maxillary canines were available for comparison with the modern human sample. The Khoisan were the least group represented group from the modern human sample. The mean of the BL diameters of the Palau population is greater than the means of all the modern human population groups measured. It is followed by the mean of Zulu males. European females have the lowest mean of all the populations measured. The BL diameters of the Tswana and Zulu population groups are larger than the European and Khoisan population groups, therefore making the difference between them and the Palauans smaller than the other two groups. The females of the modern human population groups have means that are smaller than the means of the males of their male counterparts.

Khoisan females have the lowest standard deviations of all the populations measured, but this might be a function of the low number of specimens available for this measurement. Palauans, Tswana and Zulu males have high standard deviations. This indicates the scattering of primary

data around the means of these groups. The Palau population ranges from 7.17-10.20 mm. Zulu males and Khoisan females range from 5.87-8.65 mm and 5.35-5.58 mm respectively. These ranges indicate that the BL diameter of the Palau population falls above the normal range of modern human variation.

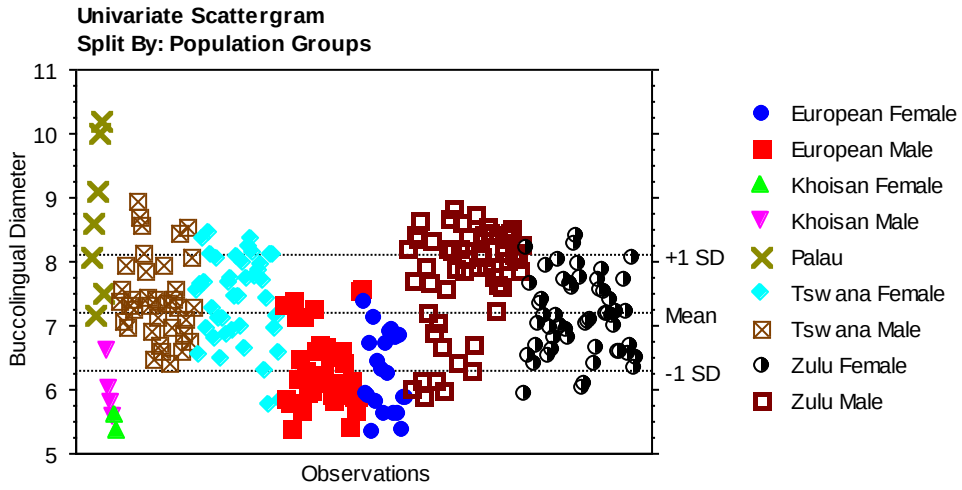

Figure 106: Univariate plot of the BL diameters of the maxillary canines.

The BL diameters of the Palau population are larger than most of the BL diameters of the modern human populations, but some equal them. The European population groups are smaller than most of the Tswana and the Zulu population groups, and are clustered on the lower end of the range of modern human variation. The BL diameters of the Tswana and the Zulu population groups are equal to each other, and to some of the Palau population. The Khoisan population groups are among the smallest of the modern humans measured.

Table 34: Crown height of the of the maxillary canines

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau	11.87	0.05	11.83-11.90	2
Khoisan males	7.99	0.57	7.53-8.82	4
Khoisan females	7.32	0.08	7.26-7.38	2
Tswana males	10.28	0.74	9.21-11.93	28
Tswana females	9.75	0.76	8.68-11.20	41
Zulu males	10.23	0.71	9.13-11.88	53
Zulu females	9.74	0.67	8.56-11.37	53
European males	9.71	0.68	8.50-10.96	33
European females	9.63	0.66	8.14-10.71	22

Two Palauan maxillary canines were available for comparison with the modern human sample. The Khoisan population was the least represented, with only six individuals. The mean of the crown height of the Palau population is greater than the means of the entire modern human sample. It is followed by the mean of the Tswana males. Khoisan females have the smallest mean of all the groups measured. The mean of the males of the modern human populations are larger than the females of their groups. Tswana and Zulu males are notably larger than the females of their groups, thus indicating the degree of sexual dimorphism observed in these groups. Tswana and Zulu females are slightly larger than European males.

The standard deviations of the Palau population and Khoisan females are the smallest compared to the rest of the groups measured, which might be influenced by the low number of specimens available for the two groups. The Palau population ranges from 11.83-11.90 mm. Tswana males and Khoisan females range from 9.21-11.93 mm and 7.26-7.38 mm respectively. These ranges indicate that the crown height of the Palau population falls within the normal range of modern human variation.

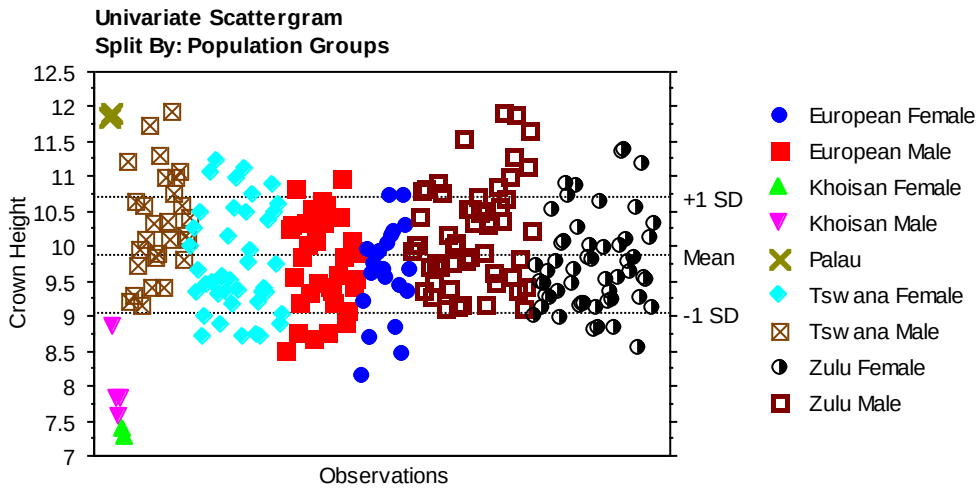

Figure 107: Univariate plot of the CH of the maxillary canines.

The crown height of the Palau population is equal to most of the crown heights of the modern humans on the uppermost end of the range of modern human variation, especially Tswana and Zulu males. Tswana and Zulu females are very similar to each other, and are comparable with European males. Khoisan population groups are among the smallest of the modern human populations measured, thus making the difference between them and the Palauans the greatest. Sexual dimorphism is quite evident in the Tswana and Zulu population groups, but very moderate on the European and Khoisan.

Table 35: MD (cej) diameters of the maxillary canines

Population groups	**MD (cej) diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.08	0.29	5.70-6.50	5
Khoisan males	5.13	0.57	4.29-5.56	4
Khoisan females	4.72	0.22	4.72-5.02	2
Tswana males	6.32	0.47	5.48-7.31	39
Tswana females	6.09	0.44	5.31-6.85	41
Zulu males	6.27	0.54	5.41-7.42	54
Zulu females	5.07	0.47	5.21-6.85	53
European males	5.99	0.44	5.03-6.68	37
European females	5.64	0.33	5.05-6.21	20

Five Palauan maxillary canines were available for comparison with the modern human populations. The mean of the MD (cej) diameter of the Palau population is smaller than the means of the Tswana population groups and Zulu males, but greater than those of the remaining modern human populations. It is 0.01 mm smaller than the Tswana females, and 0.01 mm larger than the Zulu females. Tswana males have the highest mean of all the populations measured, whereas Khoisan females have the smallest. The mean of the MD (cej) diameter of modern human males is greater than the mean of females. The difference is quite marked in Tswanas and Zulus.

Khoisan females have the lowest standard deviations of all the populations measured, which all have small standard deviations. This indicates that the primary data of the different groups are clustered around the means of the groups. The MD (cej) diameter of the Palauans ranges from 5.70-6.5 mm. Tswana males range from 5.48-7.31 mm, while Khoisan females range from 4.72-5.02 mm. These ranges indicate that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

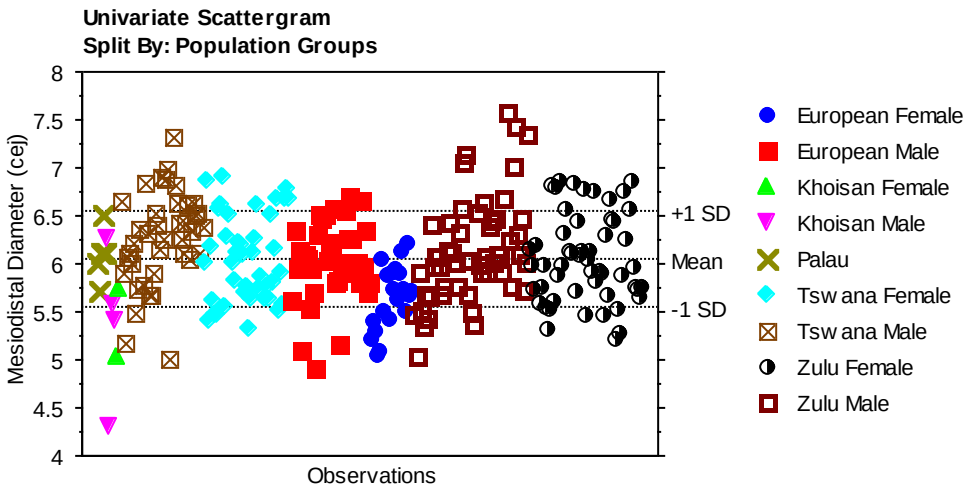

Figure 108: Univariate plot of the MD (cej) diameters of the maxillary canines.

The MD (cej) diameter of the Palau population is equal to most of the MD (cej) diameters of the modern human populations, being mostly equal to those plotted in the middle of the range. Tswana and Zulu males are similar to each other, and so are the females of these two groups. The MD (cej) diameter of the Europeans is smaller than those of the Tswana and Zulu population groups, but larger than the Khoisan. Most of the Khoisan are among the smallest of the modern human populations measured. The females of the modern human population groups are smaller than the males of their groups, accounting for the degree of sexual dimorphism observed in this measurement.

Table 36: BL (cej) diameters of the maxillary canines

Population Groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.15	0.58	7.30-8.80	6
Khoisan males	7.68	0.29	7.49-8.10	4
Khoisan females	7.56	0.06	7.51-7.60	2
Tswana males	8.57	0.47	7.33-9.41	39
Tswana females	8.18	0.53	7.20-9.08	41
Zulu males	8.54	0.63	7.43-9.65	56
Zulu females	8.17	0.46	7.26-9.04	53
European males	8.16	0.38	7.25-8.83	35
European females	7.86	0.33	7.34-8.55	21

Six Palauan maxillary canines were available for comparison with the modern humans. The Khoisan are the least represented, with only six individuals. The mean of the BL (cej) diameter of the Palau population is smaller than the means of the Tswana and Zulu population groups, as well as European males. Tswana males have the highest mean of all the populations measured, whereas Khoisan females have the smallest. The males of the Modern human males have higher means than their female counterparts. The difference between the sexes of the same group is quite evident amongst the Tswana and Zulus. All the groups have small standard deviations, indicating that the primary data are clustered around the means, with Khoisan females having the smallest.

The range of the BL (cej) diameters of the Palau population is 7.30-8.80 mm. The Tswana males range from 7.33-9.41 mm, while Khoisan females range from 7.51-7.60 mm. These ranges indicate that the Palauans have normal BL (cej) diameters compared to the modern human populations.

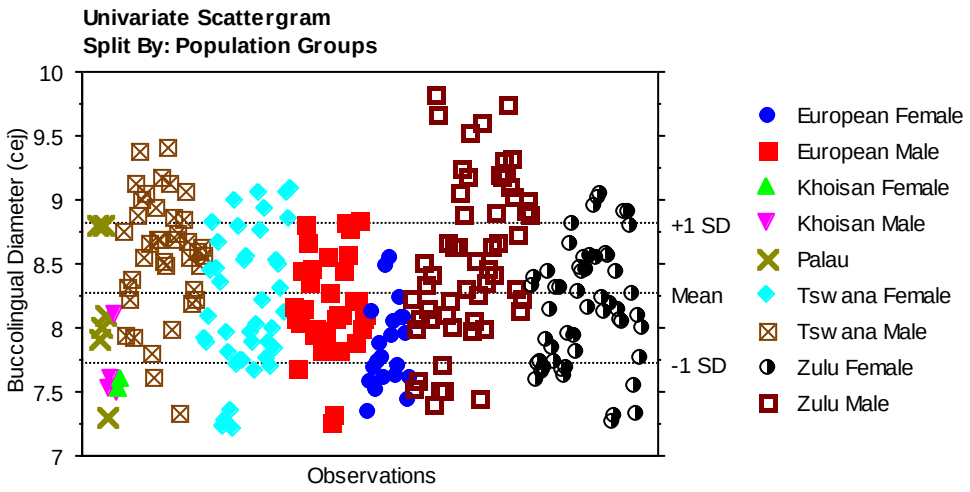

Figure 109: Univariate plot of the BL (cej) diameters of the maxillary canines.

The BL (cej) diameter of the Palau population is equal to most of the BL (cej) diameters of the modern human population groups. Tswana and Zulu population groups have BL (cej) diameters that are larger than those of the Palauans. The females of different groups are smaller than the males of their similar groups. The Khoisan population groups are clustered on the lower end of modern human variation.

Table 37: Total root length of the maxillary canines

Population groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	16.17	1.1	14.50-17.43	5
Khoisan males	15.16	0.81	14.23-15.64	3
Tswana males	17.34	0.47	13.58-21.68	10
Tswana females	15.89	1.67	12.44-18.12	17
Zulu males	16.54	2.38	12.12-20.58	40
Zulu females	15.92	1.69	13.18-17.89	9
European females	15.63	2.82	13.62-17.64	2

Five maxillary canines were available for comparison with the modern human sample. Khoisan females and European males were not available for this comparison. European females and

Khoisan males were the least represented, with only two and three individuals present from each group. The mean of the total root length of the Palau population is smaller than the means of the Tswana and Zulu males, but greater than the ones of the remaining groups. Tswana males have the highest mean of all the populations measured, whereas Khoisan males have the lowest. Females of different groups have means that are smaller than the means of their male counterparts.

Tswana males have the smaller standard deviation of all the populations measured. The remaining groups have very large standard deviations, indicating that the primary data are scattered from the means of the different groups. The Palau population ranges from 14.50-17.43 mm. Khoisan males range from 14.23-15.64 mm, whereas Tswana males range from 12.44-18.12 mm. These ranges indicate that the Palau population has a total root length that falls within the normal range of modern human variation.

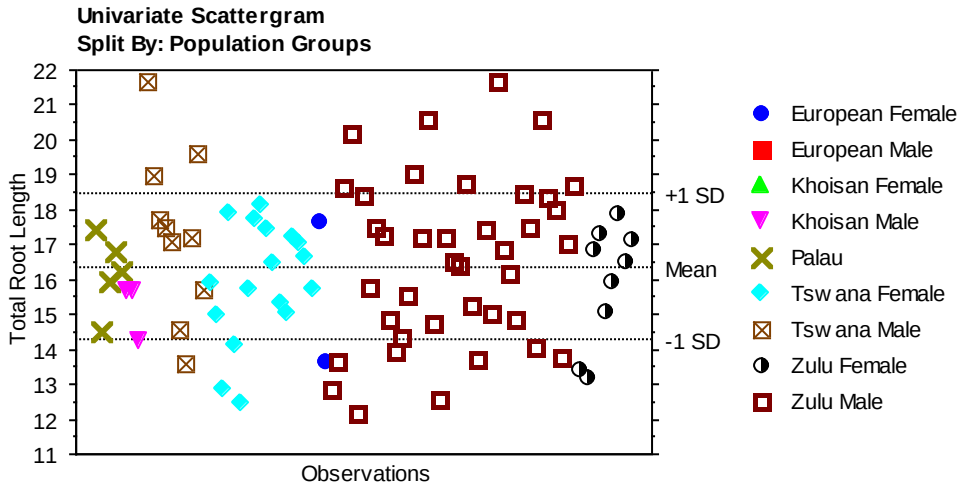

Figure 110: Univariate plot of the total root length of the maxillary canines.

The total root lengths of the Palau population are equal to most of the total root lengths of the human population groups. They are mostly equal to those in the middle of the range of modern human variation. There is little difference between the total root lengths of the modern human population groups. The total root length of the modern human population groups cover a very wide range and some groups such as the Zulu males are represented evenly along the range.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL diameters of the maxillary canines.

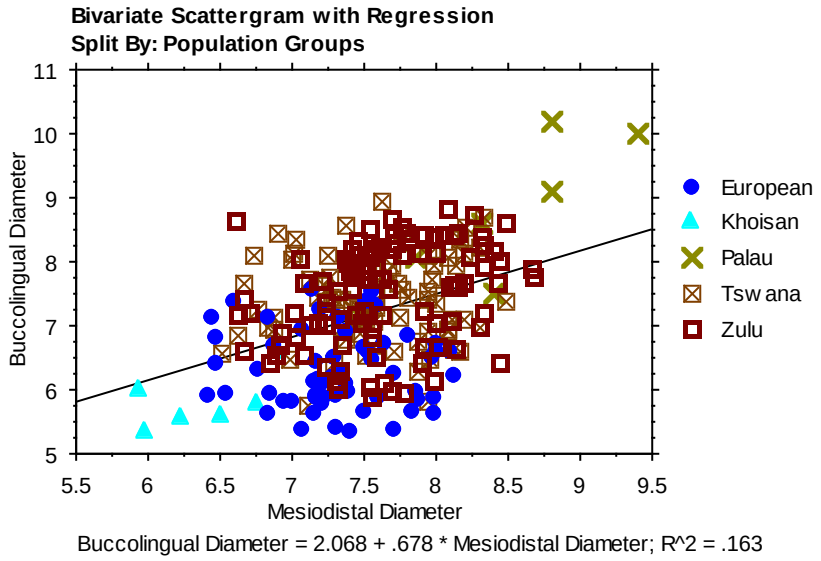

Figure 111: Bivariate plot of the MD and BL diameters of the maxillary canines.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation, and some are notably larger than those of modern humans. Tswana and Zulu populations are equal to each other, and are greater than the European and Khoisan. Khoisan are clustered on the lower end of the range of modern human variation, and are equal to the smallest

of the modern humans recorded. The difference between the Palau population and modern humans is the greatest between the Palauans and the Khoisan.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation, and some are markedly larger compared to those of modern humans. Tswana and Zulu populations are similar to each other and are larger than the European and Khoisan. Europeans are clustered in the middle of the range of modern humans, with most of the Tswana and Zulus. Khoisan are clustered on the lower end of the range, making the difference between them and the Palauans the greatest. There is a low positive correlation between the MD and BL diameter of the humans measured, (r= 0.40, n= 252, p< 0.0001, 95% CI 0.294-0.502). The correlation between these two variables is statistically significant.

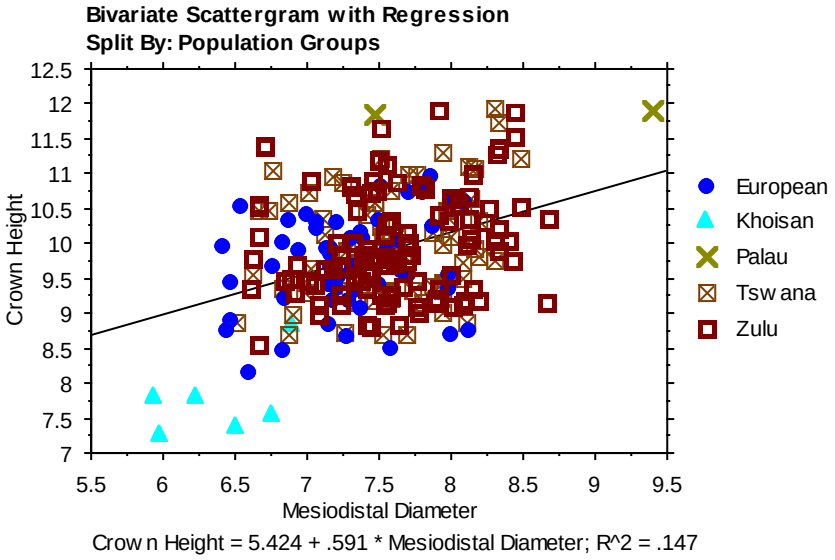

Figure 112: Bivariate plot of the MD diameters and CH of the maxillary canines.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. One is 1 mm larger than the entire modern human sample. Tswana and Zulu

populations are similar to each other, and are larger than the Europeans and Khoisan. The Khoisan are among the smallest of the modern humans measured, and this makes the difference between them and the Palauans the greatest.

The CH of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. Tswana and Zulu populations are equal to each other, and are evenly distributed along the regression line of the range of modern human variation. The Khoisan population has the lowest measurements obtained for this variable. There is a low positive correlation between the MD diameter and the CH of the humans studied (r= 0.38, n= 235, p<0.0001, 95% CI 0.269-0.488). The correlation between these variables is statistically significant.

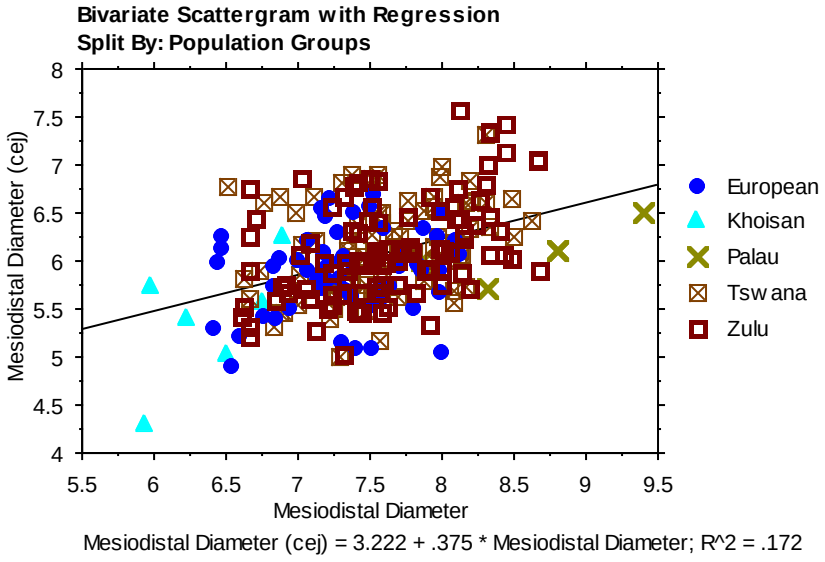

Figure 113: Bivariate plot of the MD and MD (cej) diameters of the maxillary canines.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation, and one is markedly larger than the entire modern human sample. Tswana and Zulu

populations are equal to each other, and are larger than the Europeans and Khoisan. The Tswana, Zulu and Europeans groups are clustered in the middle of the range, while the Khoisan are on the lower end of the range of modern human variation.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are equal to each other, and are greater than the Palauan, and most Europeans. The Khoisan has the smallest measurements recorded for this variable. There is a low positive correlation between the MD and MD (cej) diameter of the humans measured (r= 0.41, n= 251, p< 0.0001, 95% CI 0.306-0.512). The correlation between these two variables is statistically significant.

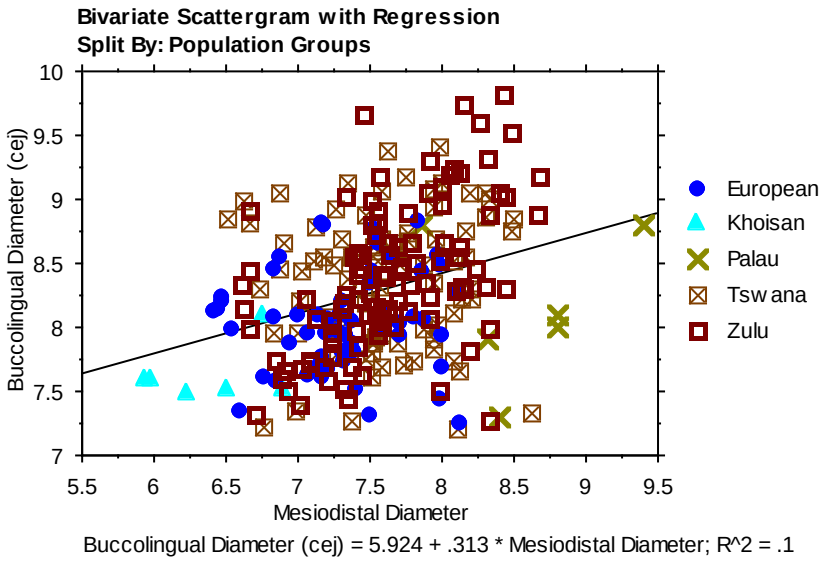

Figure 114: Bivariate plot of the MD and BL (cej) diameters of the maxillary canines.

The MD diameter of the Palau population falls at the upper end of modern human variation. Tswana and Zulu populations are similar to each other, and are greater than the European and Khoisan. A few of the Tswana and Zulus are equal to the MD diameters of the Palauans.

Europeans are clustered in the middle of the range of modern human variation, while the Khoisan are at the lower end. This makes the difference between the Palau population and the Khoisan the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. The majority are plotted below the regression line of the range of variation of modern humans. The BL (cej) diameter of the human sample is very diverse, ranging from 6.50-9.50 mm. Tswana and Zulu populations are evenly distributed along the range of variation. Europeans are clustered in the middle, while the Khoisan are clustered below. There is a low positive correlation between the MD and BL (cej) diameter of the humans measured (r= 0.32, n= 253, p< 0.0001, 95% CI 0.201-0.424). The correlation between these variables is statistically significant.

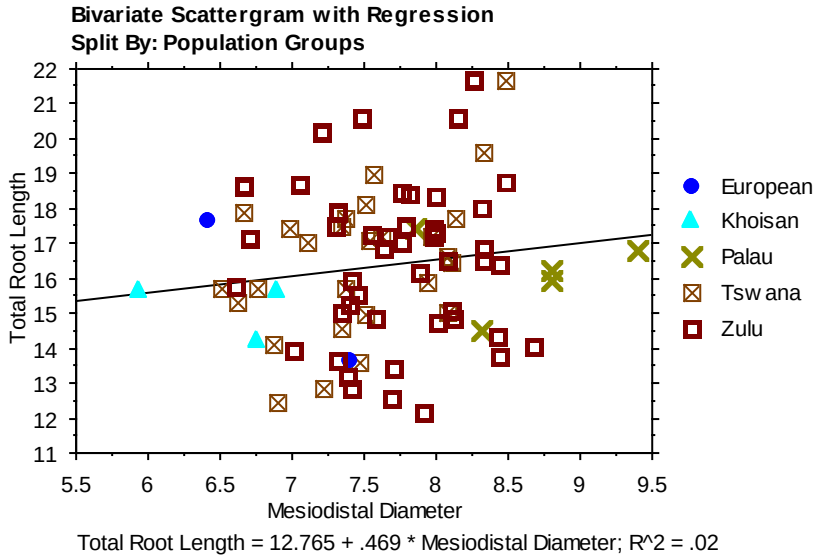

Figure 115: Bivariate plot of the MD diameters and the TRL of the maxillary canines.

The MD diameter of the Palau population falls above the range of modern human variation. A few are equal to the Tswanas and Zulus on the upper end of the range of modern human

variation. Tswana and Zulu populations are similar to each other, and are larger than the European and Khoisan. The Europeans and Khoisan available are on the lower end of the range of modern human variation, and this makes the difference between them and the Palauans the greatest.

The total root length of the Palau population falls within the range of modern human variation. The majority are plotted below the regression line of the range of modern human variation. The Tswana and Zulu populations are distributed evenly along the regression line, while the Khoisan are mainly below. There is a low positive correlation between the MD diameter and the TRL of the humans measured (r= 0.14, n= 83, p= 0.2025, 95% CI -0.077-0.342). The correlation between these two variables is not statistically significant.

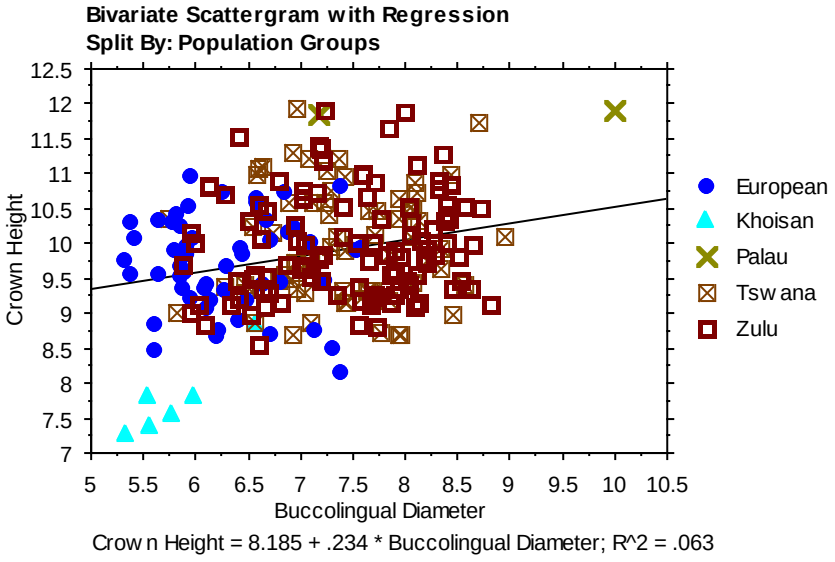

Figure 116: Bivariate plot of the BL diameters and the CH of the maxillary canines.

The BL diameter of the Palau population falls within and above the range of modern human variation. Of the two measurements available, one is notably larger while one is equal to those of

modern humans. The majority of the European populations are smaller than the Tswana and Zulus, and few are equal to the Khoisan. The difference between the Palau population and the modern human populations increases from the Tswana and Zulu, to European and Khoisan population.

The CH of the Palau population falls at the upper end of the range of modern human variation. The Khoisan population is very small compared to the majority of the modern humans sampled. Tswana and Zulu populations are equal to each other, and are larger than the European and Khoisan; and are evenly distributed along the regression line, with equal quantities on either side. There is a low positive correlation between the BL diameter and CH of the humans studied (r= 0.25, n= 237, p< 0.0001, 95% CI 0.128-0.367). The correlation between these two variables is statistically significant.

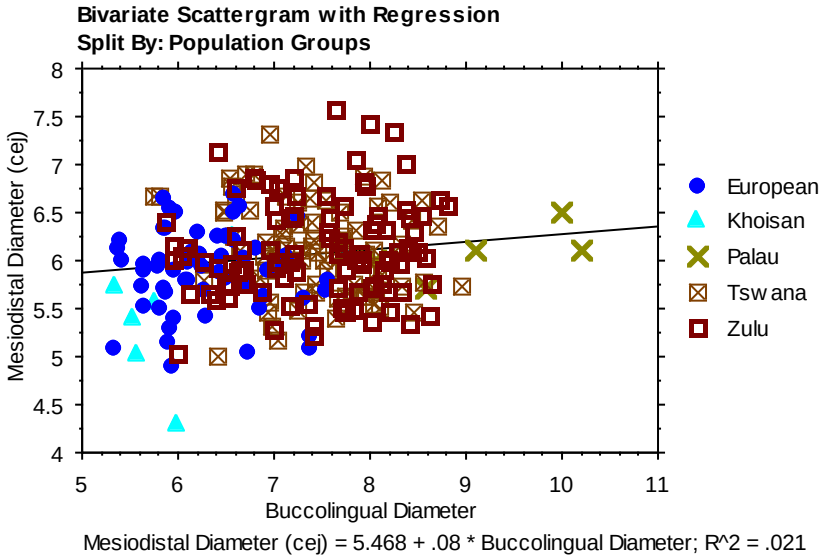

Figure 117: Bivariate plot of the BL and MD (cej) diameters of the maxillary canines.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the European and Khoisan. The European and Khoisan population are clustered on the lower end of the range of modern humans. The difference between the Palau population and the modern humans is the greatest when the comparison is made between the Palauans and the European and Khoisan populations.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those of modern humans that are in the middle of the range of modern human variation. Tswana and Zulu populations are evenly distributed along the regression line, and a few are larger than the Palau population. Europeans are clustered in the middle of the range of modern human variation. The Khoisan are among the smallest of the modern humans measured, therefore making the difference between them and the Palauans the greatest. There is a low positive correlation between the BL and MD (cej) diameter of the humans measured ($r= 0.15$, $n= 250$, $p=0.0214$, 95% CI 0.022-0.265). The correlation between these two variables is statistically significant.

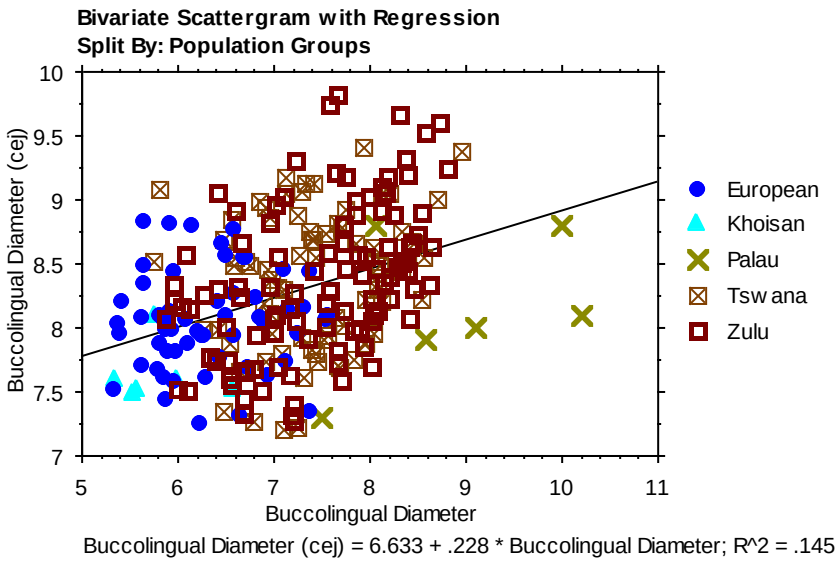

Figure 118: Bivariate plot of the BL and BL (cej) diameters of the maxillary canines.

The BL diameter falls at the upper end of the range of modern human variation. Two are noticeably greater than the entire modern human sample. The Tswana and Zulu populations are at the upper end of the range of modern human variation, while the European and Khoisan are at the lower end. This makes the difference between the Palau population and modern humans the greatest when comparing them to the European and Khoisan.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. Only one is above the regression line of the range of variation, while the majority is below the line. Tswana and Zulu populations are similar to each other, and are evenly distributed along the regression line. Europeans are clustered on the lower end of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured, therefore making the difference between them and the Palau population the greatest. There is a low positive correlation between the BL and BL (cej) diameter of the humans measured (r= 0.38,

n= 252, p< 0.0001, 95% CI 0.270-0.482). The correlation between these two variables is statistically significant.

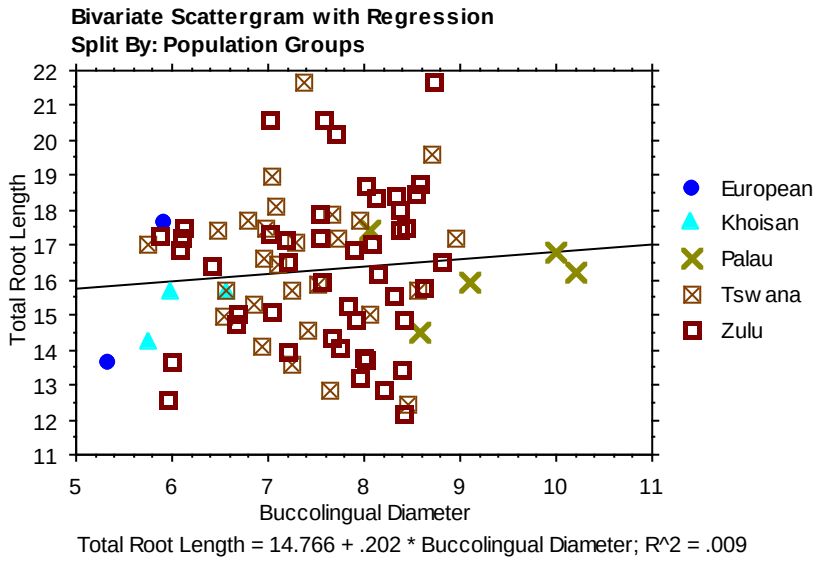

Figure 119: Bivariate plot of the BL diameters and the TRL of the maxillary canines.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation, while two are markedly greater than the rest of the modern humans. The Tswana and the Zulu populations are very similar to each other, and are clustered on the upper end of the range of modern human variation. The European and Khoisan are clustered on the lower end of the range, making the difference between them and the Palauans greater than the other two modern human populations.

The TRL of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are distributed evenly along the range of modern human variation. The Europeans and Khoisan are in the middle of the range, and are equal to the Palau population. There is a low positive correlation between the BL diameter and TRL of the humans studied (r=

0.094, n= 83, p= 0.3969, 95% CI -0.124-0.304). The correlation between these two variables is not statistically significant.

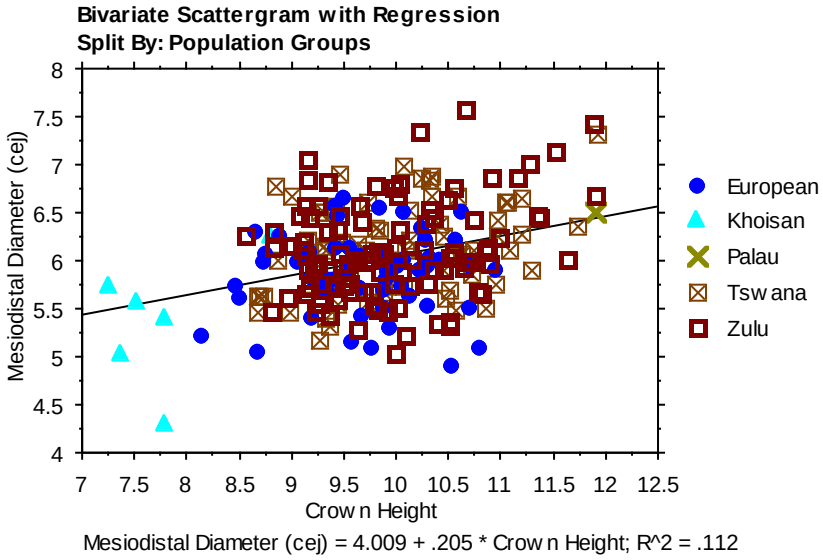

Figure 120: Bivariate plot of the CH and the MD (cej) diameters of the maxillary canines.

Only one measurement from the Palau population was available for this variable. The CH of the Palau population falls at the upper end of the range of modern human variation. Tswana and Zulu populations are equal to each other, and they cover a wide range of modern human variation. Europeans are clustered in the middle of the range. The Khoisan population is the smallest of the modern human populations measured.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are greater than the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation. The Khoisan are among the smallest of the modern humans populations measured. There is a low positive correlation

between the CH and the MD (cej) diameter of the humans measured (r= 0.34, n= 233, p< 0.0001, 95% CI 0.215-0.444). The correlation between these two variables is statistically significant.

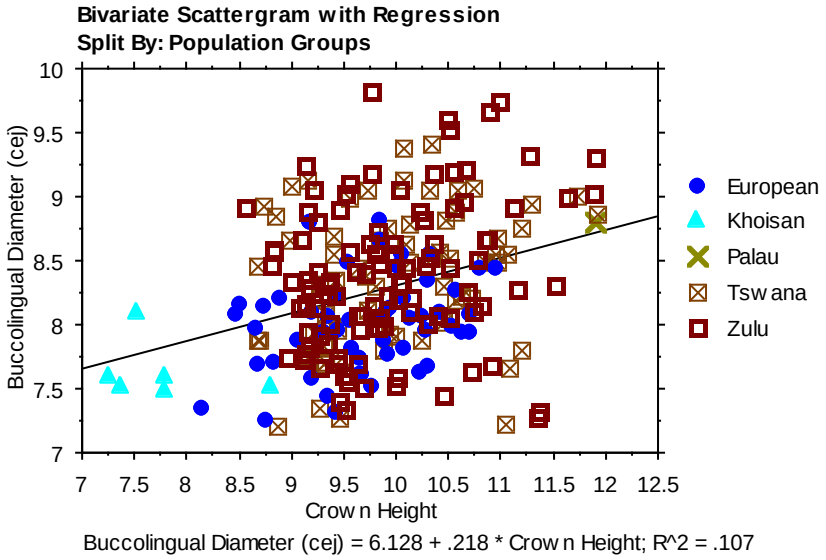

Figure 121: Bivariate plot of the CH and the BL (cej) diameters of the maxillary canines.

The CH of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are similar to each other, and are larger than the European and Khoisan. The Khoisan population is among the smallest of the modern humans measured. The difference between the Palau and the modern human populations increases from the Tswana and Zulu, to European, followed by the Khoisan.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are equal to each other, and are larger than the European and Khoisan. The majority of the Europeans are clustered below the regression line of the range of modern human variation. The Khoisan are the smallest of all the modern humans measured. There is a low positive correlation between the CH and BL (cej) diameter of the humans

measured (r= 0.33, n= 234, p< 0.0001, 95% CI 0.201-0.437). The correlation between these two variables is statistically significant.

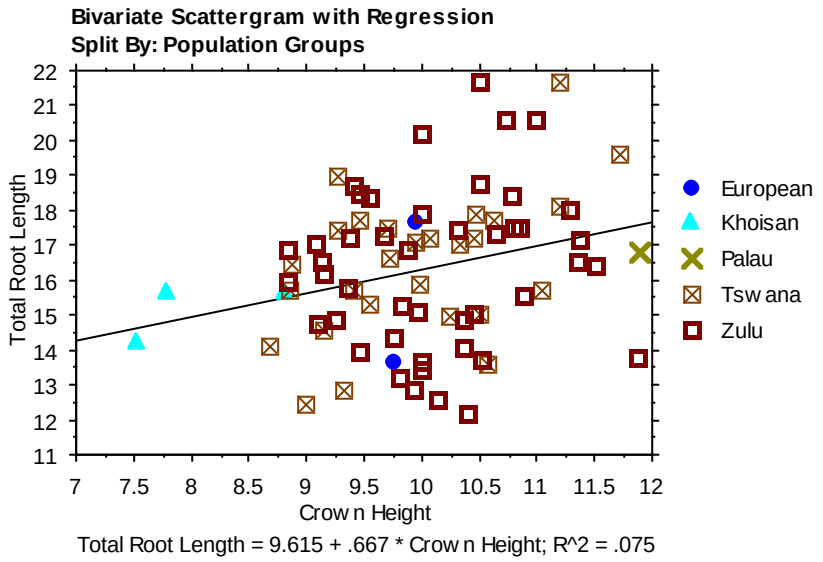

Figure 122: Bivariate plot of the CH and the TRL of the maxillary canines.

The CH of the Palau population falls at the upper end of the range of modern human variation, and is equal to a few of the Tswana and Zulus. Tswana and Zulu populations are equal to each other, and are greater than the Europeans plotted in the middle of the range of the modern human variation. The Khoisan population is the smallest of all the human populations measured.

The TRL of the Palau population falls within the range of modern human variation. The TRL of the Tswana and Zulu populations are equal to each other, and they cover a wide range of modern human variation. European and Khoisan populations are at the middle of the range. There is a low positive correlation between the CH and TRL of the humans measured (r= 0.27, n= 78, p= 0.0152, 95% CI 0.054-0.467). The correlation between these two variables is statistically significant.

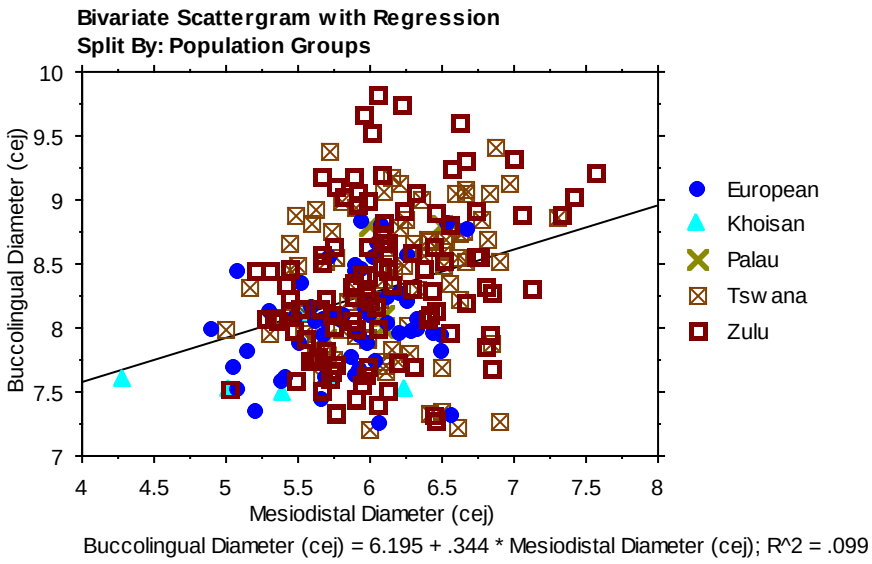

Figure 123: Bivariate plot of the MD (cej) and the BL (cej) diameters of the maxillary canines.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and plots in the middle of the range. Tswana and Zulu populations are equal to each other, and are slightly larger than the Europeans. Europeans are clustered in the middle of the range of modern human variation. The Khoisan are among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau populations falls within the range of modern human variation. The Tswana and Zulu populations are similar to each other. They are distributed equally along the regression line of the range of modern human variation, with equal quantities on both sides. Europeans are clustered below the regression line. The Khoisan are among the smallest of the modern humans measured. There is a low positive correlation between the MD (cej) and BL (cej) diameter of the humans measured ($r= 0.32$, $n= 253$, $p< 0.0001$, 95% CI 0.199-0.422). The correlation between these two variables is statistically significant.

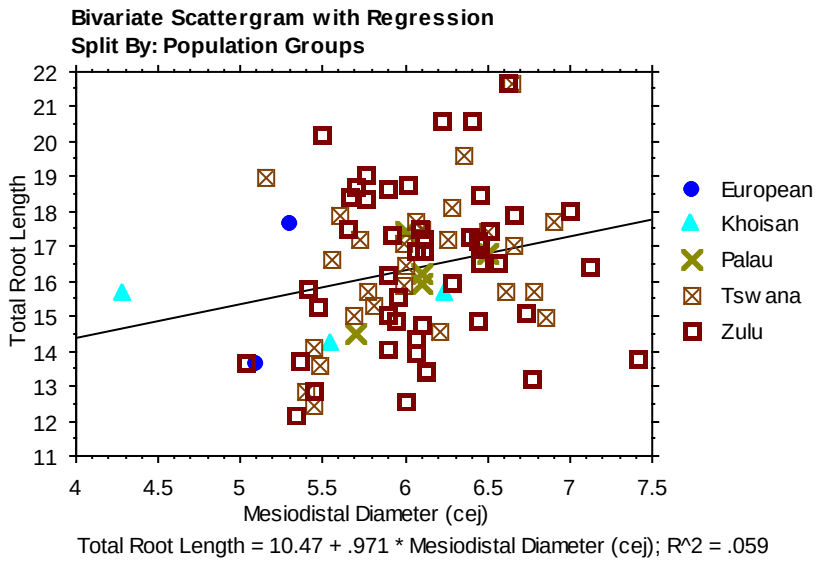

Figure 124: Bivariate plot of the MD (cej) diameter and the TRL of the maxillary canines.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and Zulu populations are similar to each other, and most are greater than the Palauans. European and Khoisan are smaller than the Tswana and Zulu recorded, and are clustered on the lower end of the range of modern human variation.

The TRL of the Palau population falls within the range of modern human variation. The TRL of the Tswana and Zulu populations are similar to each other, and cover a wide range of modern human variation. Only two Europeans are available for this comparison, and one is plotted below the regression line of the range of modern human variation, while the other is above the line. The Khoisan are among the smallest of the modern humans measured. There is a low positive correlation between the MD (cej) diameter and TRL of the humans measured (r= 0.24, n= 84, p= 0.0259, 95% CI 0.030-0.434). The correlation between these two variables is statistically significant.

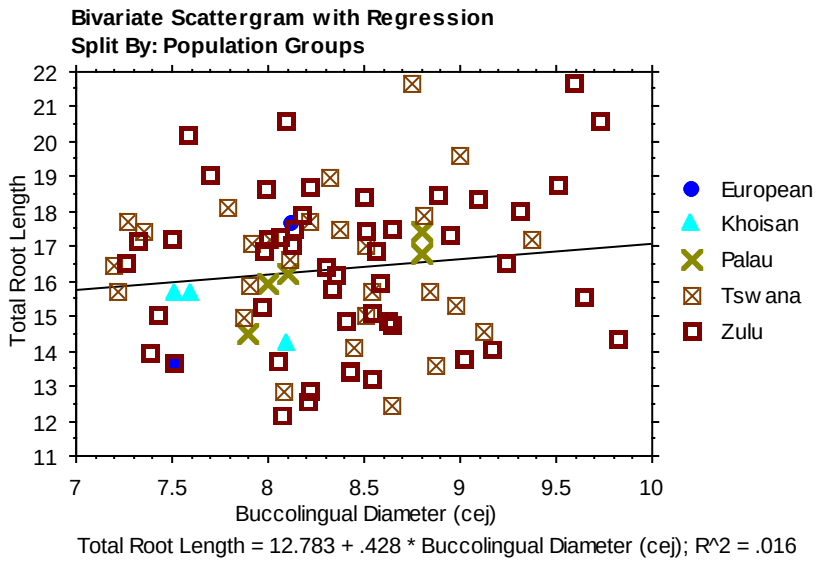

Figure 125: Bivariate plot of the BL (cej) diameters and the TRL of the maxillary canines.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are similar to each other and are distributed along the regression line of the range of modern human variation, and they also have the smallest sample minimum obtained for this variable. The European and Khoisan populations are equal to some of the Tswana and the Zulus.

The TRL of the Palau population falls within the range of modern human variation. The total root lengths of the Tswana and Zulu populations are similar to each other, and they cover a wide range of variation. The Khoisan are at the lower end of the range of the modern human variation, whereas the Europeans are in the middle. There is a low positive correlation between the BL (cej) diameter and TRL of the humans measured (r= 0.13, n= 85, p=0.2458, 95% CI -0.088-0.332). The correlation between these two variables is statistically significant.

Mandibular 3rd Premolars

The size of mandibular 3rd premolars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of mandibular 3rd premolars. In addition the univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 38: MD diameters of the mandibular 3rd premolars

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.65	0.48	7.10-8.30	11
Khoisan males	6.59	0.07	6.54-6.64	2
Khoisan females	6.58	0.21	6.39-6.80	3
Tswana males	7.25	0.52	6.34-8.67	60
Tswana females	7.17	0.46	6.42-8.05	38
Zulu males	7.26	0.54	6.20-8.66	64
Zulu females	7.16	0.39	6.34-8.08	58
European males	6.85	0.40	5.99-7.85	63
European females	6.72	0.48	5.84-7.68	36

Eleven Palauan mandibular 3rd premolars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented, with only five individuals. The mean of the MD diameters of the Palau population is greater than the mean of all the modern human population groups. It is followed by those of the Zulu and Tswana males respectively. Khoisan females have the lowest mean of all the populations measured. The females of modern humans have means that are smaller than the means of the males of their similar groups.

All the groups measured have very low standard deviations, indicating clustering of the primary data around the means of the different groups. The MD diameter of the Palau population ranges from 7.10-8.30 mm. Zulu males, have the greatest mean of all the modern humans studied, ranging from 6.20-8.66 mm, whereas the Khoisan females range from 6.39-6.80 mm. These ranges indicate that the MD diameter of the mandibular 3rd premolar of the Palau population falls within the normal range of modern human variation.

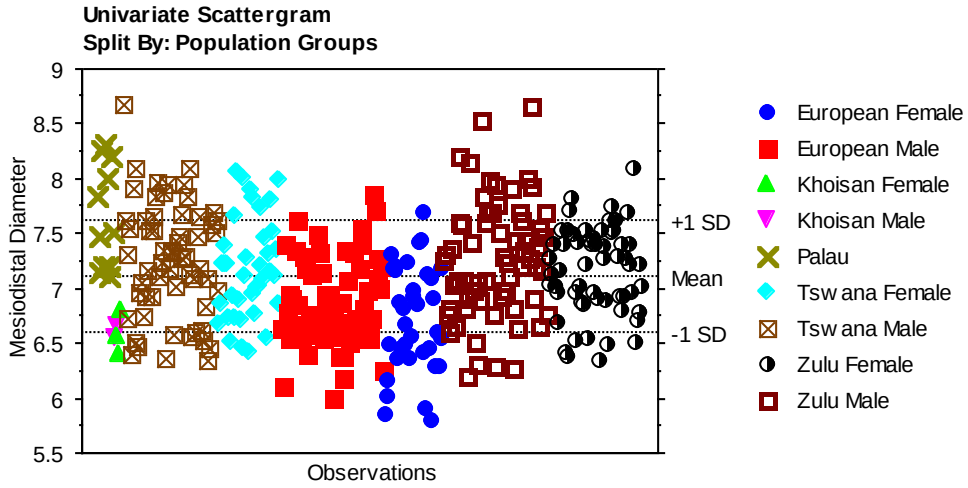

Figure 126: Univariate plot of the MD diameters of the mandibular 3rd premolars.

The MD diameters of the Palau population are equal to the MD diameters of the modern human population groups, plotting on the upper range of modern human variation. Zulu and Tswana males are similar to each other, and are larger than Khoisan and European males. The same trend is followed by the females of the entire modern human sample. Khoisan population groups are among the smallest of the modern human populations measured. They are clustered on the lower end of modern human variation. Sexual dimorphism is moderate in all the groups measured. This is evidenced by the ranges of the different population groups, e.g. Zulu males and females range

from 6.20-8.66 mm and 6.34-8.08 mm respectively, while the European males and females range from 5.99-7.85 mm and 5.84-7.68 mm respectively.

Table 39: BL diameters of the mandibular 3rd premolars

Population groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.52	0.54	7.70-9.70	11
Khoisan males	6.84	0.09	6.77-6.90	2
Khoisan females	6.81	0.22	6.68-7.06	3
Tswana males	8.05	0.63	6.88-9.32	61
Tswana females	7.71	0.34	6.89-8.41	40
Zulu males	8.05	0.49	6.89-9.32	65
Zulu females	7.81	0.47	6.60-8.67	59
European males	7.45	0.46	6.33-8.63	62
European females	7.42	0.53	6.24-8.34	37

Eleven Palauan mandibular 3rd premolars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only five individuals. The mean of the BL diameters of the Palau population is greater than the means of the entire modern human sample. It is followed by those of the Tswana and Zulu males. Khoisan females have the lowest mean of all the populations measured. Europeans are smaller than the Palauans, Tswanas and Zulus, but larger than the Khoisan. The males of the modern human sample have means that are larger than the means of the females of their similar groups.

All of the groups measured have smaller standard deviations, indicating the clustering of primary data around the means of the different groups. The BL diameter of the Palauans ranges from 7.70-9.70 mm. Khoisan females have the smallest mean and they range from 6.68-7.06 mm, whereas Tswana and Zulu males, having the highest means of all the modern humans, range from 6.88-9.32 mm and 6.89-9.32 mm respectively. These ranges show that the BL diameter of the Palau population falls within and above the normal range of modern human variation.

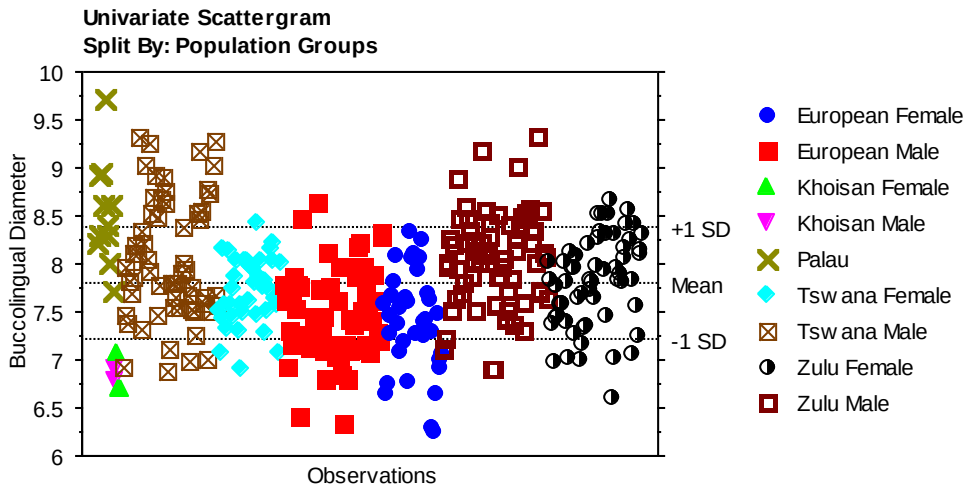

Figure 127: Univariate plot of the BL diameters of the mandibular 3rd premolars.

The BL diameters of the Palau population are similar to the BL diameters of the modern human populations. One of the Palauans is larger than the entire modern human sample. Zulu and Tswana males are similar to each other, but are very different from European and the Khoisan males. Tswana and European males range from 6.88-9.32 mm and 6.33-8.63 mm respectively. The same applies to the females of these groups. Tswana and Zulu females are larger than European and Khoisan females. Tswana and Khoisan females range from 6.89-8.41mm and 6.68-7.06 mm respectively. Sexual dimorphism is moderate in the Tswana and Zulu populations, while very low in the Khoisan and the European populations. Tswana males and females range from 6.88-9.32 mm and 6.89-8.41 mm, whereas the European males and females range from 6.33-8.63 mm and 6.24-8.34 mm respectively.

Table 40: CH of the mandibular 3rd premolars

Population groups	Crown Height			
	Mean	***Std dev***	***Range***	***N***
Palau	9.29	1.58	8.17-10.4	2
Khoisan males	7.06	0.11	6.98-7.13	2
Khoisan females	6.67	0.49	6.27-7.22	3
Tswana males	8.46	0.69	7.33-9.86	54
Tswana females	8.30	0.62	7.25-9.25	40
Zulu males	8.42	0.60	7.40-9.93	65
Zulu females	8.28	0.62	7.22-9.35	59
European males	8.26	0.49	7.00-8.97	58
European females	7.79	0.62	6.56-8.74	37

Two Palauan mandibular 3rd premolars were available for comparison with the modern human sample. Khoisan population groups are the least represented, with only five individuals. The mean of the crown height of the Palau population is greater than those of the entire modern human sample. It is followed by one of the Tswana males. Khoisan females have the lowest mean of all the populations measured. The means of the crown height of the females of the modern humans are smaller than means of the males of their similar groups. Tswana and Zulu population groups are equal to each other, and are larger than the Khoisan and Europeans.

The standard deviation of the Palau population is the highest compared to those of the modern human populations. The rest of the modern humans have very small standard deviations, indicating the clustering of the primary data around the means of the different groups.

The crown height of the Palau population ranges from 8.17-10.40 mm. Khoisan females have the lowest mean and they range from 6.27-7.22 mm, whereas Tswana males range from 7.33-9.86 mm. These ranges indicate that the crown height of the Palau population falls within and above the normal range of modern human variation.

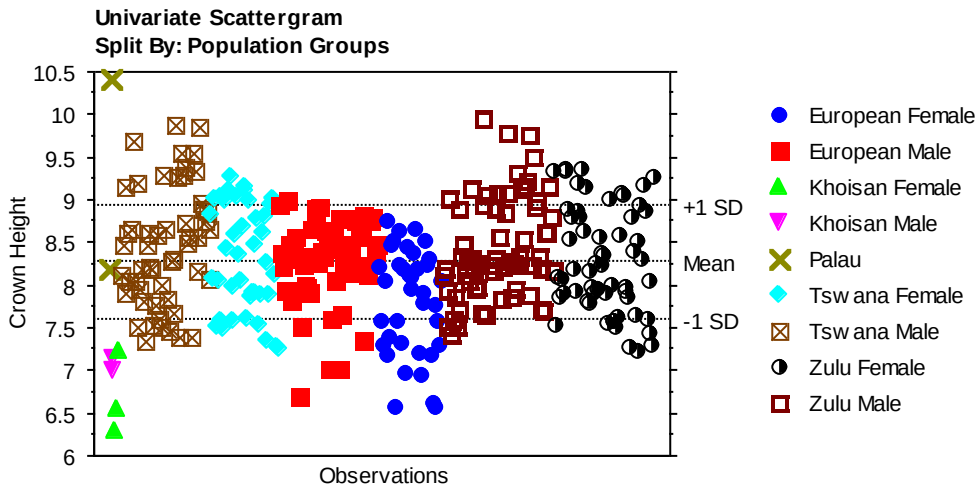

Figure 128: Univariate plot of the crown height of the mandibular 3rd premolars.

The crown height of the Palau population is equal to that of modern human populations, but one is larger than the entire modern human sample. Tswana and Zulu males are similar to each other, and the same applies to the females of these two groups. Khoisan population groups are clustered on the lower end of modern human variation. Sexual dimorphism is extensive on the Tswanas and the Zulus, as opposed to the Europeans and the Khoisan. This is evidenced by the following ranges: Tswana males and females range from 7.33-9.86 mm and 7.25-9.25 mm respectively, while European males and females from 7-8.97 mm and 6.56-8.74 mm respectively.

Table 41: MD (cej) diameters of the mandibular 3rd premolars

Population groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	5.19	0.26	4.60-5.40	10
Khoisan males	5.41	0.05	5.37-5.44	2
Khoisan females	5.08	0.33	4.81-5.45	3
Tswana males	5.74	0.53	4.67-7.24	60
Tswana females	5.70	0.41	4.83-6.68	39
Zulu males	5.72	0.56	4.58-6.90	64
Zulu females	5.69	0.57	4.79-6.56	57
European males	5.48	0.33	4.91-6.43	60
European females	5.46	0.37	4.54-6.00	35

Ten Palauan mandibular 3rd premolars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented, with only five individuals. The mean of the MD (cej) diameters of the Palau population is greater than the mean of the Khoisan females, but smaller than that of the remaining modern humans. Tswana males have the highest mean of all the populations measured, while Khoisan females have the lowest of all the modern humans measured. The females of the modern humans have means that are smaller than their male counterparts.

Standard deviations of all the groups studied are small, indicating the clustering of primary data around the means of the different groups. The MD (cej) diameter of the Palau population ranges from 4.60-5.40 mm. Tswana males; having the largest mean of all the human populations measured, range from 4.67-7.24 mm. Khoisan females range from 4.81-5.45 mm. These ranges indicate that the MD (cej) diameter of the Palau population falls below and within the normal range of modern human variation.

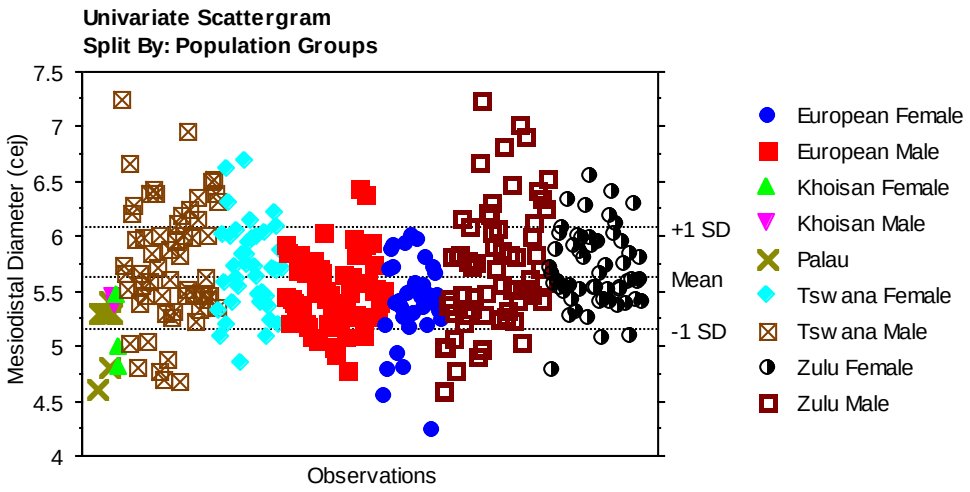

Figure 129: Univariate plot of the MD (cej) diameters of the mandibular 3rd premolars.

The MD (cej) diameter of the Palau population is equal to most of the modern human population groups, especially those on the lower end of modern human variation. Most of the modern human males are larger than the MD (cej) diameters of the Palau population. Tswana and Zulu males are comparable with each other, as are the females of these two groups. Tswana and Zulu females are similar to European males. Khoisan population groups are clustered on the lower end of modern human variation. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in the Europeans and Khoisan. This is evidenced by the ranges listed in the table above, especially the sample maximum of the Tswanas and Zulus; while the sample minimum and maximum of the Europeans and Khoisan support the moderate sexual dimorphism observed on these two groups.

Table 42: BL (cej) diameters of the mandibular 3rd premolars

Population groups	BL (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	7.38	0.47	6.60-8.10	10
Khoisan males	6.19	0.16	6.11-6.27	2
Khoisan females	5.93	0.52	5.59-6.53	3
Tswana males	8.03	0.57	6.72-9.21	60
Tswana females	7.80	0.40	6.87-8.79	40
Zulu males	8.08	0.58	6.64-9.22	65
Zulu females	7.89	0.44	6.77-8.65	58
European males	7.59	0.41	6.56-8.28	62
European females	7.38	0.46	6.30-8.13	37

Ten Palauan mandibular 3rd premolars were available for comparison with the modern human sample. The Khoisan population was the least represented from the modern human sample, with only five individuals. The mean of the BL (cej) diameters of the Palau population is greater than the means of the Khoisan population groups, but smaller than the means of the remaining modern human groups. Zulu males have the greatest mean of all the populations studied, whereas Khoisan females have the smallest. The females of the modern human sample have means that are smaller than those of the males of their similar groups.

Standard deviations of all the groups measured are low, indicating the clustering of the primary data around the means of the different groups. The BL (cej) diameters of the Palauans range from 6.60-8.10 mm. Zulu males range from 6.64-9.22 mm, whereas Khoisan females range from 5.59-6.53 mm. These ranges indicate that the BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

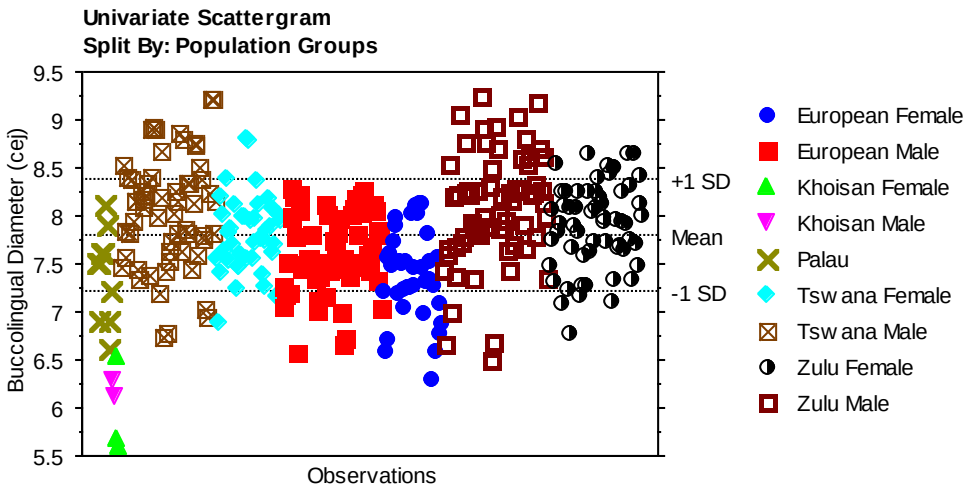

Figure 130: Univariate plot of the BL (cej) diameters of the mandibular 3rd premolars.

The BL (cej) diameters of the Palau population are equal to most of the BL (cej) diameters of the modern human populations. They are mostly equal to the females of the modern human sample, and modern human males plotted in the middle of the graph. Most of the males of the Tswana and Zulu population groups are greater than the MD (cej) diameters of the Palau population. The MD (cej) diameters of the modern human populations cover a very wide range, e.g. Tswana and Zulu males range from 6.72-9.21 mm and mm 6.64-9.22 mm respectively. The Khoisan population groups are among the smallest of the human populations measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate on the Europeans and Khoisan. This is evidenced by the ranges of the modern human populations listed above.

Table 43: Total root length of the mandibular 3rd premolars

Population groups	Total Root Length			
	Mean	***Std dev***	***Range***	***N***
Palau	14.22	1.05	12.40-15.56	8
Tswana males	14.05	1.91	11.13-16.83	8
Tswana females	12.67	1.00	11.54-13.79	6
Zulu males	12.80	1.42	10.67-16.64	26
European females	12.39	1.54	10.78-13.84	3

Eight Palauan mandibular 3rd premolars were available for comparison with the modern human sample. Only the Tswana population groups, Zulu males and European females were present for this comparison. The mean of the total root length of the Palau population is greater than the mean of the modern human populations. It is followed by those of the Tswana males. European females have the lowest mean of all the groups measured. The females of the modern human populations present are smaller than the males that are available for this comparison.

All of the groups measured have high standard deviations, indicating the scattering of primary data around the means of the different groups. The Palauans range from 12.40-15.56 mm. Tswana males range from 11.13-16.83 mm, whereas European females range from 10.78-13.84 mm. These ranges indicate that the Palauans have normal total root length when compared to modern humans.

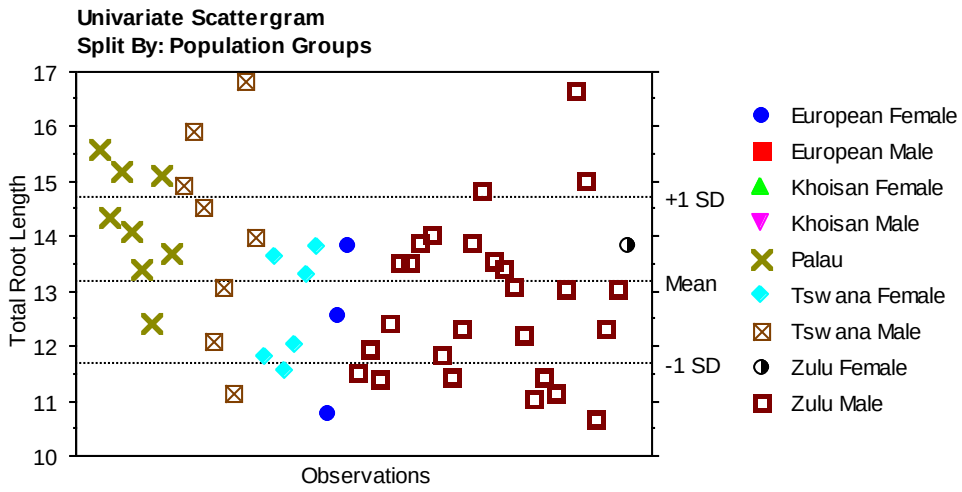

Figure 131: Univariate plot of the total root length of the mandibular 3rd premolars.

The total root lengths of the Palau population are virtually equal to the total root lengths of the modern human population groups, especially those of the Tswana and Zulu males. A few of the Tswana and Zulu males have total root lengths greater than those of the Palauans. There is little difference between the modern human population groups. For example, the ranges of the Tswana and Zulu males are similar, even though the means are slightly different. Sexual dimorphism can only be inferred from the Tswana population as both the males and females are adequately represented, and it is extensive.

Bivariate analysis

The first variables compared were the crown measurements, the MD and BL of the mandibular 3rd premolars.

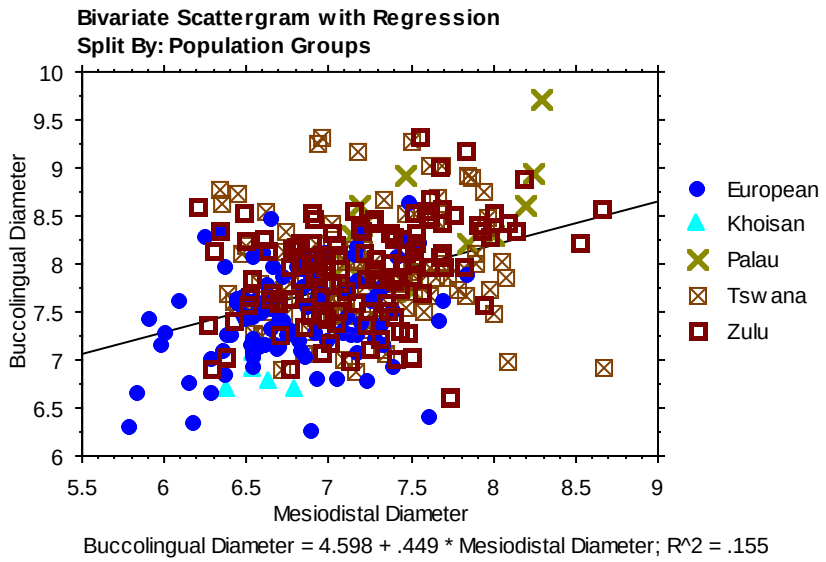

Figure 132: Bivariate plot of the MD and BL diameters of the mandibular 3rd premolars.

The MD diameters of the Palau population fall within and above the range of modern human variation. The Tswana and Zulu populations are similar to each other, are clustered on the upper end, and are greater than the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation. Khoisan are among the smallest of the modern humans measured, making the difference between them and the Palauans the greatest.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are equal to each other, and are clustered mainly on the upper end of the range. Europeans are clustered in the middle of the range of the variation, while the Khoisan are among the smallest of the modern humans measured. The difference between the Palau population and the modern human populations is the greatest when comparing the Palauans to the Europeans and Khoisan. There is a low positive correlation between the MD and BL diameter of the modern humans, ($r= 0.39$, $n= 333$, $p< 0.0001$, 95% CI 0.299-0.481). The correlation between these two variables is statistically significant.

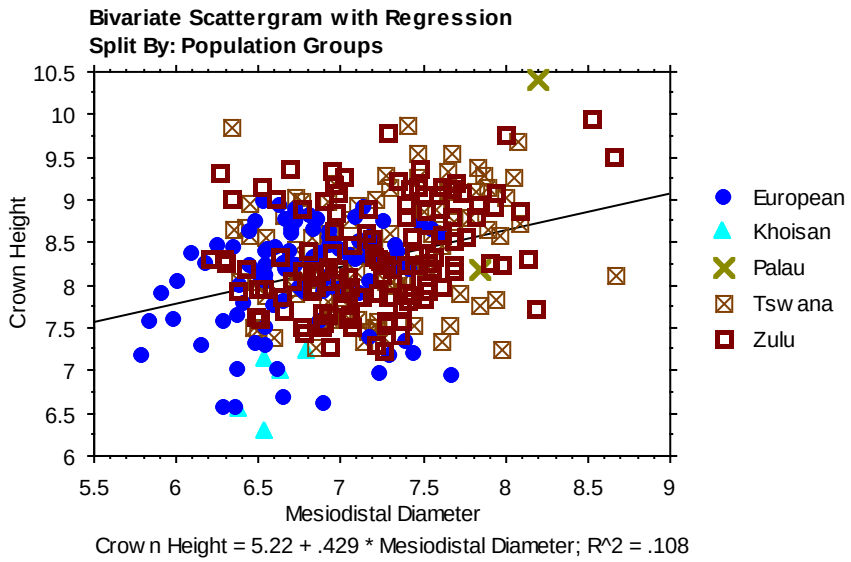

Figure 133: Bivariate plot of the MD diameters and the CH of the mandibular 3rd premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The MD diameter of the Tswana and Zulu populations are equal to each other, and are larger than those of the European and the Khoisan. They are plotted close to the Palauans, making the difference between them smaller than the remaining two modern human populations.

The crown height of the Palau population falls within and above the range of modern human variation. One is greater than the entire modern human sample. Most of the Tswana and Zulu populations are larger than the Europeans, who are clustered in the middle of the range. The Khoisan are among the smallest of the modern humans measured. There is a low positive correlation between the MD diameter and CH of the humans studied, ($r= 0.33$, $n= 314$, $p< 0.0001$, 95% CI 0.226-0.424). The correlation between these two variables is statistically significant.

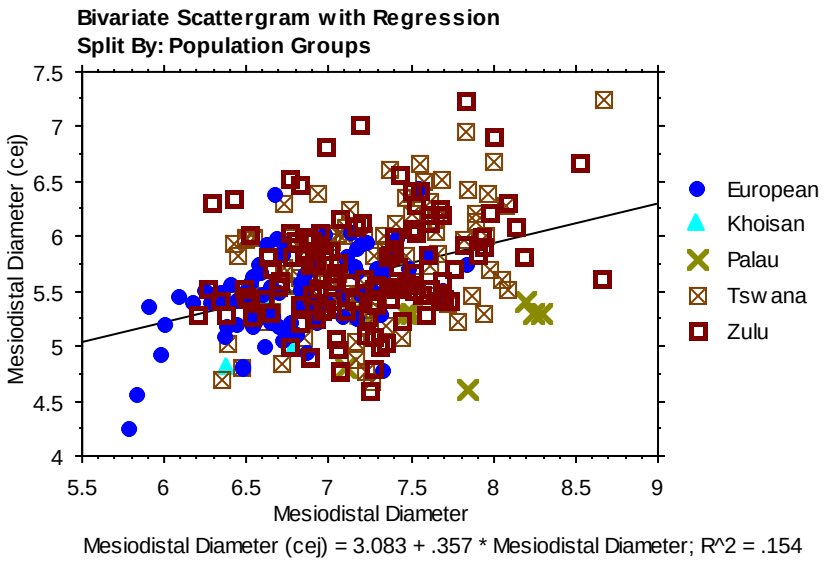

Figure 134: Bivariate plot of the MD and MD (cej) diameters of the mandibular 3rd premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the upper end of the range. The MD diameter of the Tswana and the Zulu populations is equal to each other and greater than the majority of the European and the Khoisan. The European and Khoisan populations are at the lower end of the range of modern human variation. This makes the difference between them and the Palauans greater than the two remaining groups of the modern humans sample.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. All of the Palauans fall below the regression line. The Tswana and the Zulu populations are similar to each other, and are larger than the European and Khoisan. Equal quantities of the Tswana, Zulu and the European populations are on either side of the regression line. The Khoisan are among the smallest of the modern humans measured. There is a low positive correlation between the MD and MD (cej) diameter of humans measured, ($r = 0.39$, $n = 325$, $p <$

0.0001, 95% CI 0.297-0.481). The correlation between these two variables is statistically significant.

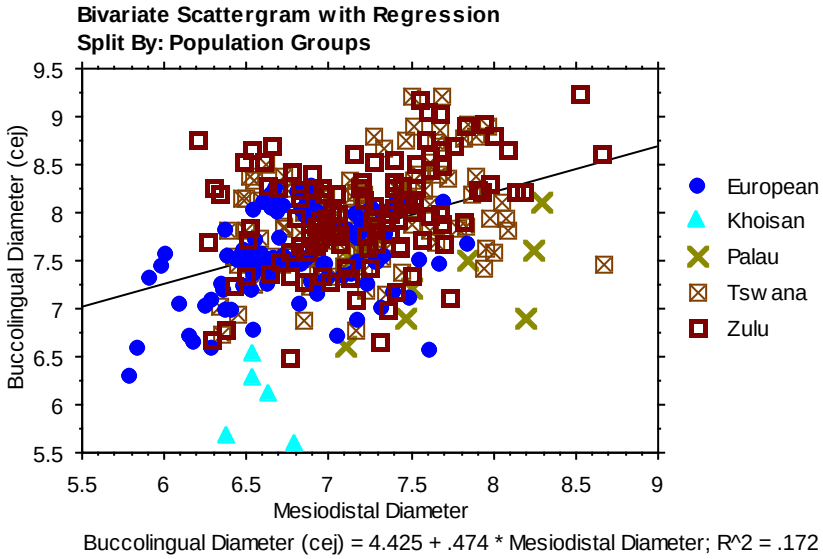

Figure 135: Bivariate plot of the MD and the BL (cej) diameters of the mandibular 3rd premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are equal to each other and are larger than the European and Khoisan. The Khoisan are among the smallest of the modern humans measured, and this makes the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. All of the Palauans are below the regression line. Most of the Tswana and the Zulu populations are at the upper end of the range of modern human variation, making the difference between them and the Palauans greater than those between the Palauans and the two remaining modern human populations. The Europeans are clustered below the regression line. The Khoisan are the

smallest of the modern humans measured. There is a low positive correlation between the MD and BL (cej) diameter of the humans measured, (r= 0.42, n= 331, p< 0.0001, 95% CI 0.322-0.501). The correlation between these variables is statistically significant.

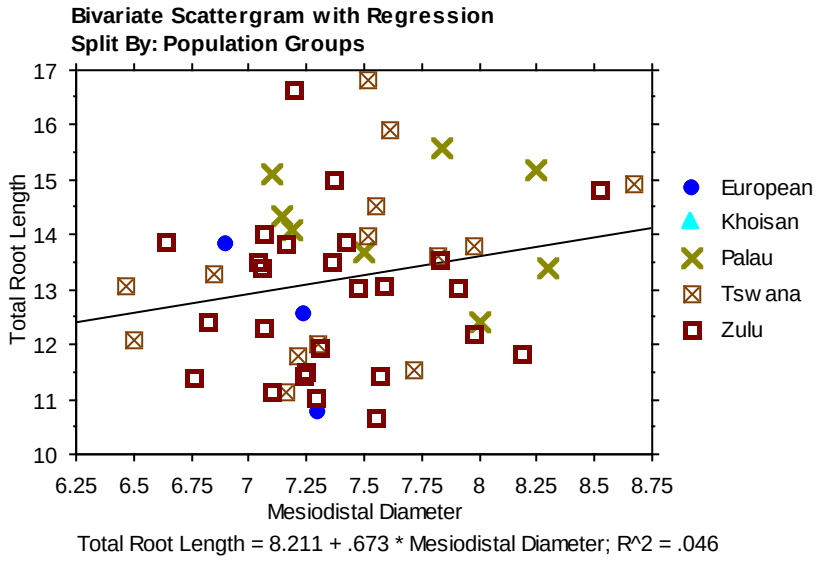

Figure 136: Bivariate plot of the MD diameters and the TRL of the mandibular 3rd premolars.

The MD diameter of the Palau population falls within the range of modern human variation. The MD diameters of the Tswana and Zulu populations are similar to each other, and are greater than the Europeans, thus making the difference between the Palauans and the Europeans the greatest.

The total root length of the Palau population falls within the range of modern human variation. The Tswana, Zulu and the European populations are equal to each other, and are comparable with the Palauans. There is a low positive correlation between the MD diameter and TRL of the humans measured, (r= 0.22, n= 51, p= 0.1296, 95% CI 0.064-0.463). The correlation between these two variables is not statistically significant.

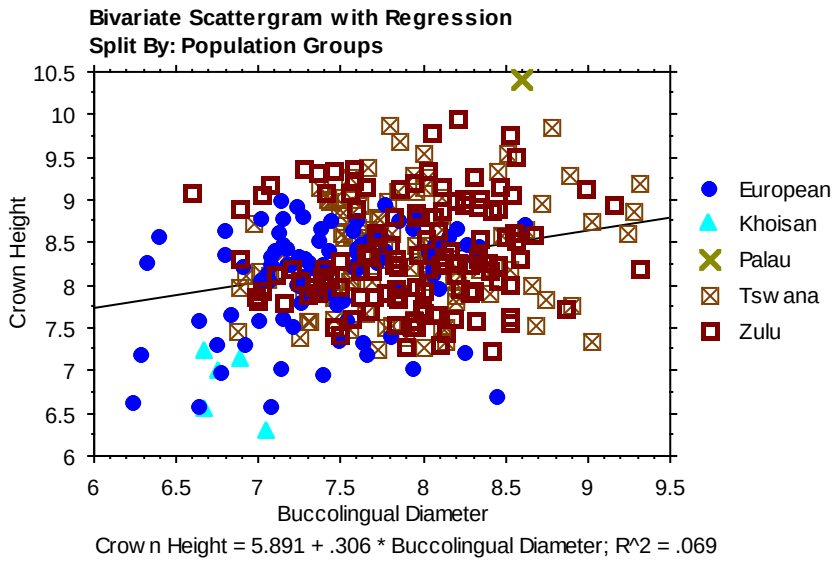

Figure 137: Bivariate plot of the BL diameters and the CH of the mandibular 3rd premolars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those Tswana and Zulu populations that are at the upper end of the range of modern human variation. Most of the European populations are clustered in the middle of the range of modern human variation, and are smaller than the Tswana and Zulu populations. The Khoisan are among the smallest of the modern humans measured, therefore making the difference between them and the Palauans the greatest.

The crown height of the Palau population falls above the range of modern human variation. The Tswana and Zulu populations are similar to each other. They are evenly distributed along the regression line of the range of variation, with equal quantities on both sides of the regression line. The European population is clustered in the middle of the range of modern human variation. The Khoisan are among the smallest of the modern human populations measured. There is a low positive correlation between the BL diameter and CH of the human populations measured, (r=

0.26, n= 318, p< 0.0001, 95% CI 0.157-0.362). The correlation between these two variables is statistically significant.

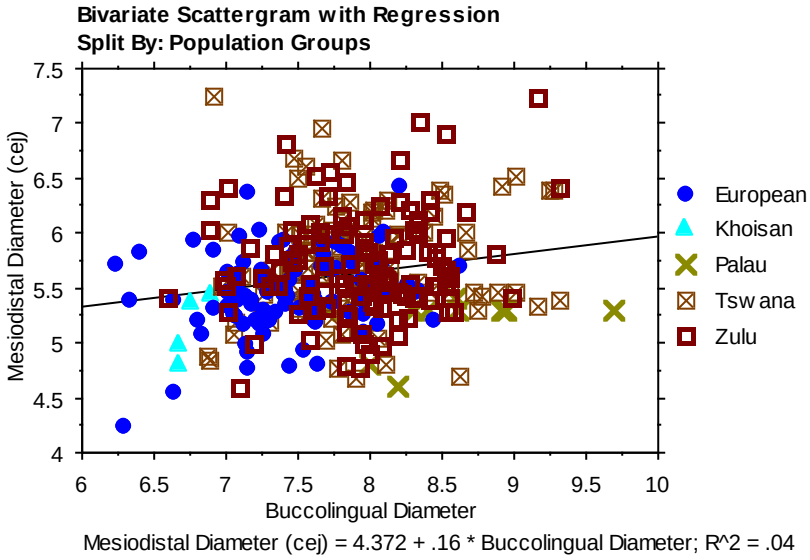

Figure 138: Bivariate plot of the BL and MD (cej) diameters of the mandibular 3rd premolars.

The BL diameter of the Palau population falls within and above the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The Europeans are clustered in the middle of the range, whereas the Khoisan are at the lower end. The difference between the Palau population and the modern human populations increases from the Tswana and Zulu, to the European and Khoisan.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. All are plotted below the regression line, and are equal to the modern humans at the lower end of the range. The Tswana and Zulu populations are equal to each other, and are larger than the European and Khoisan. The difference between the Palauans and the Tswanas and Zulus are the

greatest since the Palauans are clustered among the Europeans and Khoisan. There is a low positive correlation between the BL and MD (cej) diameter of the humans measured, (r= 0.20, n= 328, p< 0.0001, 95% CI 0.094-0.302). The correlation between these two variables is statistically significant.

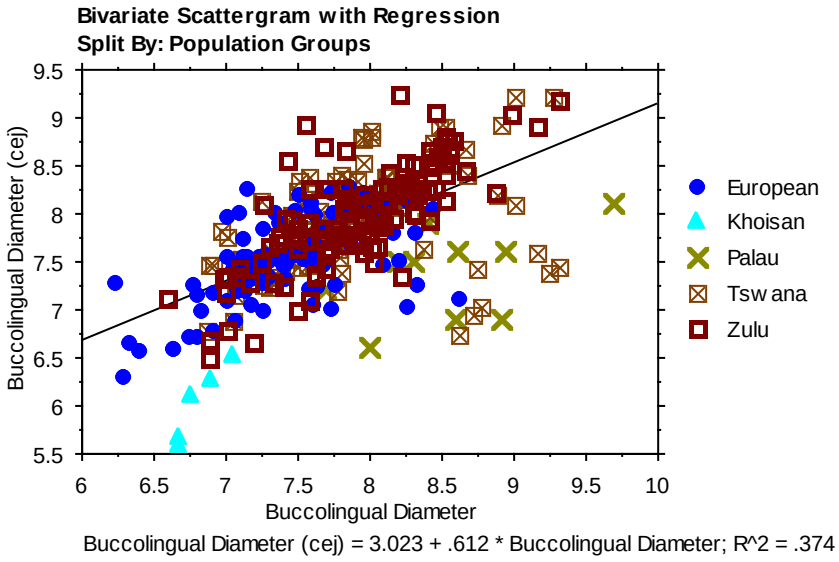

Figure 139: Bivariate plot of the BL and the BL (cej) diameters of the mandibular 3rd premolars.

The BL diameter of the Palau population falls within and above the range of modern human variation. The BL diameters of the Tswana and the Zulu populations are equal to each other and are larger than most of the Europeans and Khoisan. The majority of the Tswanas, Zulus and Europeans are plotted on the expected slope of modern human variation. The Khoisan are among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is smaller than the majority of the modern humans. The BL (cej) diameter of the modern

humans covers a wide range of variation, with the Tswanas and Zulus being clustered on the upper end of the range, whereas Europeans are in the middle. The Khoisan are clustered on the lower end of the range, and this makes the difference between them and the Palau population the greatest. There is a moderate positive correlation between the BL and BL (cej) diameter of the humans measured (r= 0.61, n= 336, p< 0.0001, 95% CI 0.540-0.675). The correlation between these two variables is statistically significant.

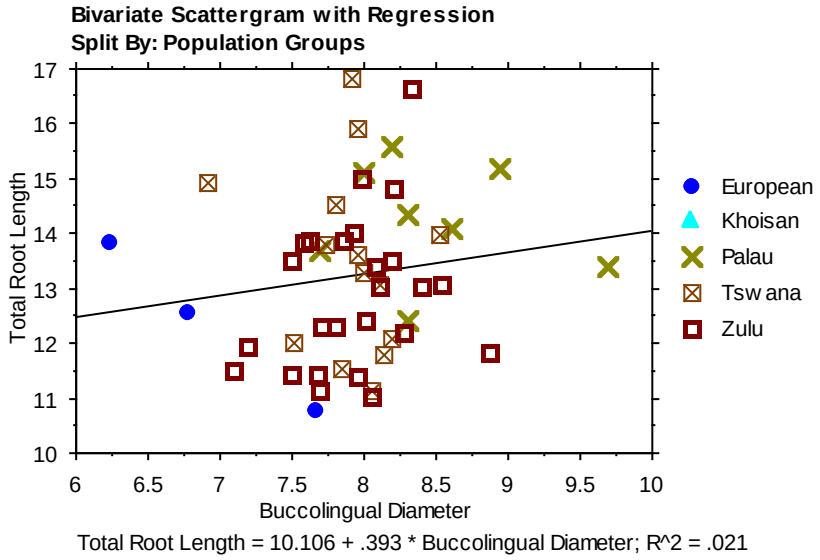

Figure 140: Bivariate plot of the BL diameters and the TRL of the mandibular 3rd premolars.

The BL diameter of the Palau population falls within and above the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are equal to most of the Palauans. The European population is at the lower end of the range of modern human variation, making the difference between them and the Palauans the greatest.

The total root length of the Palau population falls within the range of modern human variation. The total root lengths of the modern humans cover a wide range of variation, and the two groups,

namely the Tswanas and Zulus are evenly distributed along the range. Two out of the three available Europeans are plotted in the middle of the range of modern human variation. There is a low positive correlation between the BL diameter and TRL of the humans measured, (r= 0.15, n= 50, p= 0.3139, 95% CI -0.138-0.408). The correlation between these two variables is not statistically significant.

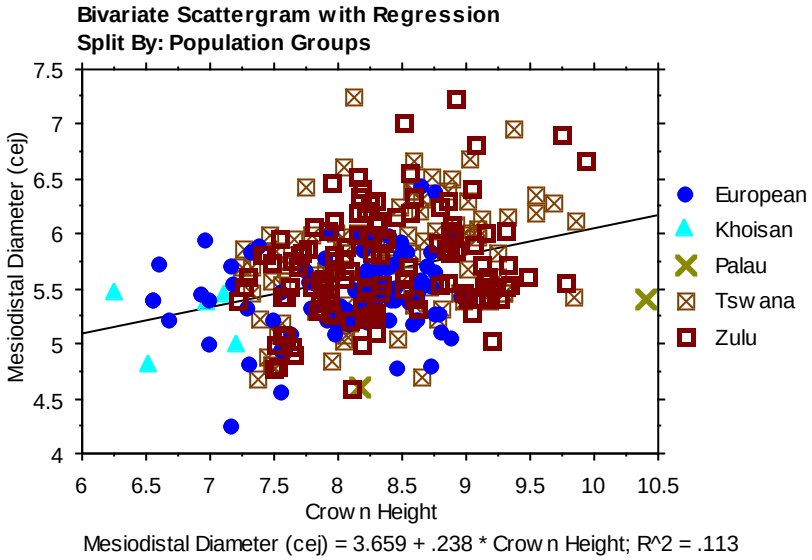

Figure 141: Bivariate plot of the CH and the MD (cej) diameters of the mandibular 3rd premolars.

The crown height of the Palau population falls within and above the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the range. Europeans are clustered in the middle, while some are on the lower end of the range together with the Khoisan. The Khoisan are among the smallest of the modern human populations measured.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Tswana and Zulu populations are similar to each other, and are clustered on the upper end of the

range of modern human variation. Europeans are clustered in the middle of the range with a few Khoisan. There is a low positive correlation between the crown height and MD (cej) diameter of the humans measured (r= 0.34, n= 309, p<0.0001, 95% CI 0.233-0.432). The correlation between these two variables is statistically significant.

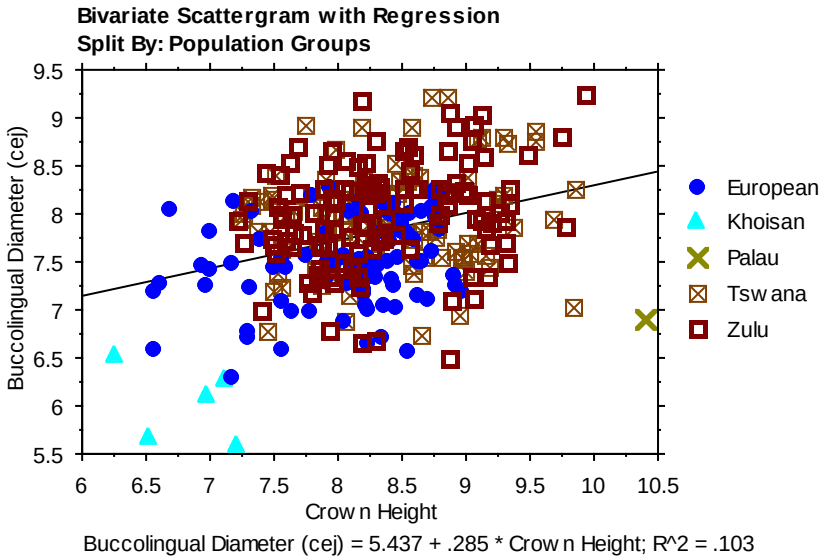

Figure 142: Bivariate plot of the CH and the BL (cej) diameters of the mandibular 3rd premolars.

The crown height of the Palau population falls above the range of modern human variation. Tswana and Zulu populations are similar to each other, and are larger than the Europeans and Khoisan. Some of the Europeans are equal to the Tswanas and Zulus, but they tend to shift towards the lower end of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those on the lower end of the range. The BL (cej) diameters of the Tswana, Zulu, and European populations are similar to one another, but the Tswana and Zulu populations are

more clustered at the upper end of the range. The Khoisan population is the smallest of the modern humans measured. There is a low positive correlation between the BL (cej) diameter and the crown height of the humans measured, (r= 0.32, n= 317, p<0.0001, 95% CI 0.219-0.417). The correlation between these two variables is statistically significant.

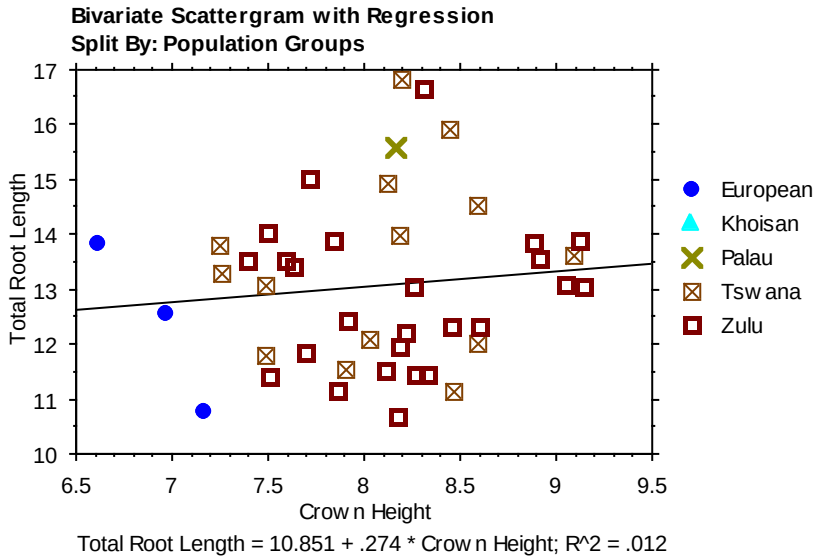

Figure 143: Bivariate plot of the CH and the TRL of the mandibular 3rd premolars.

The crown height of the Palau population falls within the range of modern human variation, and is equal to those of the Tswana and Zulu populations. The Europeans are at the lower end of the range of modern human variation.

The total root length of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. Tswana and Zulu populations are equal to each other, and cover a wide range of variation. Europeans are smaller than the Tswana, Zulu and Palau populations. There is a low positive correlation between the crown height and the TRL

of the humans measured, (r= 0.11, n= 43, p= 0.4891, 95% CI -0.198-0.396). The correlation between these two variables is not statistically significant.

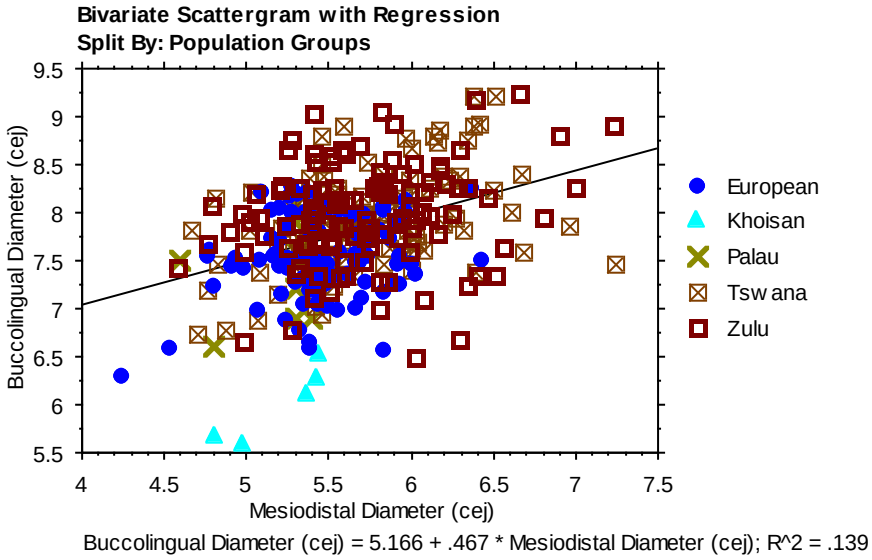

Figure 144: Bivariate plot of the MD (cej) and the BL (cej) diameters of the mandibular 3rd premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and Zulu populations are equal to each other and are at the upper end of the range, while the European and Khoisan population are clustered at the lower end.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those plotted in the middle and at the lower end of the range. The Tswana and Zulu populations are similar to each other, and are at the upper end of the range of modern human variation. Europeans are clustered in the middle of the range, whereas the Khoisan are at the lower end. There is a low positive correlation between the MD (cej) and BL (cej) diameter of

humans measured, (r= 0.37, n= 327, p< 0.001, 95% CI 0.276-0.463). The correlation between these two variables is statistically significant.

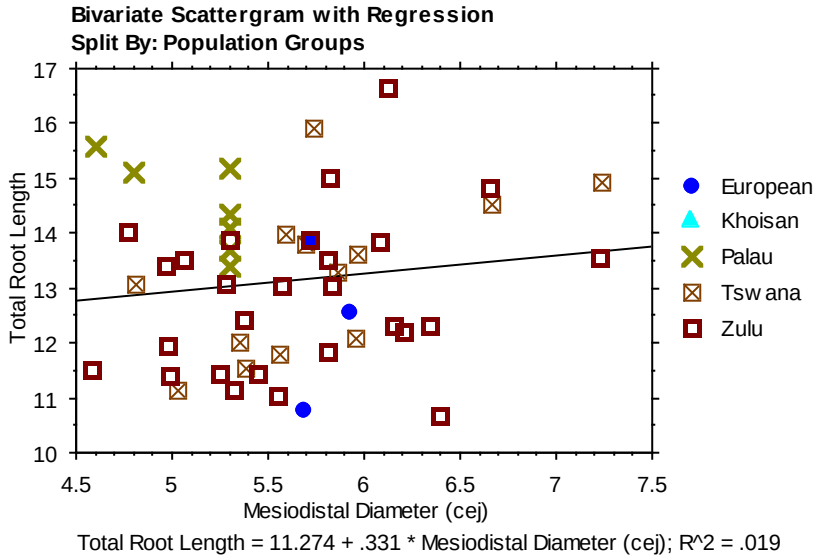

Figure 145: Bivariate plot of the MD (cej) diameter and the TRL of the mandibular 3rd premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The MD (cej) diameters of the three modern human populations are similar to one another. The Tswana and Zulu populations cover a wide range of variation.

The total root length of the Palau population falls at the upper end of the range of modern human variation. The three modern human population groups represented are similar to each other, though the Tswanas and Zulus cover a wide range of variation. There is a low positive correlation between the MD (cej) diameter and the TRL of the humans measured, (r= 0.14, n= 50, p= 0.3443, 95% CI -0.147-0.400). The correlation between these two variables is not statistically significant.

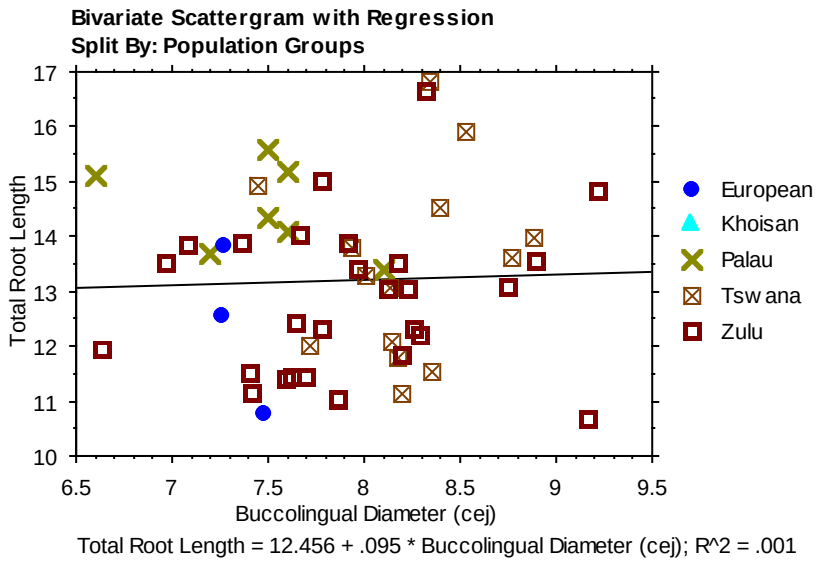

Figure 146: Bivariate plot of the BL (cej) diameters and the TRL of the mandibular 3rd premolars.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those on the lower end and in the middle of the range. The BL (cej) diameters of the Tswana and Zulu populations are similar to each other, and are larger than the Europeans.

The total root length of the Palau population falls at the upper end of the range of modern human variation. The three modern human populations available for the comparison with the Palauans are similar to one another, though the Tswana and the Zulu shift towards the upper end of the range. There is a very low positive correlation between the BL (cej) and TRL of the humans measured, (r= 0.04, n= 51, p= 0.8001, 95% CI -0.242-0.309). The correlation between these two variables is not statistically significant.

Maxillary 3rd Premolars

The size of maxillary 3rd premolars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of maxillary 3rd premolars. In addition, a univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 44: MD diameters of the maxillary 3rd premolars

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.63	0.32	7.22-8.10	7
Khoisan males	6.35	0.56	5.36-6.68	5
Tswana males	7.13	0.52	6.01-8.39	49
Tswana females	6.96	0.36	6.20-7.67	36
Zulu males	7.08	0.49	6.08-8.18	59
Zulu females	6.99	0.36	6.29-7.79	52
European males	6.80	0.40	5.98-7.51	46
European females	6.49	0.48	5.95-7.37	16

Seven maxillary 3rd premolars were available for comparison with the modern human sample. Out of the 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD diameters of the Palau population is greater than the means of all the modern human populations. It is followed by the means of the Tswana and Zulu males respectively. The females of the different groups are smaller than their male counterparts. Khoisan males have the lowest mean of all the populations measured. The standard deviations of all the groups studied

are very small, indicating the clustering of primary data around the means of the different groups.

The MD diameters of the Palauans range from 7.22-8.10 mm. Tswana males range from 6.01-8.39 mm and Khoisan males from 5.36-6.68 mm. These ranges indicate that the MD diameter of the Palau population falls within the normal range of modern human variation, but shifts to the upper end.

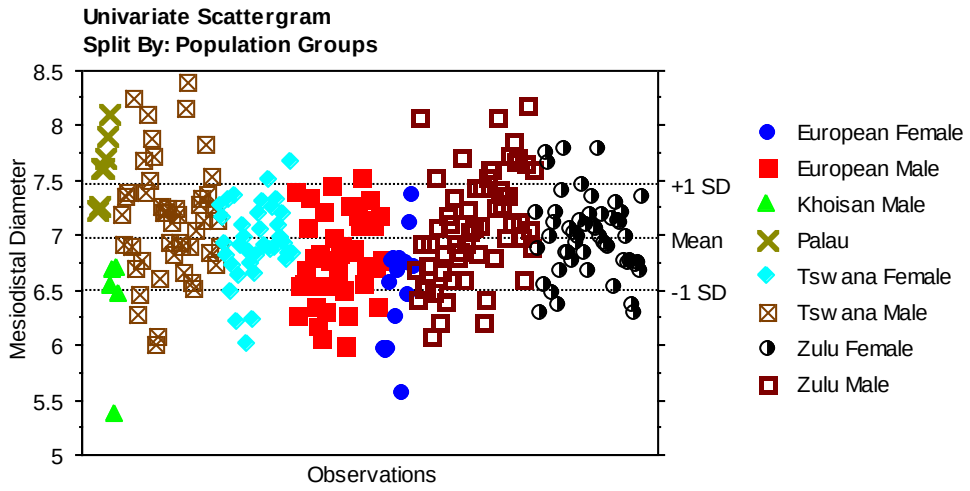

Figure 147: Univariate plot of the MD diameters of the maxillary 3rd premolars.

The MD diameters of the Palau population is equal to most of the MD diameters of the modern human population groups. It is most like those of males in the modern human sample, mainly Tswana and Zulu males. Tswana and Zulu males are very similar to each other, and the same applies to the females of these groups. The difference between the males and females of the Tswana and Zulu population groups are more extensive than the difference between the Europeans. Khoisan males are clustered on the lower end of modern human variation, therefore making the difference between them and the Palauans the greatest.

Table 45: BL diameters of the maxillary 3rd premolars.

Population groups	BL Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	9.67	0.44	9.20-10.30	5
Khoisan males	8.32	0.49	7.99-8.90	5
Tswana males	9.2	0.52	7.58-10.42	48
Tswana females	9.1	0.37	8.32-9.60	37
Zulu males	9.29	0.62	7.80-10.57	57
Zulu females	9.06	0.46	8.45-10.12	52
European males	8.63	0.59	7.25-9.58	47
European females	8.52	0.52	7.54-9.42	16

Five Palauan maxillary 3rd premolars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only five individuals. The mean of the BL diameters of the Palau population is greater than those of the modern human populations. It is followed by Zulu and Tswana males respectively. Tswana and Zulu females are smaller than their male conterparts, but larger than the European population groups and Khoisan males. Khoisan males have the smallest mean of all the populations measured. All the groups measured have low standard deviations, indicating clustering of primary data around the means of the different groups.

The Palauans range from 9.20-10.30 mm. Khoisan males have the smallest mean of the modern human populations, whereas Zulu males have the highest. They range from 7.99-8.90 mm and 7.80-10.57 mm respectively. These ranges show that the BL diameter of the Palau population falls within the normal range of modern human variation, but is situated at the upper end.

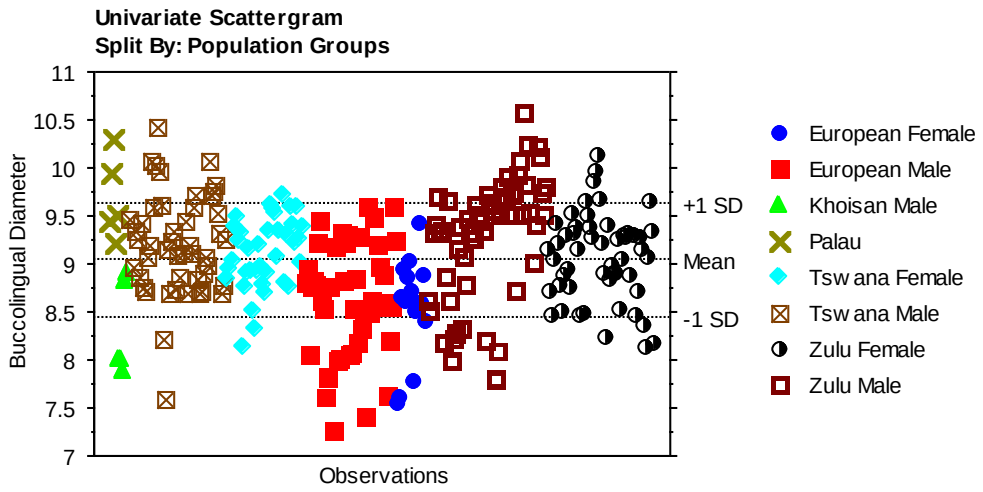

Figure 148: Univariate plot of the BL diameters of the maxillary 3rd premolars.

The BL diameters of the Palau population are equal to most of the BL diameters of the modern human population groups, especially those of the Tswana and Zulu males on the upper end of the range of variation. The BL diameters of the European males a the sample maximum which is comparable to the Tswana females, but a very small sample minimum when compared to the Tswana and Zulu population groups. The BL diameters of the Khoisan males are equal to those of modern humans on the lower end of the range of variation.

Table 46: Crown height of the of the maxillary 3rd premolars

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	6.3	0.77	5.36-7.20	5
Tswana males	8.16	0.79	6.38-9.69	44
Tswana females	7.73	0.70	6.75-9.34	37
Zulu males	8.0	0.80	6.55-9.46	59
Zulu females	7.74	0.66	6.61-9.14	52
European males	7.70	0.70	6.46-8.90	47
European females	7.47	0.53	6.70-8.31	17

Only one Palauan was available for comparison with the modern human sample. The Khoisan population was the least represented, with only five individuals. Tswana males have the highest mean; whereas the Khoisan males have the lowest for all the populations measured. The females of the sample have means that are smaller than the males of their similar groups. Zulu males have the highest standard deviation of all the populations studied. The standard deviations of the remaining groups are comparable with those of Zulu males. These small standard deviations indicate that the primary data of the different groups are clustered along the means of the different groups. Having only one specimen makes it impossible to determine the range of the Palauans. Even so, the available Palauan plotted above the sample maximum of the entire sample of modern humans. The crown height of the only available Palauan is 10.00 mm. Tswana males range from 6.38-9.69 mm, while Khoisan males range from 5.36-7.2 mm.

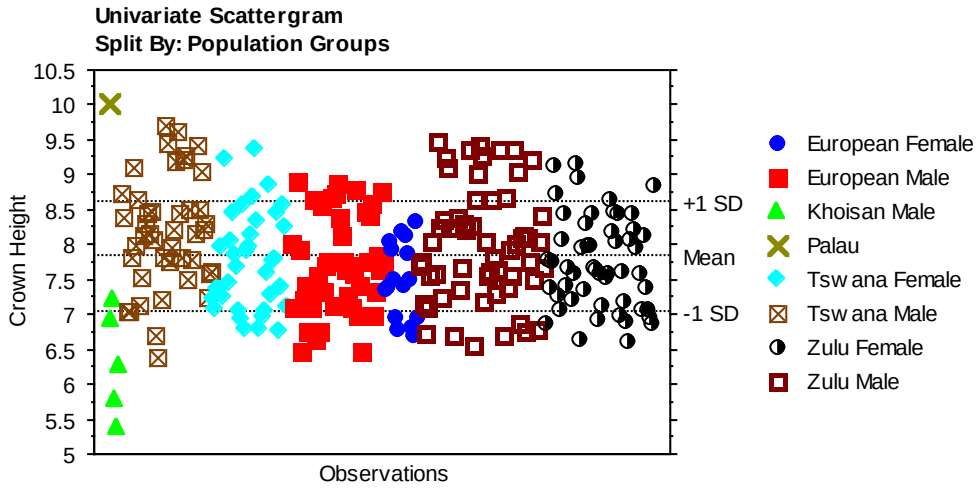

Figure 149: Univariate plot of the crown height of the maxillary 3rd premolars.

The only available crown height of the Palau population is larger than all of the crown heights of the modern human populations. Tswana and Zulu males are equal to each other, and are slightly

smaller than the Palauan. Tswana and Zulu females are also comparable with one another. Khoisan males are clustered on the lower end of modern human variation.

Table 47: MD (cej) diameters of the maxillary 3rd premolars

Population groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	4.88	0.73	3.90-5.90	5
Khoisan males	5.17	0.64	4.13-5.82	5
Tswana males	5.58	0.48	4.60-6.52	49
Tswana females	5.36	0.43	4.41-6.08	37
Zulu males	5.40	0.46	4.44-6.49	59
Zulu females	5.34	0.36	4.38-6.05	52
European males	5.28	0.40	4.39-6.05	47
European females	5.20	0.41	4.58-5.84	17

Five Palauan maxillary 3rd premolars were available for comparison with the modern human sample. Out of the 400 modern humans sampled, the Khoisan population was the least represented. The mean of the MD (cej) diameters of the Palau population is smaller than the means of all the modern humans. Tswana males have the highest mean of all the populations measured, and Khoisan males have the lowest mean of all the modern humans studied. Females of the modern human populations have means that are smaller than those of the males of their similar groups. The standard deviations of the groups studied are small, indicating the clustering of primary data around the means of the different groups.

The MD (cej) diameters of the Palauans range from 3.90-5.90 mm. Tswana males range from 4.60-6.52 mm, whereas Khoisan males range from 4.13-5.82 mm. These ranges indicate that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

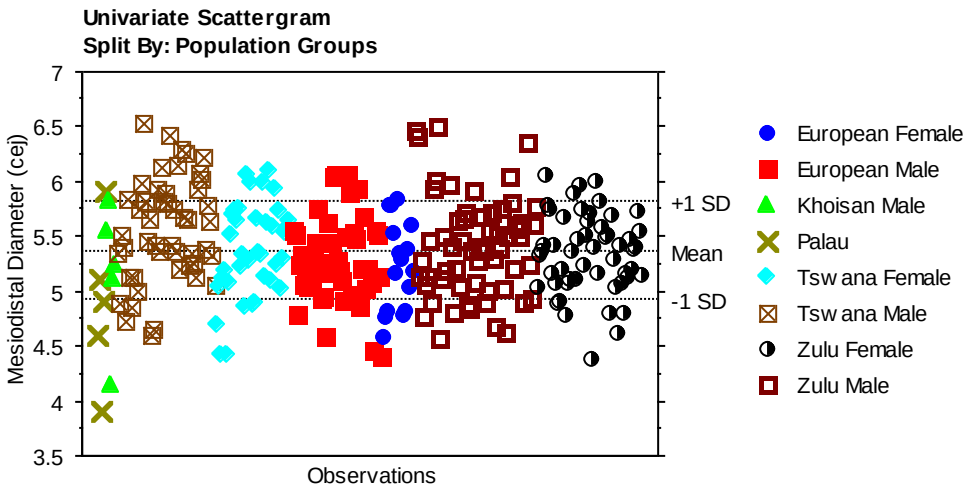

Figure 150: Univariate plot of the MD (cej) diameters of the maxillary 3rd premolars.

The MD (cej) diameters of the Palau population are equal to most of the MD (cej) diameters of the modern human population groups. There is little difference between the modern human sample. Tswana and Zulu males are comparable, and the same applies to the females of these groups. The MD (cej) diameters of the European male are similar to those of Zulu females, especially the sample maximum. The sample maximum of these two groups is equal. The MD (cej) diameters of Khoisan males are distributedin the middle of modern human variation, as opposed to being clustered on the lower end.

Table 48: BL (cej) diameters of the maxillary 3rd premolar

Population groups	BL (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	8.28	0.67	7.50-9.10	6
Khoisan males	7.83	0.37	7.46-8.34	5
Tswana males	9.54	0.49	8.39-10.54	49
Tswana females	9.29	0.45	8.53-10.46	37
Zulu males	9.51	0.53	8.45-10.59	57
Zulu females	9.29	0.47	8.37-10.48	52
European males	9.1	0.56	7.62-10.08	46
European females	8.92	0.58	7.74-9.46	17

Six Palauan maxillary 3rd premolars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only five individuals. The mean of the BL (cej) diameters of the Palau population is smaller than all of the modern humans measured. Tswana males have the highest mean of all the populations measured, whereas Khoisan males have the lowest. Female modern humans have means that are smaller than their male counterparts. European population groups are smaller than the Tswana and Zulu population groups. The standard deviations of all the populations measured are small, and this is indicative of the clustering of the primary data around the means of the different groups.

The BL (cej) diameters of the Palau population range from 7.50-9.10 mm. Tswana males and Khoisan males range from 8.39-10.54 mm and 7.46-8.34 mm respectively. The BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

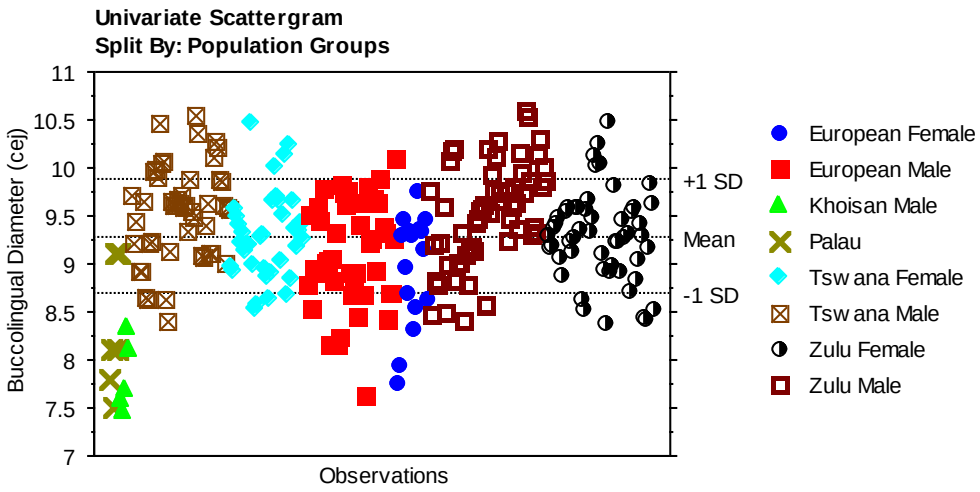

Figure 151: Univariate plot of the BL (cej) diameters of the maxillary 3rd premolars.

The BL (cej) diameters of the Palau population are equal to most of the BL (cej) diameters of the modern human populations, especially those on the lower end of modern human variation. The BL (cej) diameters of the Tswana and Zulu males are similar to each other, and so are the females of these groups. Khoisan males are clustered on the lower end of the range of modern human variation, and are equal to most of the Palauans.

Table 49: Total root length of the maxillary 3rd premolars

Population groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	14.23	2.66	11.40-17.70	4
Khoisan males	13.01	0.70	12.40-13.78	3
Tswana males	14.48	1.49	12.60-16.87	9
Tswana females	14.05	0.97	12.84-15.69	15
Zulu males	14.52	1.41	11.39-16.85	30
Zulu females	14.31	1.13	12.88-15.79	8

Four Palauan maxillary 3rd premolars were available for comparison with the modern human sample. Khoisan population was the least represented, with only three individuals. No Europeans

were available for comparison. The mean of the TRL of the Palau population is greater than the means of the Tswana females and Khoisan males, but smaller than those of Tswana males and the Zulu population groups. Zulu males have the highest mean of all the groups studied, while Khoisan males have the smallest. The females of the modern human sample have means that are smaller than the means of their male counterparts. Tswana females and Khoisan males have low standard deviations, whereas the remaining groups have high standard deviations, showing that the primary data are scattered further away from the means of the different groups.

The TRL of the Palauans ranges from 11.40-17.70 mm. Zulu males range from 11.39-16.85 mm, while Khoisan males from 12.40-13.78 mm. These ranges indicate that the total root length of the Palau population falls within the normal range of modern human variation.

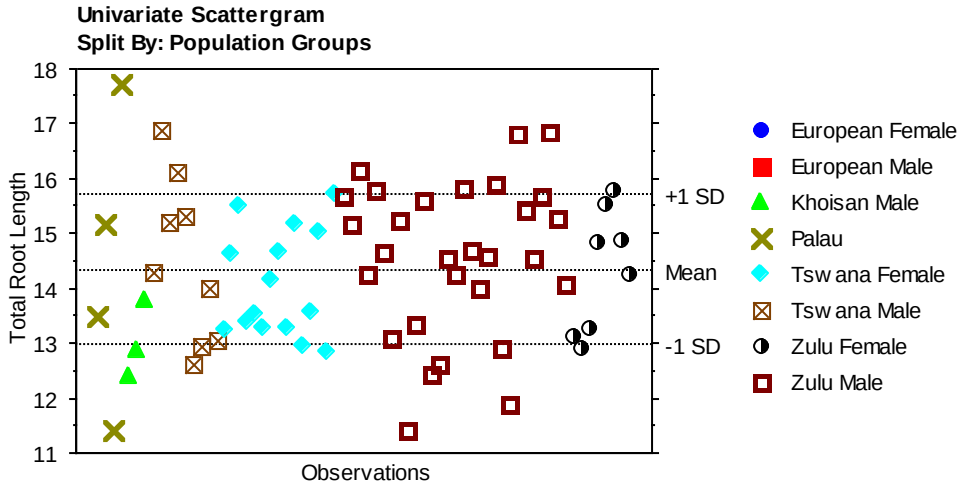

Figure 152: Univariate plot of the total root length of the maxillary 3rd premolars.

The total root lengths of the Palau population are equal to the total root lengths of the modern human populations. There is little difference between the total root lengths of modern humans.

Tswana and Zulu males are similar to each other, as are the females of these two groups. Khoisan males are among the smallest of the humans measured.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the maxillary 3rd premolars.

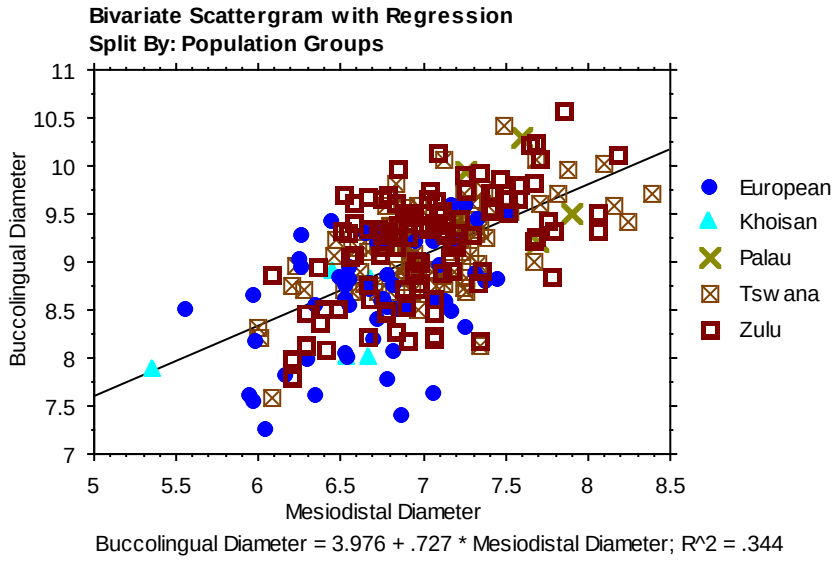

Figure 153: Bivariate plot of the MD and BL diameters of the maxillary 3rd premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The MD diameters of the Tswana and Zulu populations are larger than majority of the Europeans, and are equal to a few of the Palauans. The Khoisan population is among the smallest of the modern humans measured, making the difference between them and the Palauans the greatest.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The BL diameter of the Tswana and Zulu populations are larger than those of the

European and Khoisan populations. Therefore the difference between the Palau population and the modern human populations increases from the Zulu and the Tswana, to the European and Khoisan populations. There is a moderate positive correlation between the MD and BL diameter of the humans measured, (r= 0.59, n= 258, p< 0.0001, 95% CI 0.500-0.661). The correlation between these two variables is statistically significant.

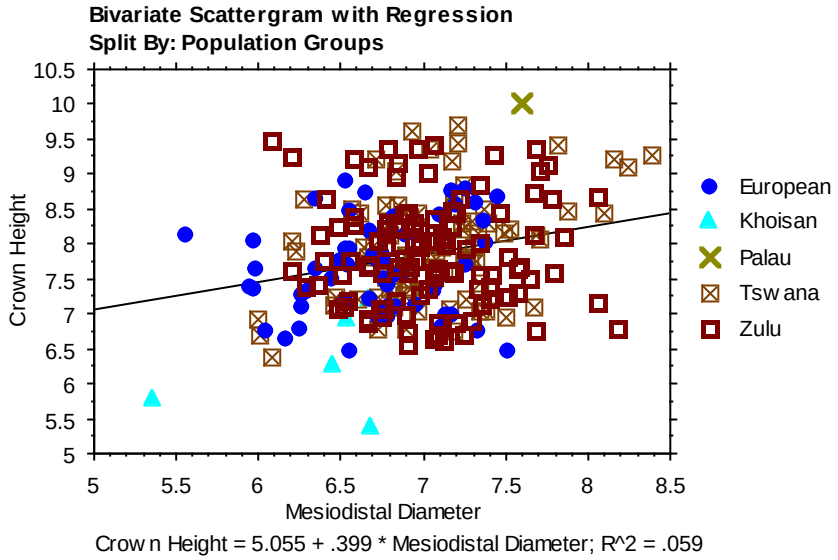

Figure 154: Bivariate plot of the MD diameters and the CH of the maxillary 3rd premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are equal to each other and to a few of the Europeans, while most are clustered in the middle of the range of modern human variation. The Khoisan are among the smallest of the modern humans measured.

The crown height of the Palau population falls above the range of modern human variation. Most of the Tswana and Zulu populations are equal to each other; and are at the upper end of the range of modern human variation, making them larger than the majority of the European and Khoisan.

Europeans are clustered in the middle of the range of modern human variation, while the Khoisan are at the lower end. This makes the difference between the Palau population and the Khoisan the greatest when compared to other modern human populations measured. There is a low positive correlation between the MD diameter and CH of the humans measured, (r= 0.4, n= 253, p< 0.0001, 95% CI 0.123-0.356). The correlation between these two variables is statistically significant.

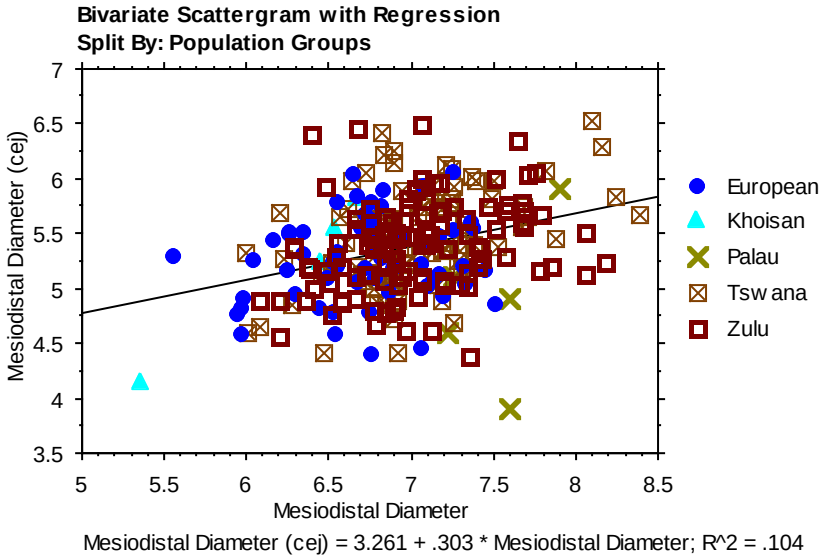

Figure 155: Bivariate plot of the MD and the MD (cej) diameters of the maxillary 3rd premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The MD diameters of the Tswana and Zulu populations are equal to each other, and are larger than most of the European and the Khoisan. The European and Khoisan populations are clustered on the lower end of the range of modern human variation. This makes the difference between them and the Palauans the greatest compared to the other two groups.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and the majority plot below the regression line. Most of the Tswana and Zulu populations are equal to each other, and are larger than the European and Khoisan. The European and Khoisan populations are clustered in the middle of the range of modern human variation. The difference between the Palauans and the modern humans is the smallest when they are compared to the European and Khoisan. There is a low positive correlation between the MD and MD (cej) diameter of the humans measured, (r= 0.32, n= 262, p< 0.0001, 95% CI 0.210-0.427). The correlation between these two variables is statistically significant.

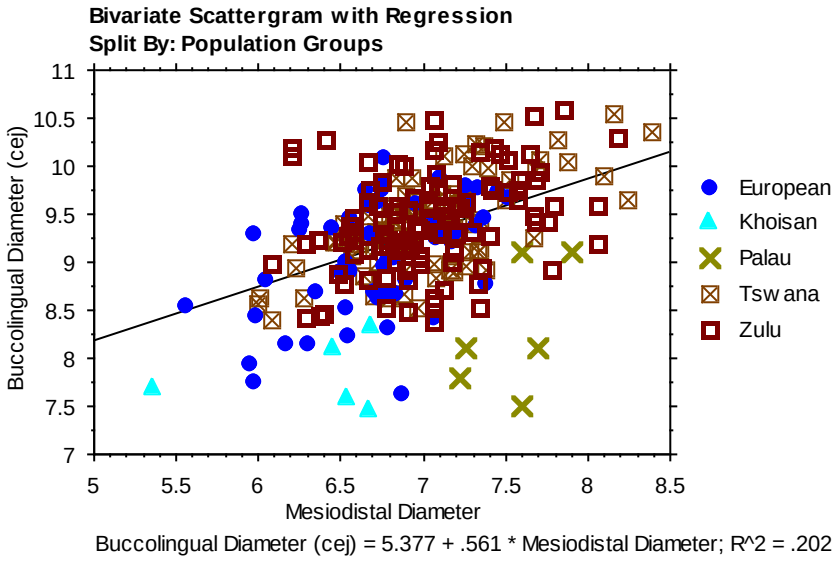

Figure 156: Bivariate plot of the MD and the BL (cej) diameters of the maxillary 3rd premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the upper end of the range. The Tswana and Zulu populations are similar to each other, and are greater than the European and Khoisan. The majority of the European and Khoisan populations are at the lower end of the range of modern

human variation. The difference between the Palau population and the modern humans is the greatest when they are compared to the European and Khoisan populations.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. It is below the regression line, and equal to those in the middle and on the lower end of the range. The BL (cej) diameter of the Tswana and the Zulu populations are equal to each other and are greater than most of the European and Khoisan populations. The difference between the Palauans and the modern human populations is marked. There is a low positive correlation between the MD and BL (cej) diameter of the humans measured, (r= 0.45, n= 260, p< 0.0001, 95% CI 0.347-0.541). The correlation between these two variables is statistically significant.

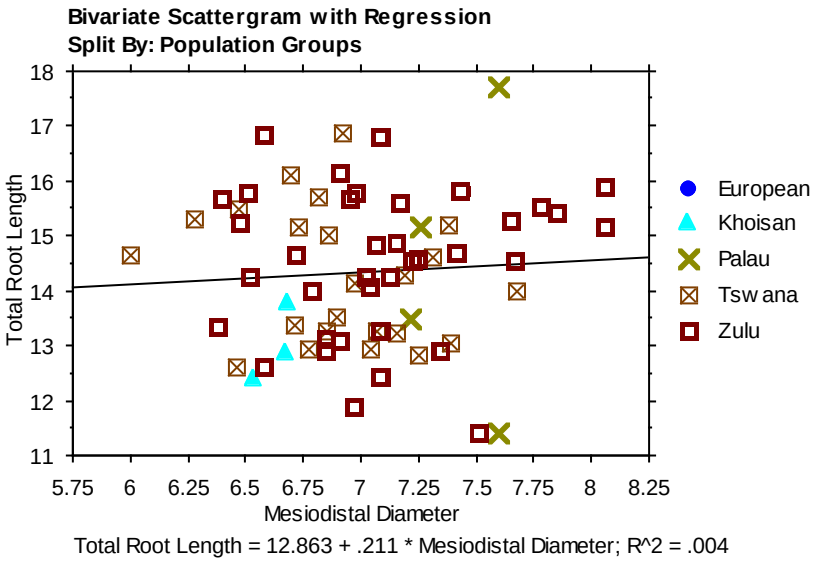

Figure 157: Bivariate plot of the MD diameters and the TRL of the maxillary 3rd premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are equal to

each other, and are greater than the Khoisan. The difference between the Palau population and the Khoisan is the greatest.

The total root length of the Palau population falls within the range of modern human variation. Two are equal to those on the upper end of the range, while two are equal to those on the lower end. The Tswana and the Zulu populations are similar to each other, and are larger than the Khoisan. There is a very low positive correlation between the MD diameter and the total root length, (r= 0.07, n= 67, p= 0.6006, 95% CI –0.178-0.301). The correlation between these two variables is not statistically significant.

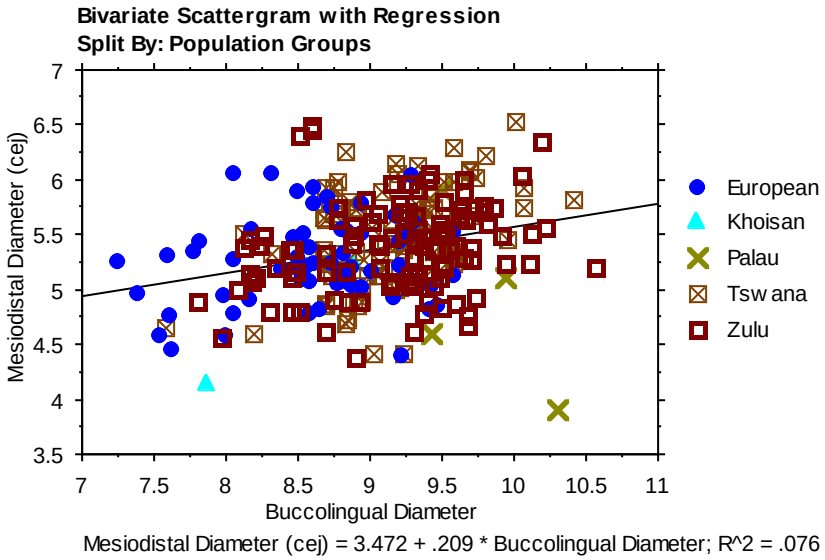

Figure 158: Bivariate plot of the BL and the MD (cej) diameters of the maxillary 3rd premolars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest

of the modern human populations measured, thus making the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. One is smaller than the entire modern human sample. There is little difference between the Tswana, Zulu and European populations, but the sample maximums of the Tswana and the Zulu are greater than that of the Europeans. The only available Khoisan is at the lower end of the range of the modern human variation. There is a low positive correlation between the BL and the MD (cej) diameter, (r= 0.28, n= 258, p< 0.0001, 95% CI 0.159-0.385). The correlation between these two variables is statistically significant.

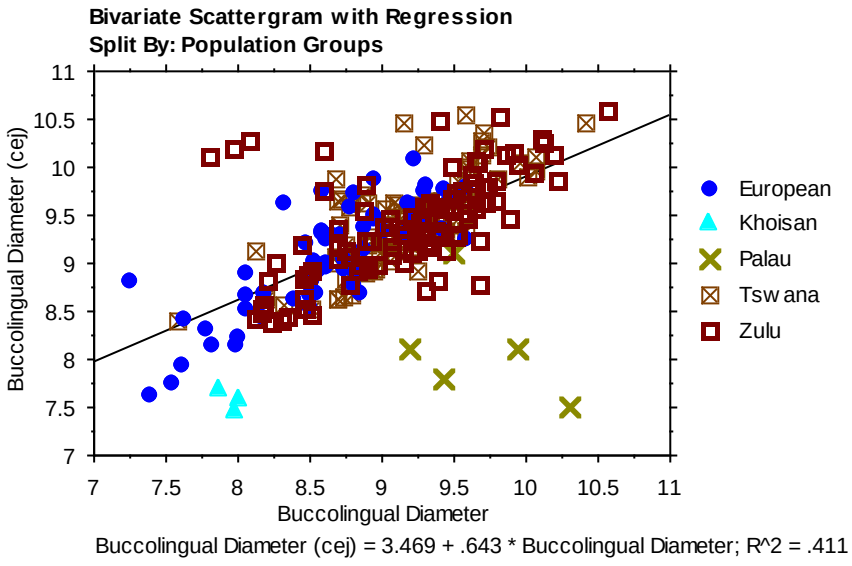

Figure 159: Bivariate plot of the BL and the BL (cej) diameters of the maxillary 3rd premolars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are similar to

each other, and are greater than the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation, while the Khoisan are at the lower end.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the European and Khoisan. The Khoisan population is among the smallest of the modern humans measured. There is a moderate positive correlation between the BL and BL (cej) diameter, (r= 0.64, n= 259, p< 0.0001, 95% CI 0.564-0.708). The correlation between these two variables is statistically significant.

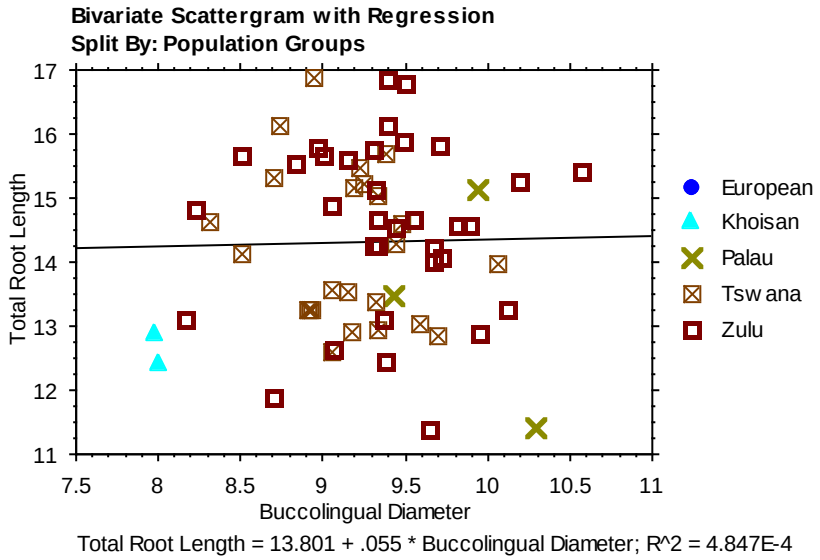

Figure 160: Bivariate plot of the BL diameters and the TRL of the maxillary 3rd premolars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those on the upper end of the range. The Tswana and the Zulu populations are equal to each other, and are greater than the Khoisan. The Khoisan are clustered on the lower end of the

range of modern human variation, thus making the difference between them and the Palau population the greatest.

The total root length of the Palau population falls within the range of modern human variation, and covers the entire range. The Tswana and the Zulu population groups are similar to each other, and are greater than the Khoisan. The Khoisan are among the smallest of the modern humans measured. There is a low positive correlation between the BL diameter and the total root length, (r= 0.02, n= 63, p= 0.8646, 95% CI -0.227-0.268). The correlation between these two variables is not statistically significant.

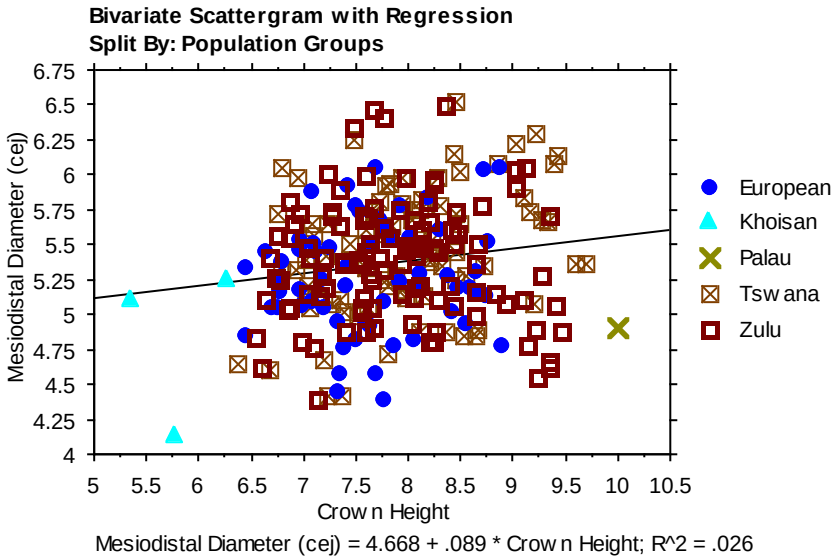

Figure 161: Bivariate plot of the CH and the MD (cej) diameters of the maxillary 3rd premolars.

The crown height of the Palau population falls above the range of modern human variation. The crown heights of the Tswana, Zulu and the European populations are equal to one another, but the sample maximums of the Tswana and the Zulu are greater than those of the European. The

Khoisan population is the smallest of the modern humans measured, and this makes the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The sample maximums of the Tswana and the Zulu populations are greater than those of the European, whereas the sample minimums are the same. The three are evenly distributed along the range of variation, with equal quantities on either sides of the regression line. The Khoisan population is at the lower end of the range of modern human variation. There is a low positive correlation between the crown height and the MD (cej) diameter, (r= 0.16, n= 254, p= 0.0105, 95% CI 0.038-0.278). The correlation between these two variables is statistically significant.

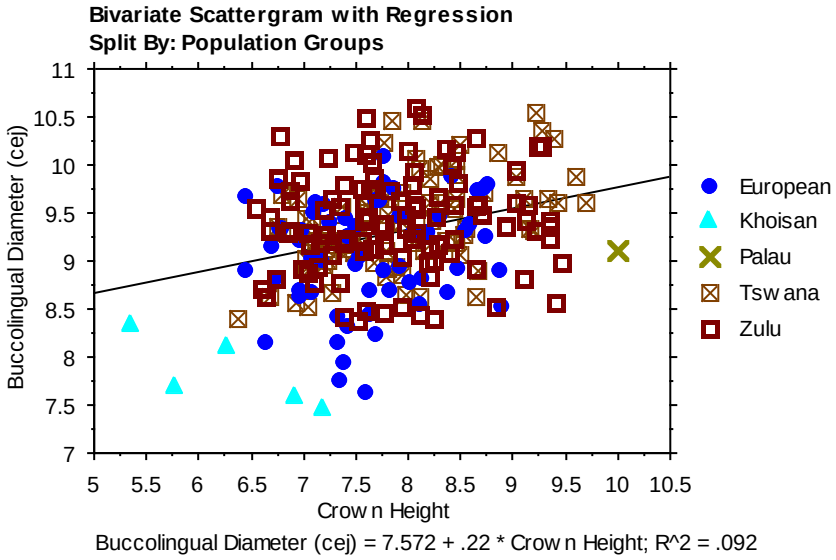

Figure 162: Bivariate plot of the CH and the BL (cej) diameters of the maxillary 3rd premolars.

The crown height of the Palau population falls above the range of modern human variation. The sample maximums of the Tswana and the Zulu populations are equal to each other, and are larger

than the Europeans. The crown height of the Khoisan population is the smallest of all the modern humans measured. This makes the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The BL (cej) diameter of the Tswana and the Zulu populations are similar to each other, and are greater than the European and Khoisan. The European population is clustered in the middle of the range of modern human variation, while the Khoisan is at the lower end. There is a low positive correlation between the crown height and the BL (cej) diameter, (r= 0.30, n= 254, p< 0.0001, 95% CI 0.186-0.410). The correlation between these two variables is statistically significant.

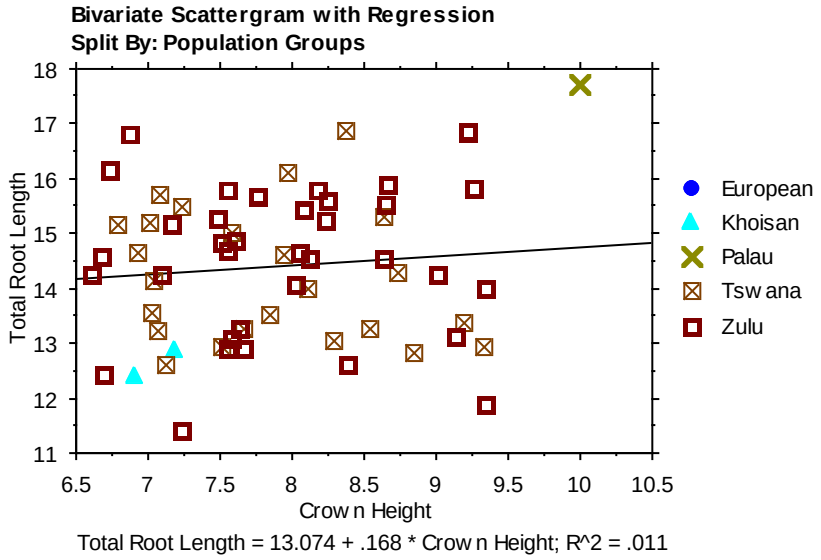

Figure 163: Bivariate plot of the CH and the TRL of the maxillary 3rd premolars.

The crown height of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Khoisan. The

Khoisan are on the lower end of the range of modern human variation, and this makes the difference between them and the Palau population the greatest.

The total root length of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Khoisan. The Khoisan are among the smallest of the modern humans measured. There is a very low positive correlation between the crown height and the total root length, (r= 0.10, n= 63, p= 0.4256, 95% CI – 0.149-0.342). The correlation between these two variables is not statistically significant.

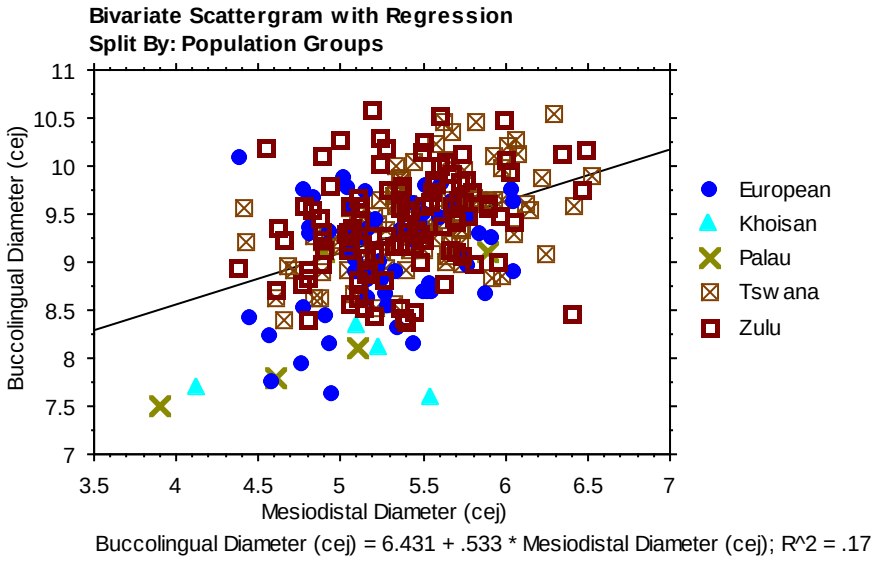

Figure 164: Bivariate plot of the MD (cej) and BL (cej) diameters of the maxillary 3rd premolars.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the lower end of the range. One is smaller than the entire modern human sample. The Tswana and the Zulu populations are similar to each other,

and are greater than the Europeans and Khoisan. The Europeans are clustered in the middle of the range of the modern human variation, while the Khoisan are at the lower end.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the lower end of the range. The Tswana and the Zulu population are similar to each other, and are greater than the Europeans and Khoisan. The Europeans are clustered in the middle of the range, while the Khoisan are at the lower end. There is a low positive correlation between the MD (cej) and the BL (cej) diameter, (r= 0.41, n= 261, p<0.0001, 95% CI 0.306-0.508). The correlation between these two variables is statistically significant.

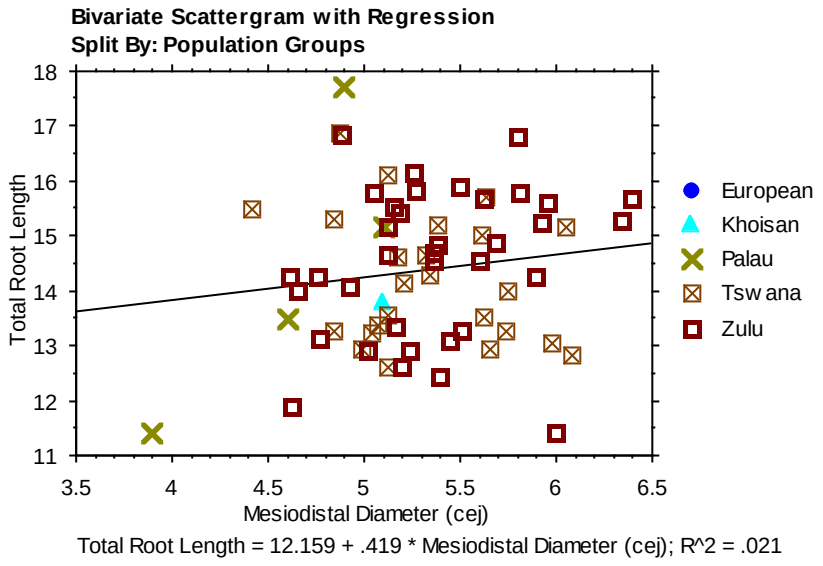

Figure 165: Bivariate plot of the MD (cej) diameters and the TRL of the maxillary 3rd premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. One is smaller than the entire modern human sample. The Tswana and the Zulu populations are equal to each other, and are greater than the Khoisan.

The total root length of the Palau population falls within the range of modern human variation. One is greater than the entire modern human sample. The Tswana and the Zulu populations are equal to each other, and to the Palauans. The Khoisan are at the lower end of the range of modern human variation. There is no difference between the Palau population and modern humans since the Palauans are evenly distributed along the range of modern human variation. There is a low positive correlation between the MD (cej) diameter and the total root length, (r= 0.15, n= 65, p= 0.2507, 95% CI -0.103-0.375), however, correlation between these two variables is not statistically significant.

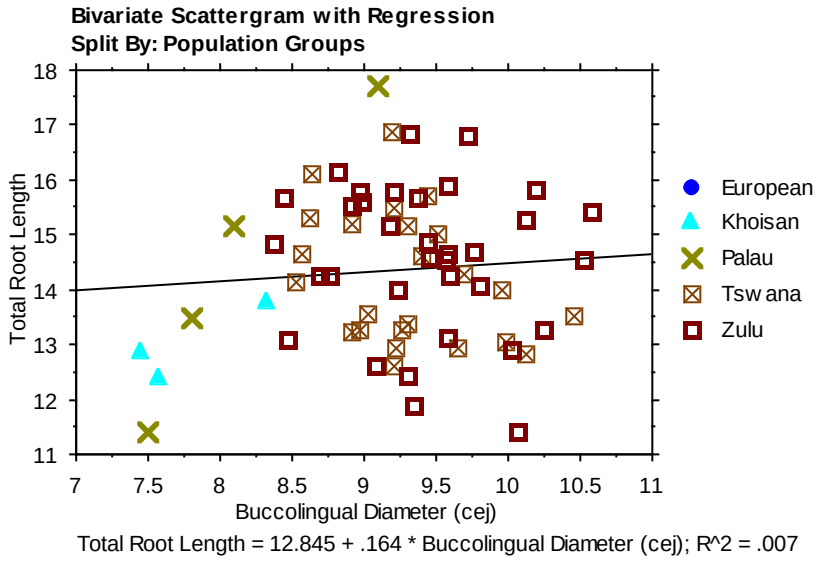

Figure 166: Bivariate plot of the BL (cej) diameter and the TRL of the maxillary 3rd premolars.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Khoisan and the Palauans. The Khoisan are clustered on the lower end of the range of modern human variation.

The total root length of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Khoisan. There is no difference between the total root lengths of the Palau population and modern humans. There is a very low positive correlation between the BL (cej) diameter and the total root length, (r= 0.08, n= 65, p= 0.5150, 95% CI -0.165-0.320). The correlation between these two variables is not statistically significant.

Mandibular 4th premolars

The size of mandibular 4th premolars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of mandibular 4th premolars. In addition, a univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 50: MD diameters of the mandibular 4th premolars

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.03	1.57	4.80-8.48	4
Khoisan males	6.46	0.03	6.44-6.48	2
Khoisan females	5.83	0.44	5.43-6.49	4
Tswana males	7.35	0.65	5.91-8.58	52
Tswana females	7.2	0.46	6.37-8.08	40
Zulu males	7.31	0.57	5.95-8.53	63
Zulu females	7.20	0.46	6.28-8.08	44
European males	7.13	0.45	6.26-7.96	40
European females	6.89	0.43	6.19-7.64	21

Four Palauan mandibular 4th premolars were available for comparison with the modern human sample. Out of the 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD diameters of the Palau population is greater than the means of the groups measured, except for Tswana and Zulu males. Tswana males have the greatest mean of all the populations measured, whereas Khoisan females have the smallest. European population groups are larger than the Khoisan, but smaller than the remaining human population groups. The females of the modern human sample have means that are smaller than the means of the males of their similar population groups. The standard deviation of the Palau population is larger than those of the modern human populations. The small standard deviations of the modern humans indicate the clustering of the primary data around the means of the different groups.

The MD diameter of the Palauans ranges from 4.8-8.48 mm. Tswana males and Khoisan females range from 5.91-8.58 mm and 5.43-6.49 mm respectively. These ranges indicate that the MD diameter of the Palauans falls within the normal range of modern human variation.

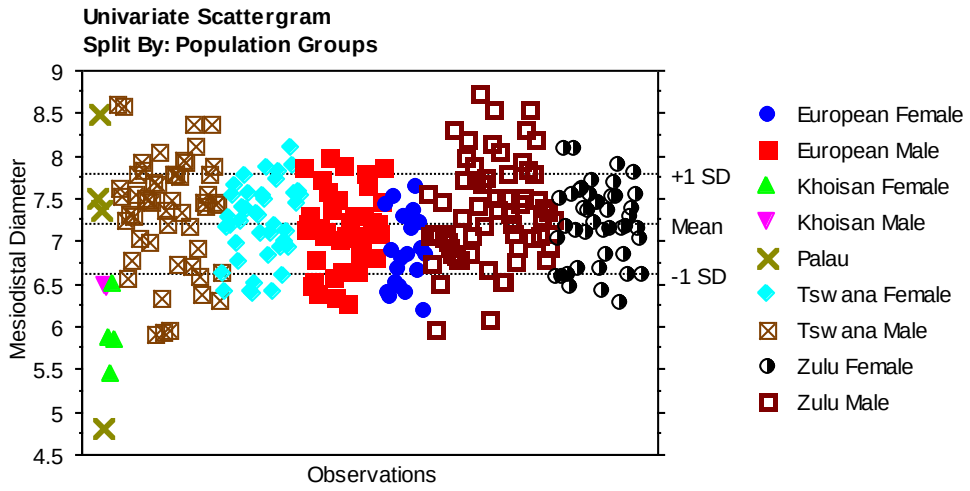

Figure 167: Univariate plot of the MD diameters of the mandibular 4th premolars.

The MD diameter of the Palau population is equal to most of the MD diameters of the modern human populations. Only one is smaller than those of all modern humans. Tswana and Zulu males are similar to each other, and so are the females of these two groups. European population groups are greater than the Khoisan, but smaller than the remaining human populations measured. European males are comparable with Tswana and Zulu females. Khoisan population groups are among the smallest of the modern humans measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in the Europeans and Khoisan.

Table 51: BL diameters of the mandibular 4th premolars

Population groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.33	1.15	7.10-9.82	4
Khoisan males	7.13	0.23	6.96-7.29	2
Khoisan females	7.02	0.22	6.80-7.27	4
Tswana males	8.40	0.58	6.92-9.53	53
Tswana females	8.13	0.62	6.63-9.18	42
Zulu males	8.38	0.60	6.93-9.52	64
Zulu females	8.14	0.61	6.64-9.15	45
European males	8.03	0.69	6.56-9.11	40
European females	7.91	0.67	6.59-9.03	21

Four Palauan mandibular 4th premolars were available for comparison with the modern human sample. Khoisan population groups are the least represented, with only six individuals. The mean of the BL diameters of the Palau population is greater than the means of the entire modern human sample, except Tswana males. It is 0.03 mm smaller than the Tswana males. Tswana males have the highest mean of all the populations measured, whereas the Khoisan females have the lowest. Modern human females have means that are smaller than those of the males. European population groups are larger than the Khoisan, but smaller than the remaining human

population groups. The standard deviation of the Palau population is larger than those of the modern human sample. The rest of the other groups have very small standard deviations, indicating the clustering of primary around the means of these groups.

The BL diameter of the Palauans ranges from 7.1-9.82 mm. Tswana males and Khoisan females range from 6.92-9.37 mm and 6.8-7.27 mm respectively. These ranges indicate that the BL diameter of the Palau population falls within and above the normal range of modern human variation.

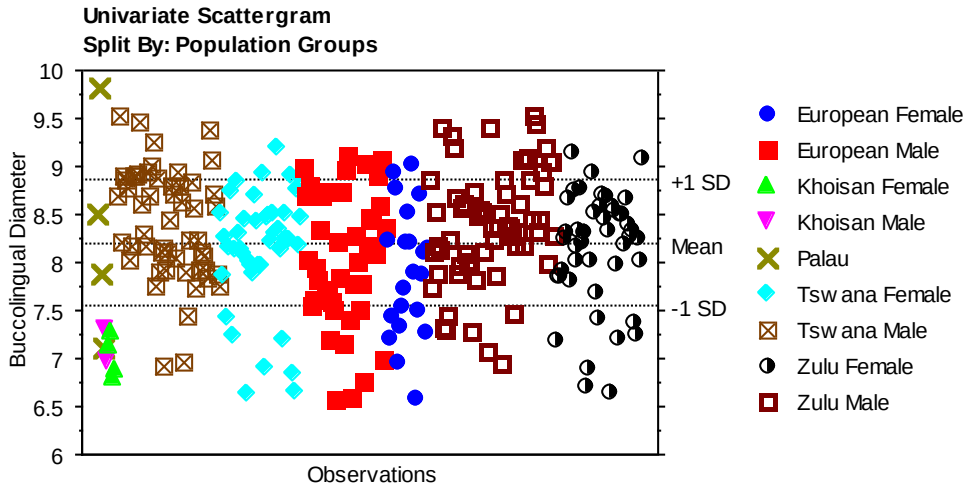

Figure 168: Univariate plot of the BL diameters of the mandibular 4th premolars.

The BL diameter of the Palau population is equal to those of the modern human population groups. One is larger than the entire human sample while others are clustered on the upper end of modern human variation. Tswana and Zulu males are similar to each other and so are the females of these two groups. European population groups are larger than the Khoisan, but smaller than the majority of the Palauan, Tswana and Zulu population groups. Khoisan are among the smallest of the human population groups. Sexual dimorphism is moderate in all of the modern

human groups. The BL diameters of the human populations cover a wide range of variation; and most of the groups are represented across the range, but the majority are clustered in the middle.

Table 52: Crown height of the of the mandibular 4th premolars

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	5.88	0.03	5.86-5.90	2
Khoisan females	5.8	0.36	5.33-6.12	4
Tswana males	7.44	0.71	5.91-8.41	48
Tswana females	6.90	0.52	5.72-8.02	42
Zulu males	7.39	0.64	5.85-8.40	65
Zulu females	6.97	0.61	5.70-7.94	45
European males	6.88	0.64	5.90-7.89	40
European females	6.69	0.70	5.86-7.74	21

No Palauans were available for comparison with the modern human sample, and the Khoisan population was the least represented. The mean of CH of the Tswana males is greater than those of the entire modern human sample. Khoisan females have the lowest mean of all the populations measured. Modern human females have means that are smaller than their male counterparts.

The standard deviations of all the groups measured are very low, indicating the clustering of the primary data around the means of the different groups. Tswana males and Khoisan females range from 5.91-8.41 mm and 5.33-6.12 mm respectively. These ranges indicate that the CH of modern humans is rather variable.

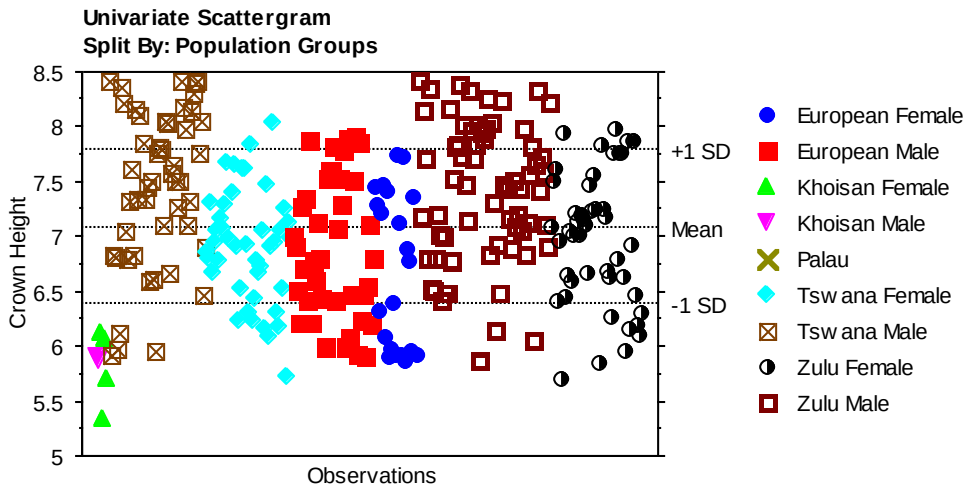

Figure 169: Univariate plot of the crown height of the mandibular 4th premolars.

No Palauans were available for this comparison. The crown heights of the Tswana and Zulu males are very similar to each other. The same applies to the females of these two population groups. European populations are smaller than the Tswanas and Zulus, but larger than the Khoisan, which are clustered among the smallest of the modern humans measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in the Europeans and Khoisan.

Table 53: MD (cej) diameters of the mandibular 4th premolars

Population groups	**MD (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	5.25	0.21	5.10-5.40	2
Khoisan males	5.32	0.07	5.27-5.37	2
Khoisan females	4.91	0.43	4.35-5.25	4
Tswana males	5.85	0.55	5.09-7.76	48
Tswana females	5.69	0.58	4.60-6.93	42
Zulu males	5.88	0.78	5.08-7.77	65
Zulu females	5.64	0.52	4.63-7.01	41
European males	5.58	0.45	4.69-6.44	33
European females	5.47	0.52	4.74-6.35	21

Two Palauan mandibular 4th premolars were available for comparison with the modern human sample. Out of the 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD (cej) diameters of the Palau population is greater than the mean of the Khoisan females, but smaller than those of the rest of the modern human sample. Zulu males have the highest mean of all the populations measured, whereas Khoisan females have the lowest. The females of the modern human sample have means that are smaller than those of the males of their similar groups. The standard deviations of all the populations measured are small, indicating the clustering of primary data around the means of the different groups.

The MD (cej) diameters of the Palau population range from 5.1-5.4 mm. Zulu males and Khoisan females range from 5.08-7.77 mm and 4.35-5.25 mm respectively. These ranges indicate that the MD (cej) diameter of the Palau populations falls within the normal range of modern human variation, but are clustered on the lower end.

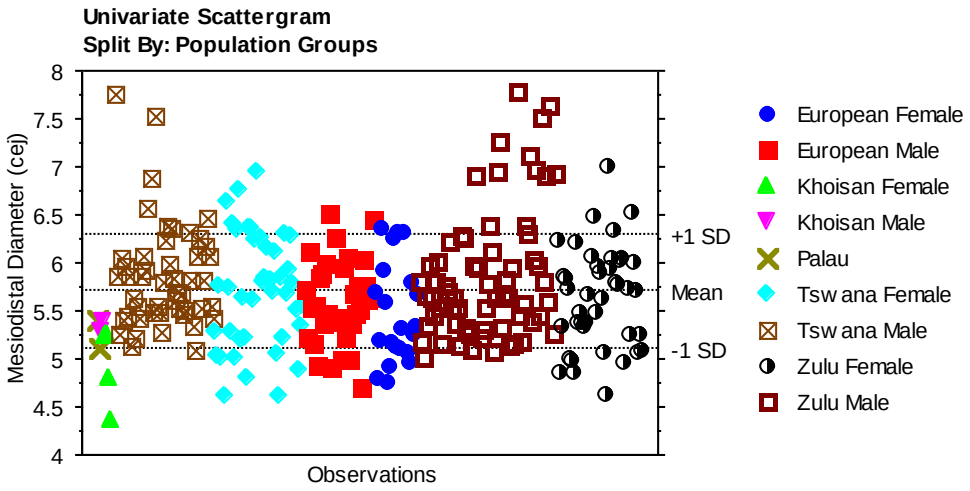

Figure 170: Univariate plot of the MD (cej) diameters of the mandibular 4th premolars.

The MD (cej) diameter of the Palau population is equal to the MD (cej) diameters of the modern human populations, clustered on the lower end of the range of modern human variation. The MD (cej) diameters of the Tswana and Zulu males are similar to each other, and so are those of the females of these two groups. European population groups are smaller than the Tswana and Zulu population groups, on the upper end of the modern human variation. Khoisan population groups are clustered on the lower end of modern human variation, and are equal to the Palauan sample. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 54: BL (cej) diameters of the mandibular 4th premolars

Population groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	6.75	0.35	6.50-7.00	2
Khoisan males	6.25	0.35	6.00-6.49	2
Khoisan females	6.08	0.36	5.74-6.45	4
Tswana males	8.48	0.52	6.72-9.61	52
Tswana females	8.26	0.38	6.85-9.12	42
Zulu males	8.40	0.60	6.97-9.61	64
Zulu females	8.21	0.54	6.87-9.15	43
European males	8.08	0.53	6.98-8.96	40
European females	7.84	0.65	6.97-8.83	20

Two Palauan mandibular 4th premolars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented. The mean of the BL (cej) diameters of the Palau population is greater than the means of the Khoisan, but smaller than those of the remaining modern human groups. Tswana males have the highest mean of all the populations measured, while Khoisan females have the lowest mean. The females of the modern human sample have means that are smaller than those of the males of their similar groups.

The standard deviations of all the populations studied are small, indicating the clustering of primary data around the means of the different groups. The BL (cej) diameters of the Palauans range from 6.5-7.0 mm. Tswana males and Khoisan females range from 6.72-9.61 mm and 5.74-6.45 mm respectively. These ranges indicate that the BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

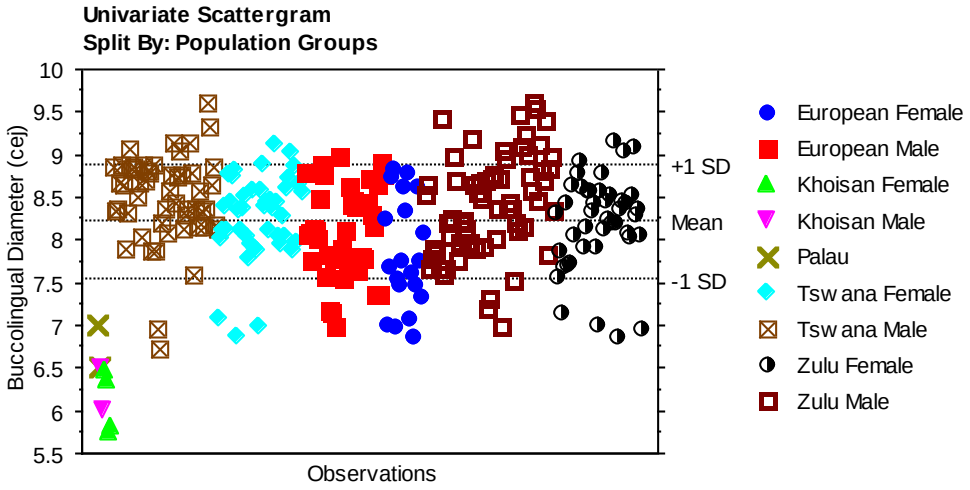

Figure 171: Univariate plot of the BL (cej) diameters of the mandibular 4th premolars.

The BL (cej) diameter of the Palau population is smaller than most of the BL (cej) diameters of the modern human population groups. They are equal to the smallest of the modern human sample. Tswana and Zulu males are similar to each other, and the same applies to the females of these two groups. European population groups are mostly equal to Tswana and Zulu females. Khoisan population groups are the smallest of the modern humans measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in the Europeans and Khoisan.

Table 55: Total root length of the mandibular 4th premolars

Population groups	Total Root Length			
	Mean	***Std dev***	***Range***	***N***
Palau	15.39	0.66	14.92-15.86	2
Tswana males	14.1	1.94	11.54-16.83	5
Tswana females	14.79	0.80	13.92-16.02	5
Zulu males	13.08	1.76	11.05-16.75	8

Two Palauan mandibular 4th premolars were available for comparison with the modern human sample, which comprised only Zulu males and the Tswana population groups. The mean of the total root length of the Palau population is greater than those of the modern human populations. It is followed by Tswana females. The standard deviations of the Tswana and the Zulu males are very high, indicating the scattering of the primary data around the means of the different groups.

The total root length of the Palauans ranges from 14.92-15.86 mm. Tswana females and Zulu males range from 13.92-16.02 mm and 11.05-16.75 mm respectively. These ranges indicate that the total root length of the Palau population falls within the normal range of modern human variation.

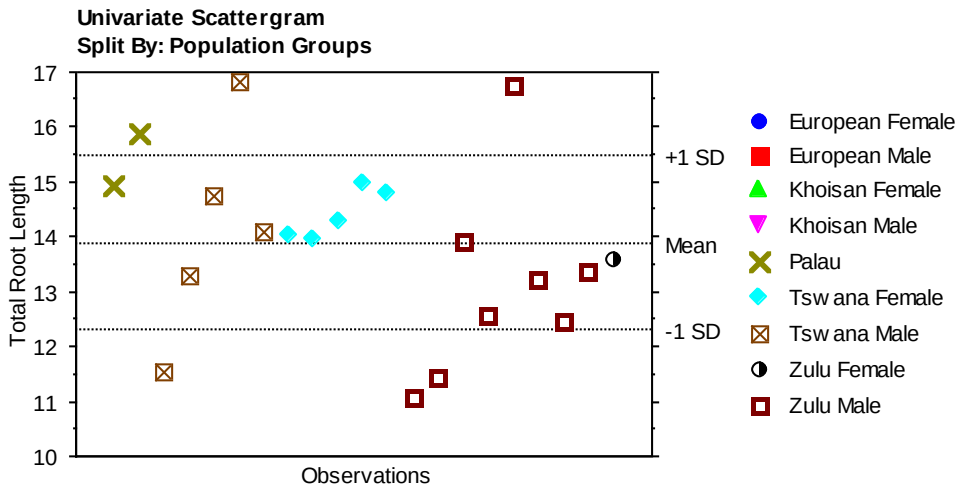

Figure 172: Univariate plot of the total root length of the mandibular 4th premolars.

The total root length of the Palau population is equal to those of the modern human population groups, in particular Tswana and Zulu males. The total root length of the Tswana and Zulu males covers a wide range of variation, whereas Tswana females are clustered together. Most of the Zulu males available are clustered on the lower end of the range of modern human variation, while few are on the upper end.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the mandibular 4th premolars.

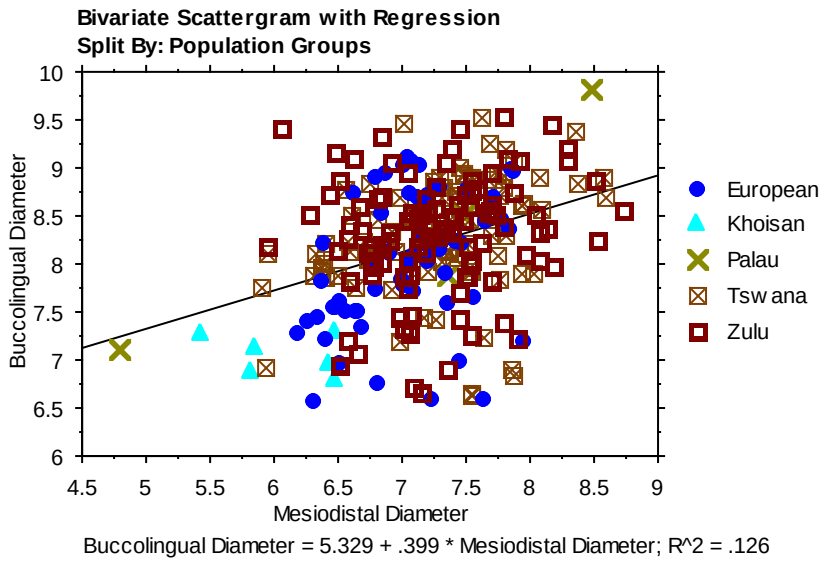

Figure 173: Bivariate plot of the MD and BL diameters of the mandibular 4th premolars.

The MD diameter of the Palau population falls within the range of modern human variation. One is smaller than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and their sample maximums are greater than those of the Europeans and Khoisan. The Europeans are clustered in the middle of the range of modern human variation.The Khoisan population is among the smallest of the modern humans measured.

The BL diameter of the Palau population falls within and above the range of modern human variation. One is smaller than the entire modern human sample. The sample minimums of the Tswana, Zulu and Europeans are similar to one another, while the sample maximum of the latter is smaller than those of the other two populations. The Khoisan population is clustered on the lower end of the range of modern human variation. There is a low positive correlation between the MD and BL diameter of the humans measured, ($r= 0.36$, $n= 269$, $p< 0.0001$, 95 CI 0.246-0.455). The correlation between these two variables is statistically significant.

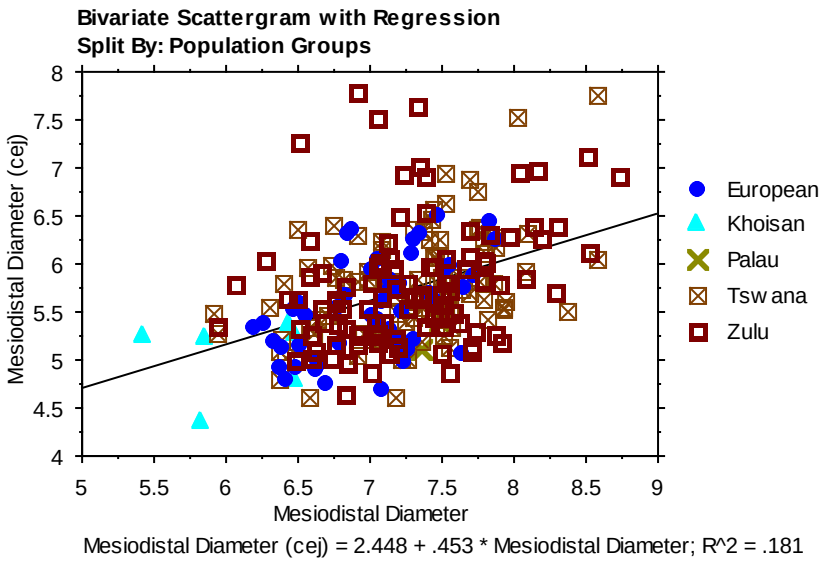

Figure 174: Bivariate plot of the MD and MD (cej) diameters of the mandibular 4th premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation, while the Khoisan are on the lower end. Even though the MD diameter of the Palau population is greater than the Khosan, it is smaller than a few of the European, Tswana and Zulus.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those on the lower end of the range. The sample maximums of the Tswana and the Zulu populations are similar to each other, and are greater than those of the Europeans. The European population is clustered in the middle of the range of modern human variation, while the Khoisan are at the lower end. This makes the difference between the Palau population and the Khoisan the greatest. There is a low positive correlation between the MD and MD (cej)

diameter, (r= 0.43, n= 251, p<0.0001, 95% CI 0.318-0.522). The correlation between these two variables is statistically significant.

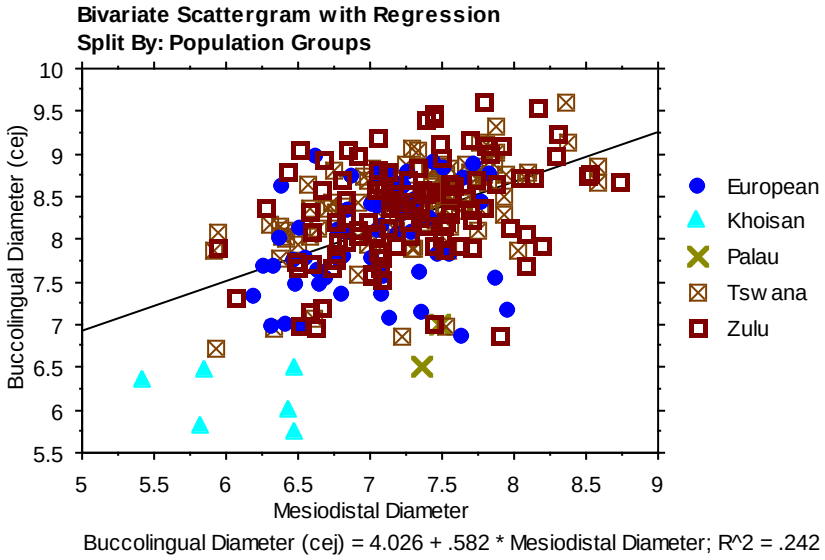

Figure 175: Bivariate plot of the MD and BL (cej) diameters of the mandibular 4th premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are equal to each other, and their sample maximums are greater than those of the Europeans and Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. It is equal to the smallest of the Tswana, the Zulu, and the European populations. The sample minimums of the Tswana, the Zulu and the European populations are similar to one another, but the sample maximums of the Tswana and the Zulu are greater than that of the European. The three populations are evenly distributed along the regression line of

variation, in equal amounts on either side of the line. The Khoisan population is the smallest of the modern humans measured. There is a low positive correlation between the MD and the BL (cej) diameter of the humans measured, (r= 0.49, n= 262, p< 0.0001, 95% CI 0.394-0.578). The correlation between these two variables is statistically significant.

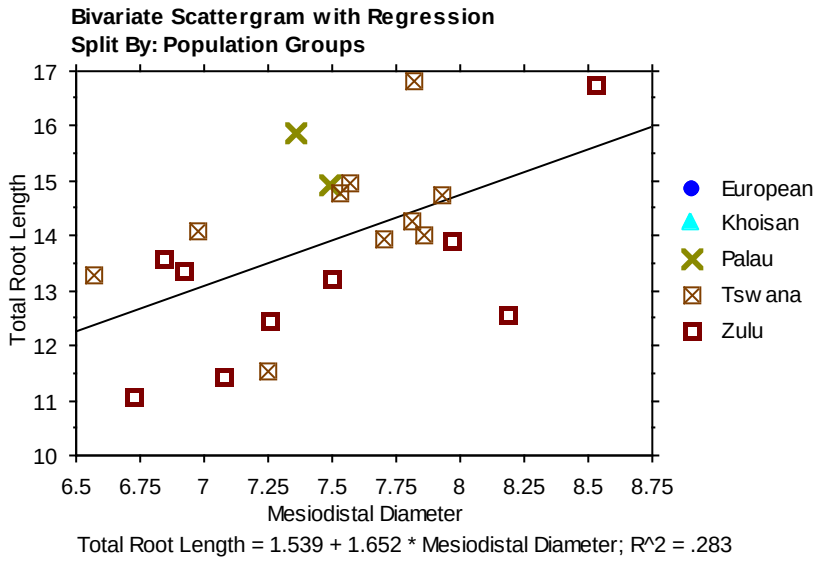

Figure 176: Bivariate plot of the MD diameters and the TRL of the mandibular 4th premolars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The MD diameter of the Tswana and the Zulu populations are similar to each other.

The total root length of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other. There is no difference between the Palau population and the modern humans, indicating a normal total root length for Palauans. There is a moderate positive correlation between the MD diameter and the total root

lengths, (r= 0.53, n= 21, p= 0.0120, 95% CI 0.130-0.784). The correlation between these two variables is statistically significant.

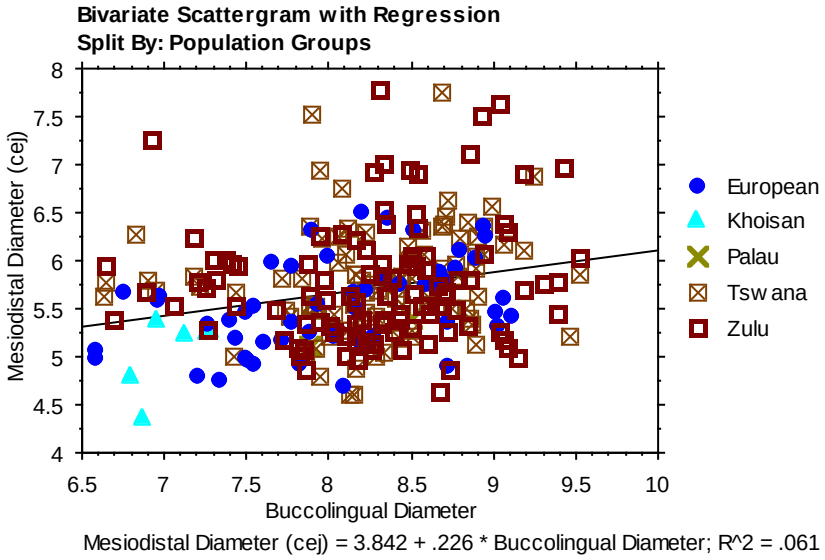

Figure 177: Bivariate plot of the BL and the MD (cej) diameters of the mandibular 4th premolars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The sample minimums of the Tswanas, Zulus and Europeans are similar to one another, while the sample maximum of the latter is smaller than those of the other two populations. The Khoisan population is clustered at the lower end of the range of modern human variation.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and they are larger than the European and Khoisan. The Europeans are clustered in the middle of the range of modern human variation, while the Khoisan are at the lower end. There is a low positive correlation between the BL and MD (cej) diameter of the humans measured, (r= 0.25, n= 256, p<

0.0001, 95% CI 0.128-0.359). The correlation between these two variables is statistically significant.

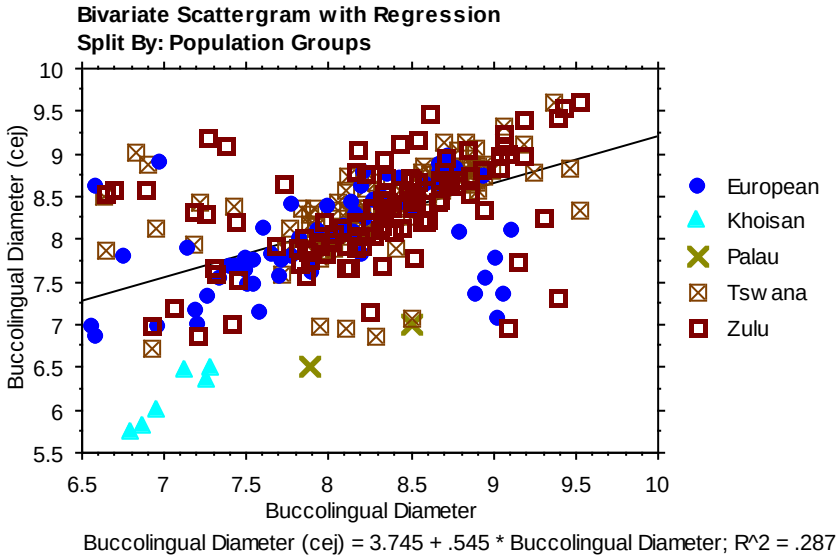

Figure 178: Bivariate plot of the BL and the BL (cej) diameters of the mandibular 4th premolars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana, Zulu and the European populations are similar to each other, but the sample maximums of the Tswana and the Zulu are a few millimetres larger than the Europeans. The Khoisan population is at the lower end of the range of modern human variation.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The sample minimums of the Tswana, the Zulu and the European populations are equal to one another, but the sample maximums of the Tswana and the Zulu are greater than that of the Europeans. The Khoisan population is the smallest of the modern humans measured. There is a moderate positive correlation between the BL and BL (cej) diameters, (r= 0.54, n=

269, p< 0.0001, 95% CI 0.445-0.616). The correlation between these two variables is statistically significant.

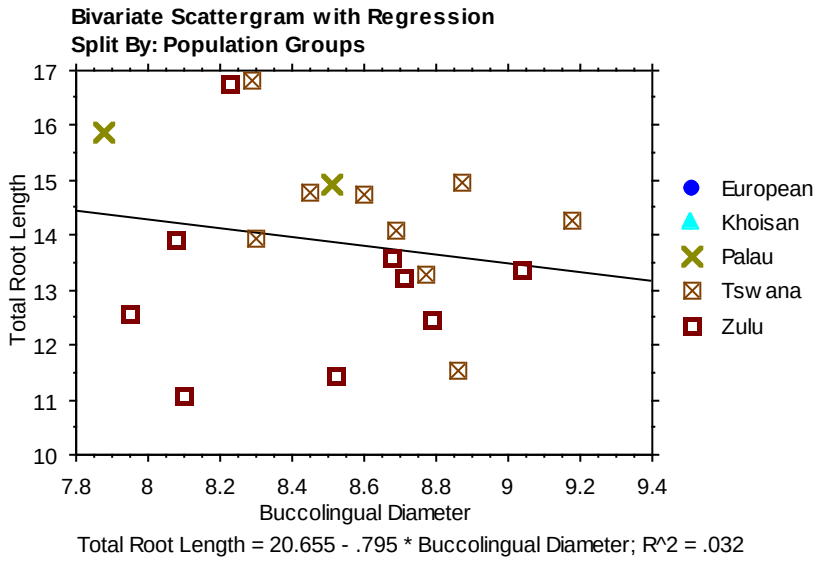

Figure 179: Bivariate plot of the BL diameters and the TRL of the mandibular 4th premolars.

The BL diameter of the Palau population falls within the range of modern human variation. One is smaller than the entire modern human sample. The BL diameter of the Tswana and the Zulu populations are similar to each other, and a few are larger than the Palau population.

The total root length of the Palau population falls at the upper end of the range of modern human variation. There is little difference between the Tswana and the Zulu populations, since the Zulus are clustered on the lower end of the range of modern human variation. There is a low negative correlation between the BL diameter and the total root length, (r= -0.18, n= 20, p= 0.4584, 95% CI -0.575-0.287). The correlation between these two variables is not statistically significant.

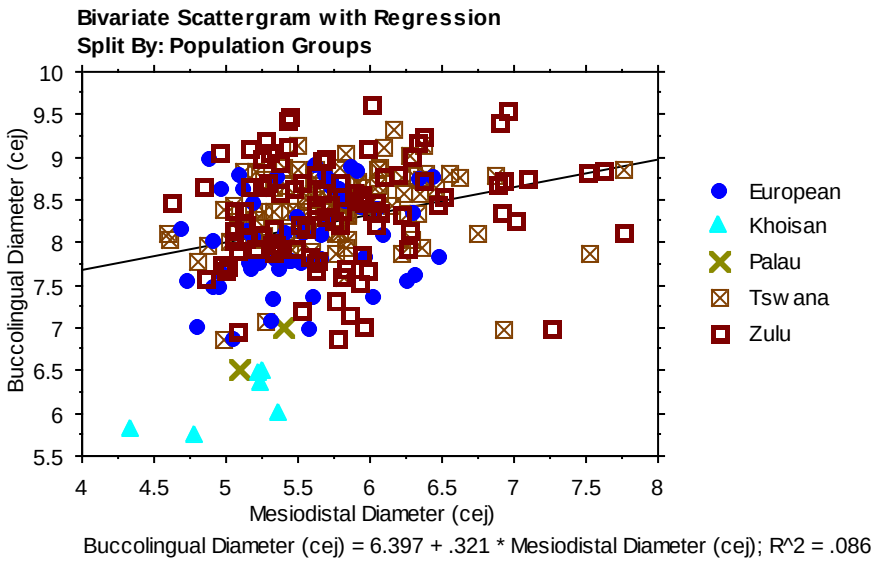

Figure 180: Bivariate plot of the MD (cej) and the BL (cej) diameters of the mandibular 4th premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are larger than the Europeans and Khoisan. The Europeans are clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana, Zulu and the European populations are similar to each other, but the sample maximums of the former two are larger than that of the Europeans. The Khoisan are the smallest of the modern humans measured. There is a low positive correlation between the MD (cej) diameter and the BL (cej) diameter, (r= 0.29, n= 255, p< 0.0001, 95% CI 0.176-0.401). The correlation between these two variables is statistically significant.

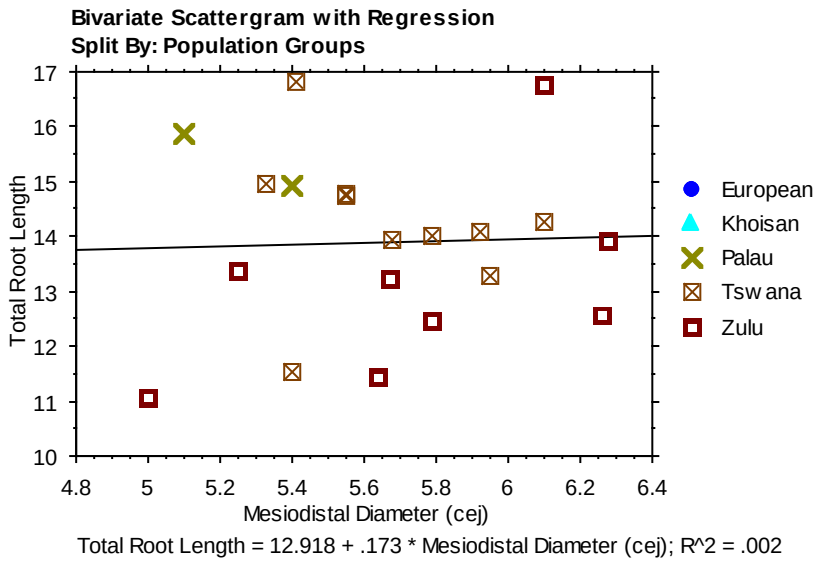

Figure 181: Bivariate plot of the MD (cej) diameters and the TRL of the mandibular 4th premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Palau population.

The total root length of the Palau population falls at the upper end of the range of modern human variation. It is equal most Tswana population and few Zulu populations. Majority of the Zulu population are smaller than the Palau and Tswana populations, and are at the lower end of the range of modern human variation. There is a very low positive correlation between the MD (cej) diameter and the total root length, (r= 0.04, n= 20, p= 0.8708, 95% CI -0.410-0.474). The correlation between these two variables is not statistically significant.

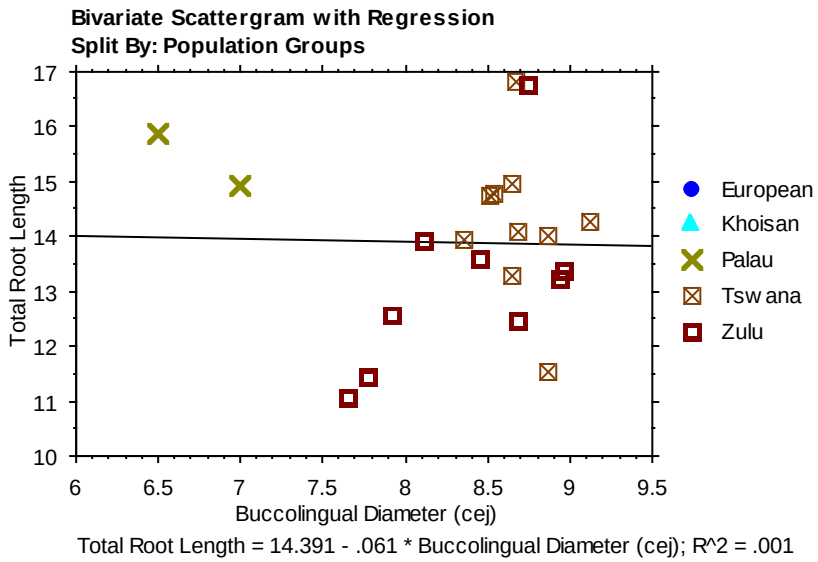

Figure 182: Bivariate plot of the BL (cej) diameters and the TRL of the mandibular 4th premolars.

The BL (cej) diameters of the Palau population falls below the range modern human variation. It is smaller than the entire modern human sample. The BL (cej) diameter of the Tswana and the Zulu populations are similar to each other.

The total root length of the Palau population falls at the upper end of the range of modern human variation. It is equal to most of the Tswana and a few of the Zulu populations. The majority of the Zulu population are below the expected slope of variation, and are smaller than the Tswana and Palau populations. There is a very low negative correlation between the BL (cej) diameter and the total root length, (r= -0.03, n= 21, p= 0.9126, 95% CI -0.453-0.410). The corrrelation between these two variables is not statistically significant.

Maxillary 4th premolars

The size of maxillary 4th premolars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in tables for each population group for comparison with the Palauan sample of maxillary 4th premolars. In addition, a univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 56: MD diameters of the maxillary 4th premolars

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	7.61	0.51	7.20-8.30	5
Khoisan males	5.81	0.60	5.01-6.51	6
Tswana males	6.87	0.50	6.06-7.87	51
Tswana females	6.54	0.27	6.10-7.05	33
Zulu males	6.84	0.51	5.99-7.83	69
Zulu females	6.58	0.34	5.97-7.09	50
European males	6.4	0.42	5.50-7.02	42
European females	6.18	0.33	5.57-6.94	15

Five Palauan maxillary 4th premolars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD diameters of the Palau population is greater than the means of the entire modern human sample. It is followed by the mean of the Tswana males. Khoisan males have the smallest mean of all the populations measured. The females of the modern humans have means that are smaller than those of their male counterparts.

The standard deviations of all the populations measured are small, indicating the clustering of primary data around the means of the different groups.

The MD diameter of the Palau population ranges from 7.2-8.3 mm. Tswana and Khoisan males range from 6.06-7.87 mm and 5.01-6.51 mm respectively. These ranges indicate that the MD diameter of the Palau population falls within and above the normal range of modern human variation.

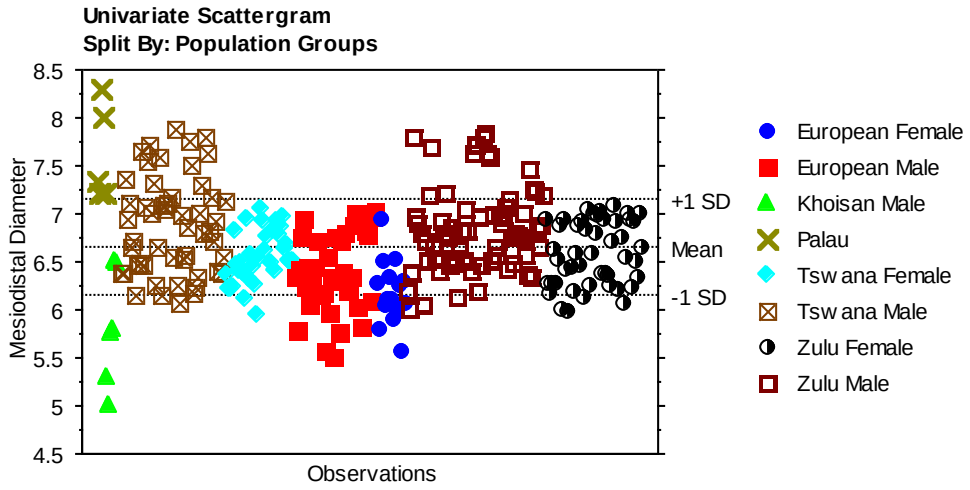

Figure 183: Univariate plot of the MD diameters of the maxillary 4th premolars.

The MD diameters of the Palau population are larger than most of the MD diameters of the modern human population groups. Some are equal to those of the modern humans. Tswana and Zulu males are very similar, and so are the females of these two groups. European males are similar to the Tswana and Zulu males. Khoisan males are clustered on the lower end of modern human variation. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in Europeans, as evidenced by the ranges of the males and females of similar groups in the table above.

Table 57: BL diameters of the maxillary 4th premolars

Population groups	BL Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	9.83	0.43	9.2-10.12	4
Khoisan males	8.18	0.35	7.72-8.73	6
Tswana males	9.14	0.50	8.13-9.91	51
Tswana females	9.07	0.37	8.38-9.64	34
Zulu males	9.16	0.48	8.15-9.93	68
Zulu females	9.06	0.37	8.34-9.62	50
European males	8.86	0.45	7.81-9.57	43
European females	8.57	0.59	7.76-9.48	15

Four Palauan maxillary 4th premolars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only six individuals. The mean of the BL diameters of the Palau population is greater than the means of all the modern human populations. It is followed by Zulu males. Khoisan males have the smallest mean of all the populations measured. European populations are larger than the Khoisan males, but smaller than the rest of the remaining human populations. The females of the modern humans are smaller than the males of their similar groups.

The standard deviations of all the populations studied are very low, indicating the clustering of primary data around the means of the different groups. The BL diameters of the Palauans range from 9.20-10.12 mm. Zulu and Khoisan males range from 8.15-9.93 mm and 7.72-8.73 mm respectively. These ranges indicate that the BL diameter of the Palau population falls within and above the normal range of modern human variation.

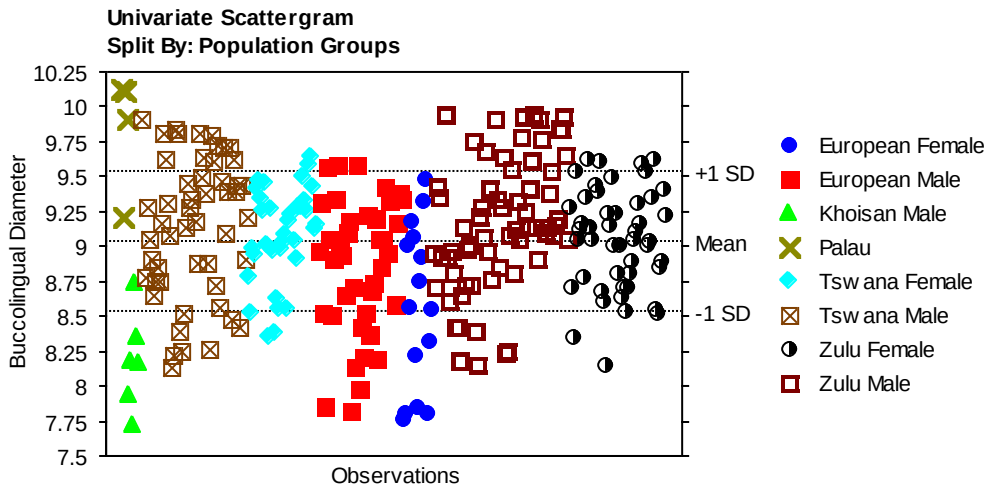

Figure 184: Univariate plot of the BL diameters of the maxillary 4th premolars.

The BL diameters of the Palau population are larger than those of the BL diameters of the modern humans. Two are equal to the modern humans on the upper end of modern human variation. Tswana and Zulu males are similar to each other, and so are the females of these two groups. Khoisan males are among the smallest of the modern humans measured. Sexual dimorphism is moderate in Tswanas and Zulus, and very low in the Europeans. This is evidenced by the following ranges: Tswana males and females range from 8.13-9.91 mm and 8.38-9.64 mm respectively, while European males and females from 7.81-9.57 mm and 7.76-9.48 mm respectively.

Table 58: Crown height of the of the maxillary 4th premolars

Population groups	Crown Height			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	5.91	0.43	5.42-6.39	6
Tswana males	7.46	0.69	6.33-8.99	47
Tswana females	7.10	0.62	5.91-8.48	34
Zulu males	7.46	0.73	6.20-8.92	70
Zulu females	7.12	0.68	5.97-8.43	50
European males	6.98	0.72	5.73-8.32	42
European females	6.81	0.61	5.81-7.61	15

Only one Palau specimen was available for comparison with the modern humans, and is plotted on the univariate graph below. The Khoisan population was the least represented, with only six individuals. Tswana and Zulu males have the highest mean of the entire modern human populations, while Khoisan males have the lowest. European population groups are larger than the Khoisan males, but smaller than the remaining modern humans groups. The females of the modern humans have means that are smaller than those of the males of their similar groups.

The standard deviations of all the groups measured are small, indicating the clustering of primary data around the means of the different groups. The only available crown height of the Palauans is 8.54 mm, and it falls within the normal range of modern human variation. Tswana and Zulu males range from 6.33-8.99 mm and 6.20-8.92 mm respectively. Khoisan males range from 5.42-6.39 mm. These ranges indicate that the crown height of modern humans covers a wide range of variation.

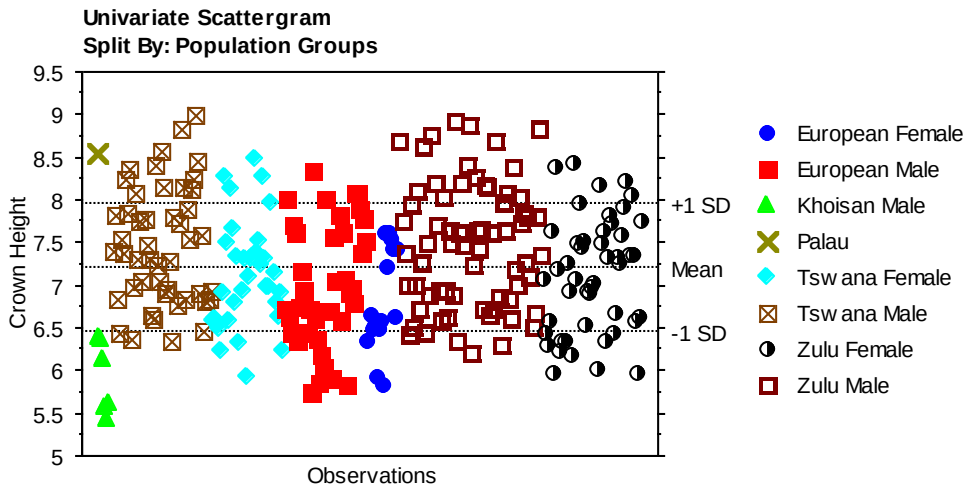

Figure 185: Univariate plot of the crown height of the maxillary 4th premolars.

The only available crown height of the Palau population is equal to the crown height of the modern humans on the upper range of the range of modern human variation. Tswana and Zulu males are similar to each other, and the same applies to the females of these two groups. European males are to some extent similar Tswana and Zulu females. Khoisan males are among the smallest of the modern humans measured. Sexual dimorphism is moderate in Tswanas and Zulus, but extensive in the Europeans. The following ranges support this claim: Zulu males and females range from 6.2-8.92 mm and 5.97-8.43 mm, whereas European males and females from 5.73-8.32 mm and 5.81-7.61 mm respectively.

Table 59: MD (cej) diameters of the maxillary 4th premolars

Population groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	4.79	0.49	4.12-5.55	6
Tswana males	5.52	0.53	4.70-6.82	50
Tswana females	5.24	0.60	4.52-6.47	33
Zulu males	5.52	0.59	4.66-6.81	70
Zulu females	5.21	0.53	4.41-6.47	51
European males	5.16	0.55	4.35-6.26	41
European females	5.04	0.66	4.14-6.13	15

Only one Palauan was available for comparison with the modern human sample, and is plotted on the univariate graph below. The Khoisan population was the least represented, with only six individuals. Tswana and Zulu males have the greatest means of all the populations measured, and are equal. Khoisan males have the smallest mean of all the modern populations measured. The females of the modern humans have means that are smaller than those of the males of their similar groups.

The standard deviations of all the groups measured are low, indicative of the clustering of primary data around the mean of the different groups. Tswana and Khoisan males range from 4.7-6.82 mm and 4.12-5.55 mm respectively. The MD (cej) diameter of the only available Palauan is 4.9 mm, and it falls within the normal range of modern human variation.

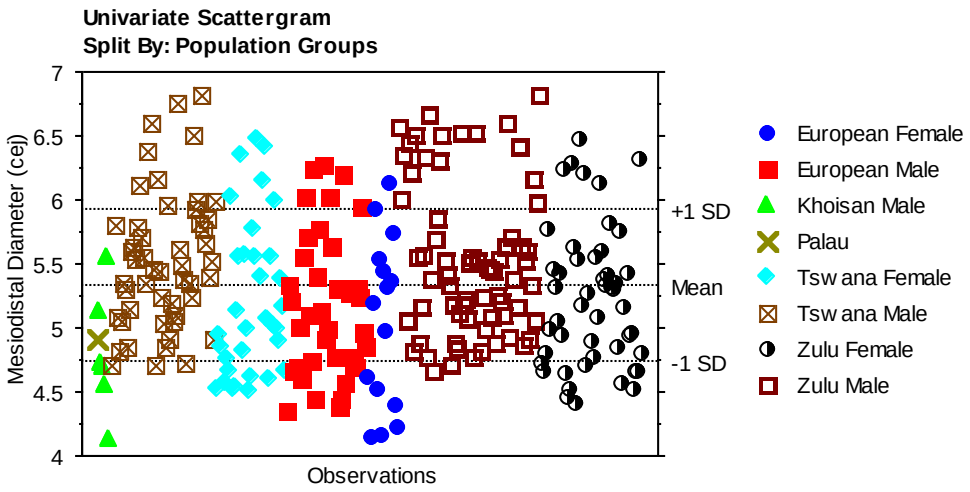

Figure 186: Univariate plot of the MD (cej) diameters of the maxillary 4th premolars.

The only available MD (cej) diameter of the Palau population is equal to most of the MD (cej) diameters of the modern humans on the lower end of modern human variation. Tswana and Zulu males are equal to each other, and so are the females of these two groups. Khoisan males are clustered among the smallest of the modern humans, but two are larger than the only available Palauan. Sexual dimorphism is moderate in Tswanas and Zulus, but very low in Europeans, evidenced by the following ranges: Tswana males and females range from 4.7-6.82 mm and 4.52-6.47 mm, whereas European males and females range from 4.35-6.26 mm and 4.14-6.13 mm respectively.

Table 60: BL (cej) diameters of the maxillary 4th premolar

Population groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	8.7	0.62	8.00-9.20	3
Khoisan males	8.22	0.41	7.59-8.82	6
Tswana males	9.37	0.42	8.43-10.04	51
Tswana females	9.23	0.44	8.37-9.96	32
Zulu males	9.35	0.52	8.46-10.08	68
Zulu females	9.24	0.36	8.47-9.91	50
European males	9.1	0.48	7.99-9.87	43
European females	8.89	0.68	7.94-9.79	15

Three Palauan maxillary 4th premolars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only six individuals. The mean of the BL (cej) diameters of the Palau population is greater than the mean of the Khoisan males, but smaller than those of all the remaining modern humans measured. Tswana males have the highest mean of all the populations measured, whereas Khoisan males have the lowest. European population groups are smaller than the Palauans, Tswanas and Zulus, but larger than the Khoisan. The females of the modern humans are smaller than the males of their similar groups.

The standard deviations of all the groups measured are low, indicating the clustering of primary data around the means of the different groups. The BL (cej) diameter of the Palauans ranges from 8.0-9.2 mm, while Tswana and Khoisan males range from 8.43-10.04 mm and 7.59-8.82 mm respectively. These ranges indicate that the BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

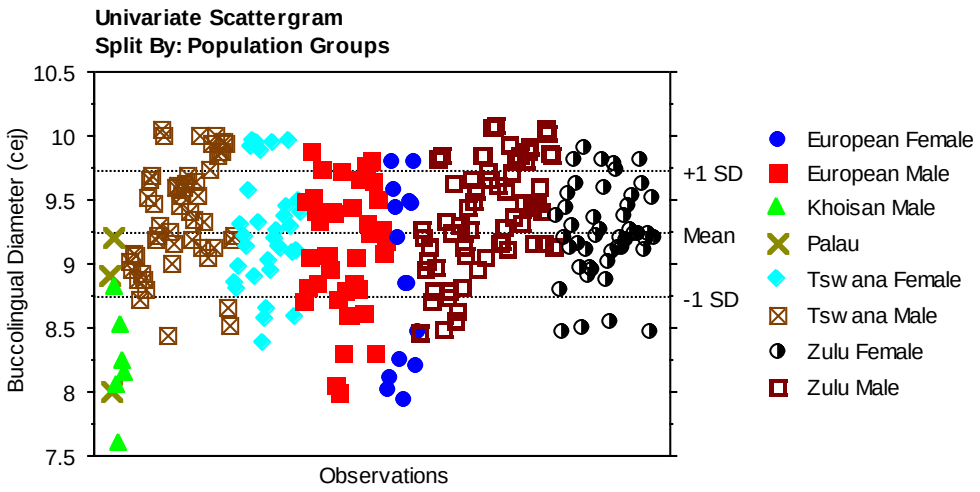

Figure 187: Univariate plot of the BL (cej) diameters of the maxillary 4th premolars.

The BL (cej) diameters of the Palau population are equal to most of the BL (cej) diameters of the modern human population groups, clustered in the middle of the range of modern human variation. One of the Palauans is equal to modern humans on the lower end. Tswana and Zulu males are similar to each other, and so are the females of these two groups. Khoisan males are among the smallest of the modern humans measured. Sexual dimorphism is very low in Tswanas, Zulus and Europeans.

Table 61: Total root length of the maxillary 4th premolars

Population groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau				
Tswana males	15.1	1.93	13.44-18.20	5
Tswana females	13.16	0.76	12.43-14.57	7
Zulu males	14.84	1.94	12.33-18.44	16
Zulu females	13.51	0.41	13.11-14.01	7

No Palauans were available for comparison with the modern human sample, and only the Tswana and Zulu population groups were available. Tswana males have the highest mean of all the populations measured, whereas Tswana females have the lowest. The females of these two groups are smaller than the males of their similar groups. The standard deviations of the males of the modern humans are high, indicating the dispersal of primary data around the means of the different groups. Tswana males and females range from 13.44-18.20 mm and 12.43-14.57 mm respectively. These ranges indicate that the total root length of the maxillary 4th premolars is extremely variable in modern humans.

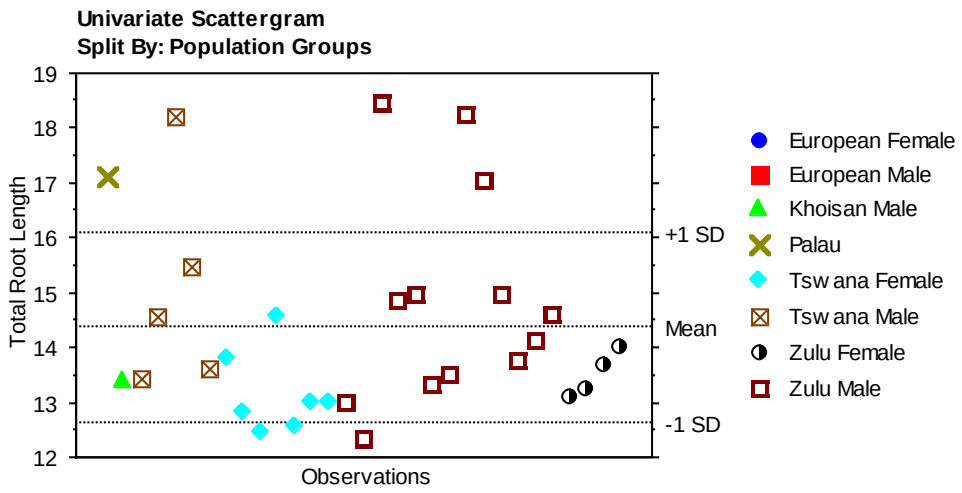

Figure 188: Univariate plot of the total root length of the maxillary 4th premolars.

The only available total root length of the Palau population is equal to some of the total root lengths of Tswana and Zulu males. Tswana and Zulu males are similar to each other, so are the females of these two groups. Sexual dimorphism is extensive in Tswanas and Zulus. The total root lengths of the modern humans cover a wide range of variation.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the maxillary 4th premolars.

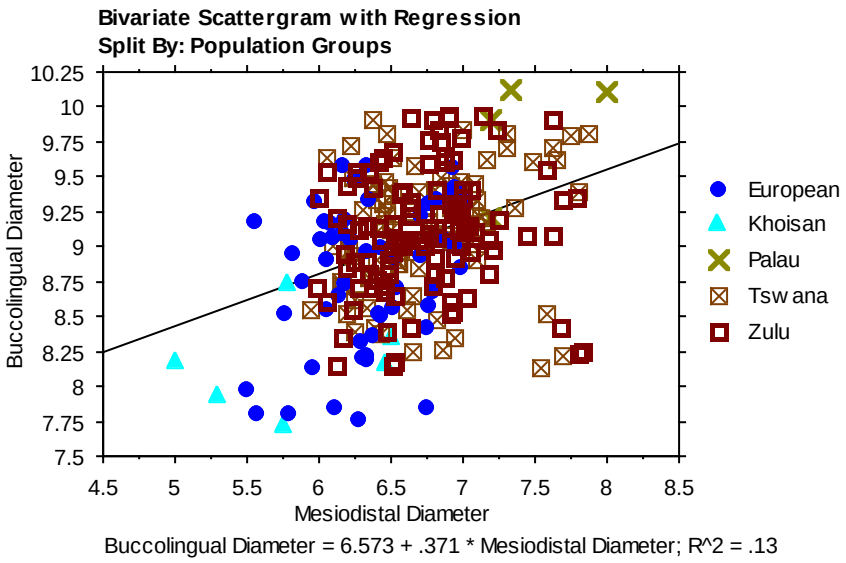

Figure 189: Bivariate plot of the MD and BL diameters of the maxillary 4th premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of the modern human variation. The Khoisan population is among the smallest of the modern humans measured, thus making the difference between them and the Palau population the greatest.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. Two are greater than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and Khoisan. The

European population is clustered in the middle of the range of modern human variation, but few are as small as the Khoisan. The Khoisan population is among the smallest of the modern humans measured, therefore making the difference between them and the Palau population the greatest. There is a low positive correlation between the MD and the BL diameter, (r= 0.36, n= 257, p< 0.0001, 95% CI 0.249-0.463). The correlation between these variables is statistically significant.

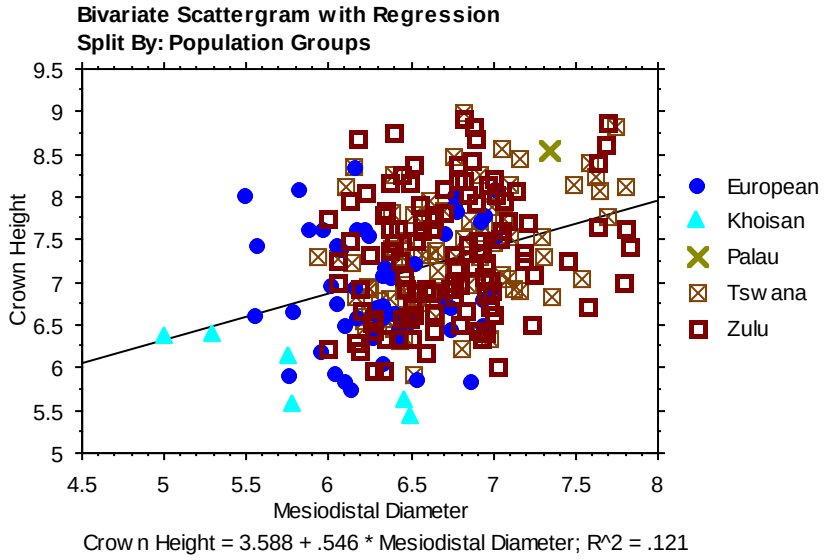

Figure 190: Bivariate plot of the MD diameters and the CH of the maxillary 4th premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are greater than the European and Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is at the lower end of the range, thus making the difference between them and the Palau population the greatest.

The crown height of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are equal to each other, and their sample maximums are greater than those of the Europeans and the Khoisan. The Khoisan population is among the smallest of the modern humans measured, therefore making the difference between them and the Palau population the greatest. There is a low positive correlation between the MD diameter and the crown height, (r= 0.35, n= 250, p< 0.0001, 95% CI 0.234-0.452). The correlation between these variables is statistically significant.

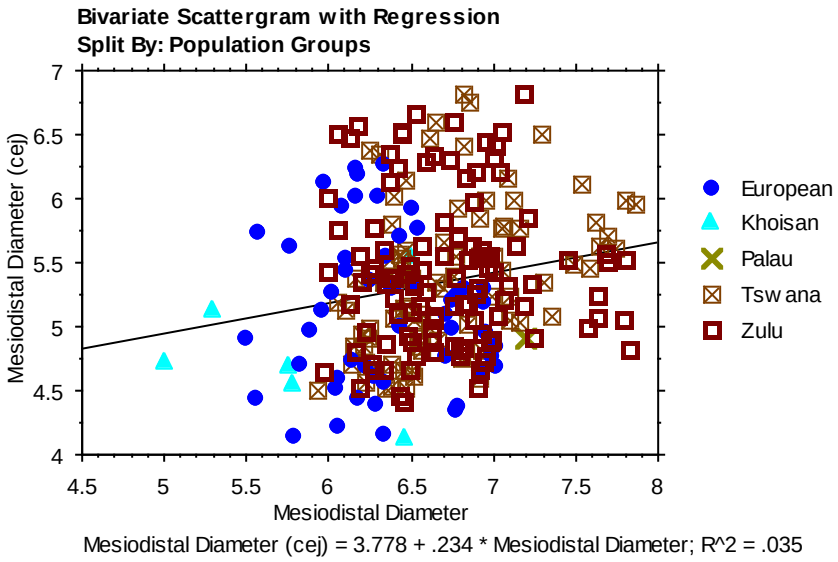

Figure 191: Bivariate plot of the MD and the MD (cej) diameters of the maxillary 4th premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and Zulu populations are similar to each other, and are greater than the European and the Khoisan. The European population is clustered in the middle of the range of modern human variation, whereas the Khoisan is at the lower end. The difference between the Palau population and the modern humans populations is the greatest when the Palauans are compared to the Khoisan.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and Khoisan. The European population is evenly distributed along the regression line, just like the Tswana and the Zulu. Its sample maximum is smaller than those of the latter two populations. The Khoisan population is among the smallest of the modern humans measured, and this makes the difference betweeen them and the Palau population the greatest. There is a low positive correlation between the MD and the MD (cej) diameter, (r= 0.19, n= 255, p= 0.0026, 95% CI 0.066-0.303). The correlation between these two variables is statistically significant.

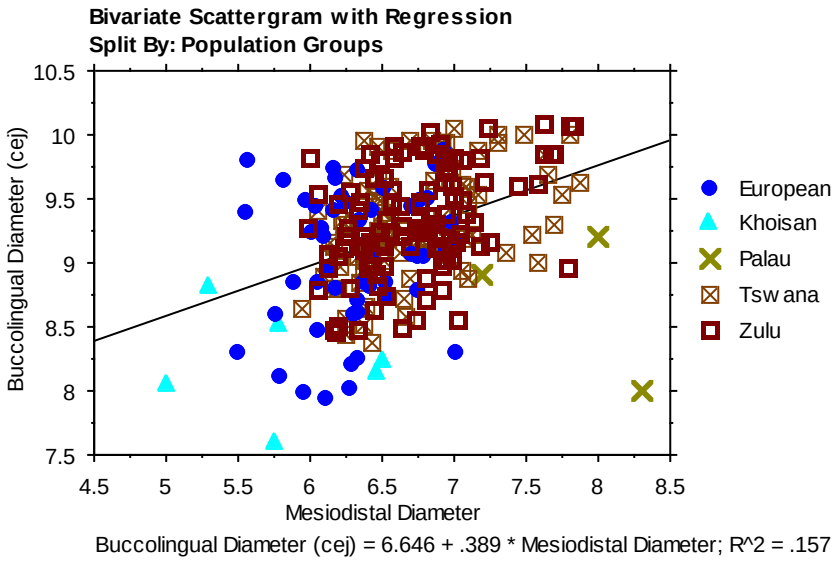

Figure 192: Bivariate plot of the MD and the BL (cej) diameters of the maxillary 4th premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. One is greater than the entire modern human sample. The Tswana and Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The

Europeans and the Khoisan populations are clustered in the middle and the lower end of the range of modern human variation respectively.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and Zulu populations are similar to each other, and are slightly greater than the European. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the MD and the BL (cej) diameter of the humans measured, (r= 0.40, n= 255, p< 0.0001, 95% CI 0.287-0.495). The correlation between these two variables is statistically significant.

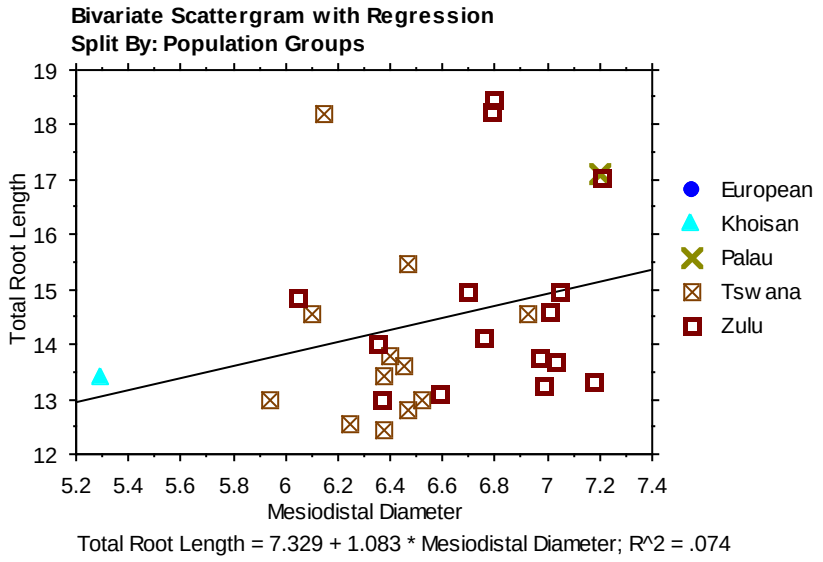

Figure 193: Bivariate plot of the MD diameters and the TRL of the maxillary 4th premolars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar toeach other, and are greater than the Khoisan. The Khoisan population is the smallest of the modern humans, and this makes the difference between them and the Palau population the greatest.

The total root length of the Palau population falls at the upper end of the range of the modern human variation. The Tswana and the Zulu populations are similar to each other, and few are equal to the only available Khoisan. The Khoisan population is at the lower end of the range of modern human variation. There is a low positive correlation between the correlation between the MD diameter and the total root length, (r= 0.27, n= 29, p= 0.1543, 95% CI -0.105-0.581). The correlation between these two variables is not statistically significant.

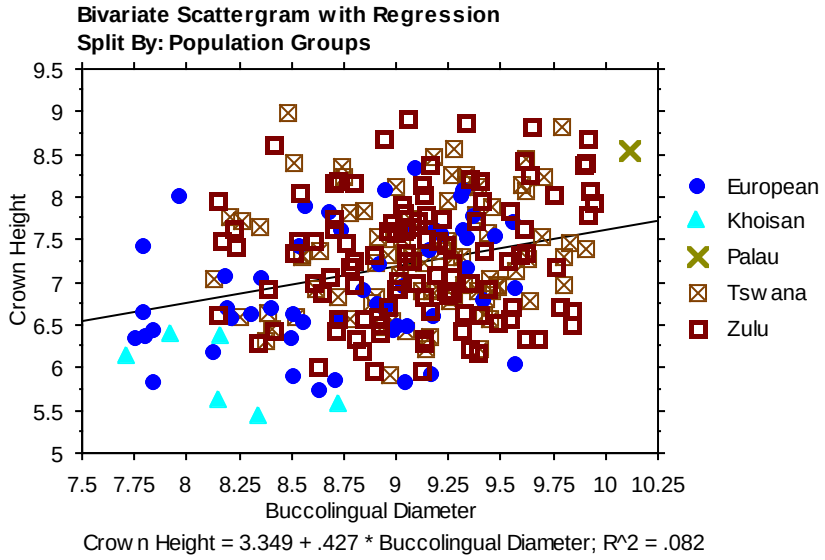

Figure 194: Bivariate plot of the BL diameters and the CH of the maxillary 4th premolars.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured, therefore making the difference between them and the Palau population the greatest.

The crown height of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and their sample maximums are greater than those of the Europeans and the Khoisan. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the BL diameter and the crown height, (r= 0.29, n= 252, p< 0.0001, 95% CI 0.169-0.396). The correlation between these two variables is statistically significant.

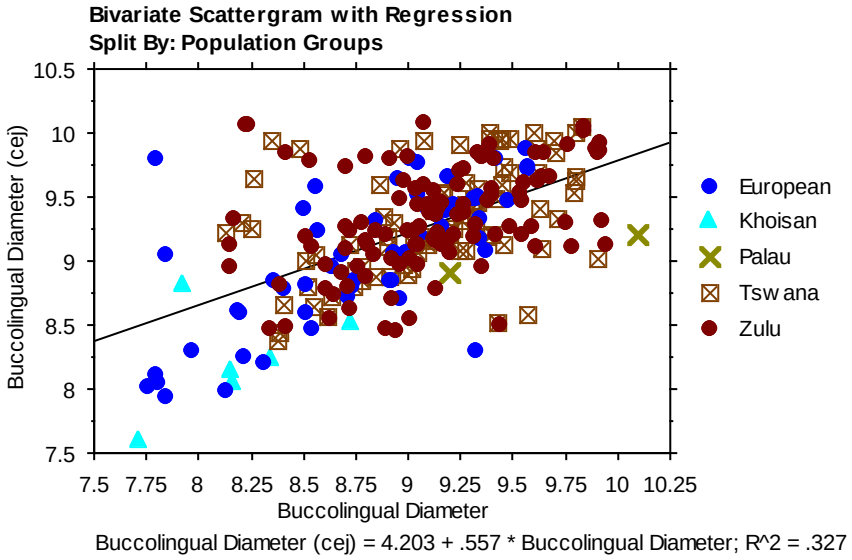

Figure 195: Bivariate plot of the BL and the BL (cej) diameters of the maxillary 4th premolars.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater that the Europeans and Khoisan. The Khoisan population is among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana, Zulu and the European populations are similar to each other, though the sample minimums of the former two are greater than than of

the latter. The Khoisan population is clustered at the lower end of the range of modern human. There is a low positive correlation between the BL and the BL (cej) diameter, (r= 0.57, n= 258, p< 0.0001, 95% CI 0.483-0.649). The correlation between these two variables is statistically significant.

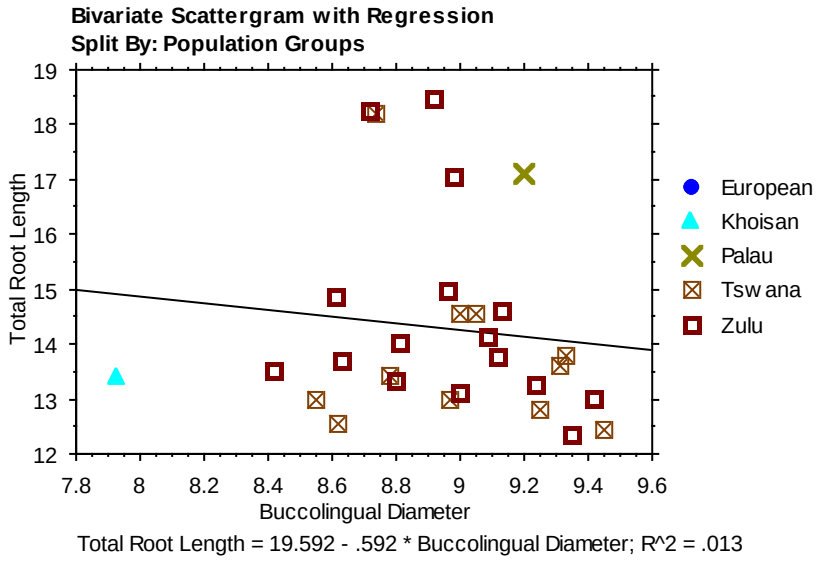

Figure 196: Bivariate plot of the BL diameters and the TRL of the maxillary 4th premolars.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Khoisan.

The total root length of the Palau population falls at the upper end of the range of modern human variation. The Tswana population and the Zulu populations are similar to each other. A few of these two groups are greater than the Khoisan, but some are equal to them. There is a low negative correlation between the BL diameter and the total root length, (r= -0.11, n= 29, p=

0.5652, 95% CI 0.460-0.265). The correlation between these two variables is not statistically significant.

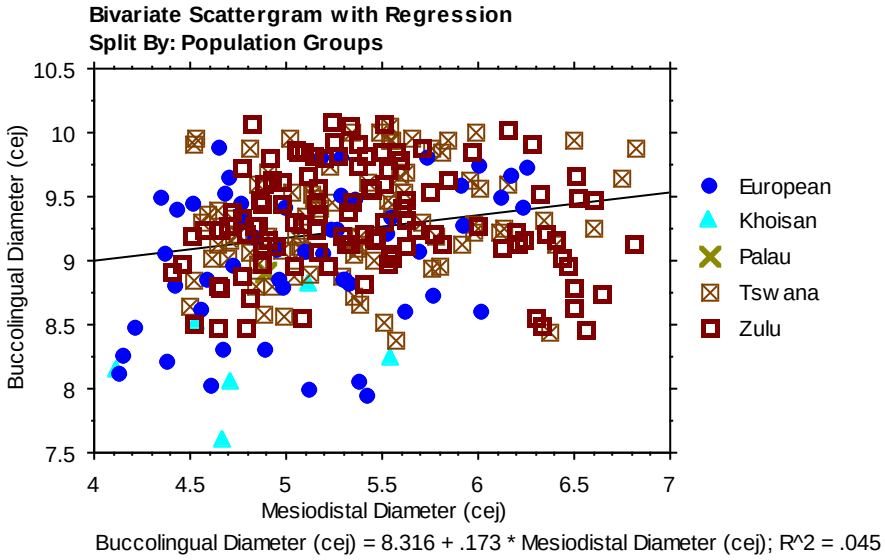

Figure 197: Bivariate plot of the MD (cej) diameter and the BL (cej) diameter of the maxillary 4th premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and their sample maximums are greater than those of the Europeans and Khoisan. The European and the Khoisan populations are clustered on the lower end of the range of modern human variation, while the Europeans extend towards the middle of the range.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, and are to some extent greater than the Europeans. The Khoisan population is clustered on the lower end of the range of modern human variation. There is a low positive

correlation between the MD (cej) and the BL (cej) diameter, (r= 0.21, n= 253, p= 0.0007, 95% CI 0.090-0.326). The correlation between these two variables is statistically significant.

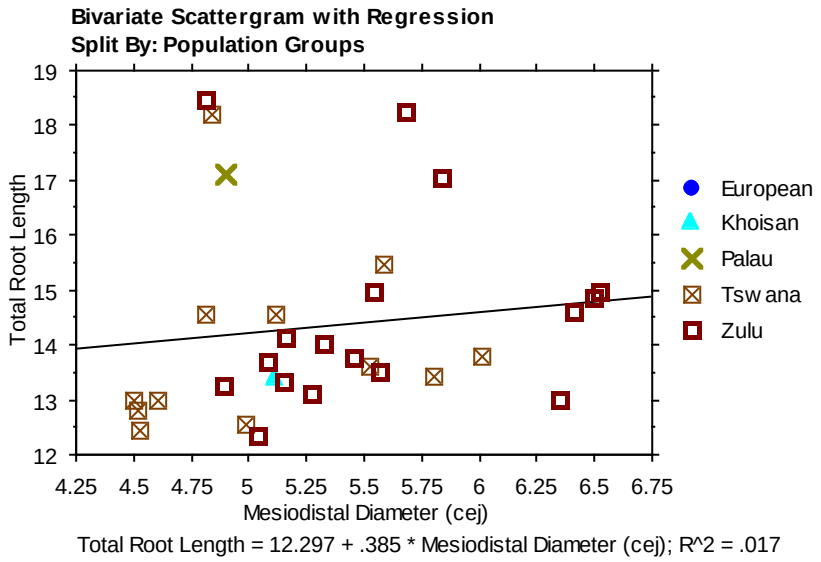

Figure 198: Bivariate plot of the MD (cej) and the TRL of the maxillary 4th premolars.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and majority are greater than the only available Khoisan.

The total root length of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the MD (cej) diameter and the total root length of the humans measured, (r= 0.13, n= 31, p= 0.4894, 95% CI -0.235-0.463). The correlation between these two variables is not statistically significant.

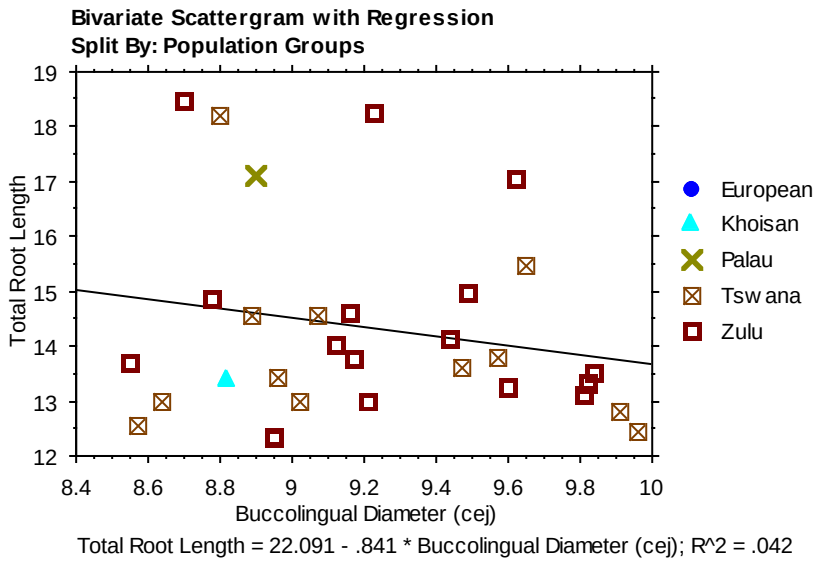

Figure 199: Bivariate plot of the BL (cej) diameters and the TRL of the maxillary 4th premolars.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are grreater than the only available Khoisan. The Khoisan population is among the smallest of the modern humans measured.

The total root length of the Palau population falls at the upper end of the range of modern human variations. The Tswana and the Zulu populations are similar to each other. Majority of these two populations are clustered at the lower end of the range, with the only available Khoisan. There is a low positive correlation between the BL (cej) diameter and the total root length, (r= 0.20, n= 30, p= 0.526, 95% CI -0.526-0.168). The correlation between these two variables is not statistically significant.

Mandibular 1st molars

The size of mandibular 1st molars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of mandibular 1st molars. In addition, a univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 62: MD diameters of the mandibular 1st molars

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	12.43	0.79	11.50-13.18	8
Khoisan males	10.59	0.51	10.03-11.14	4
Khoisan females	10.03	0.42	9.72-10.51	3
Tswana males	11.47	0.64	9.71-12.78	45
Tswana females	11.12	0.50	9.85-11.98	32
Zulu males	11.20	0.60	9.73-12.69	66
Zulu females	11.17	0.52	9.97-12.10	45
European males	11.00	0.63	9.65-11.86	35
European females	10.72	0.61	9.63-11.82	20

Eight Palauan mandibular 1st molars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD diameters of the Palau population is greater than those of all the modern human populations. It is followed by the one of the Tswana males. Khoisan females have the lowest mean of all the populations measured. European and Khoisan population groups are smaller than the Tswanas and Zulus, making the difference between them and the Palauans the greatest. The females of the modern human sample are smaller than their male counterparts. The

standard deviations of all the populations measured are small, indicating the clustering of primary data around the means of the different groups.

The MD diameters of the Palauans range from 11.50-13.18 mm. Tswana males have the highest mean of all the modern population groups, ranging from 9.71-12.78 mm, while Khoisan females have the lowest mean, ranging from 9.72-10.51 mm. These ranges indicate that the MD diameters of the Palau population fall within and above the normal range of modern human variation, but plot mostly towards the upper end of variation.

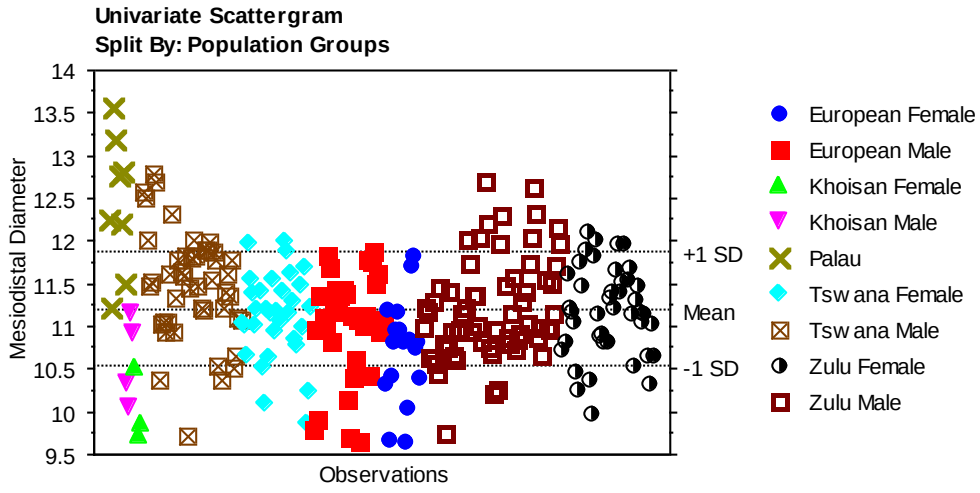

Figure 200: Univariate plot of the MD diameters of the mandibular 1st molars.

The MD diameters of the Palau population are larger than most of the MD diameters of the modern human population groups, though a few are equal. There is little difference between the MD diameters of the modern human populations. Tswana and Zulu males are slightly larger than the females of their similar groups. European males and females are very similar to each other. The Khoisan population groups are clustered on the lower end of the range of variation.

Table 63: BL diameters of the mandibular 1st molar

Population groups	BL Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	11.48	0.61	10.70-12.4	9
Khoisan males	9.65	0.41	9.24-10.15	4
Khoisan females	9.55	0.28	9.15-9.78	4
Tswana males	10.81	0.56	9.92-11.95	43
Tswana females	10.33	0.42	9.62-11.09	33
Zulu males	10.76	0.50	10.10-12.02	60
Zulu females	10.40	0.42	9.53-11.12	43
European males	10.18	0.50	9.20-10.87	35
European females	10.01	0.44	9.24-10.68	18

Nine Palauan mandibular 1st molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only eight individuals. The mean of the BL diameters of the Palau population is greater than the means of the entire human sample. It is followed by the mean of the Tswana males. Khoisan females have the lowest mean of all the populations measured. Females of the modern humans have means that are smaller than the males of their similar groups. Europeans are larger than Khoisan, but smaller than the remaining human populations.

The standard deviations of all the groups studied are small, indicating the clustering of primary data around the means of the different groups. The BL diameters of the Palauans range from 10.7-12.4 mm. Tswana males and Khoisan females range from 9.92-11.95 mm and 9.15-9.78 mm respectively. These ranges indicate that the BL diameters of the Palauans fall within and above the normal range of modern human variation.

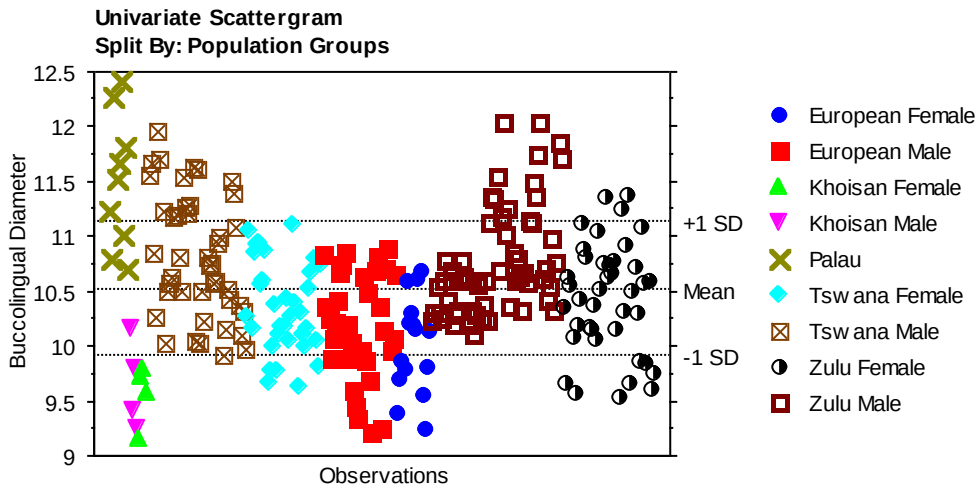

Figure 201: Univariate plot of the BL diameters of the mandibular 1st molars.

The BL diameters of the Palau population are greater than most of the BL diameters of the modern human populations. These are followed by those of Tswana and Zulu males, which in turn are very similar to each other. The same applies to the females of these two groups, which are also similar to each other. Europeans are larger than the Khoisan, but smaller than the remaining human populations sampled. Khoisan population groups are clustered among the smallest of the human populations measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in the Europeans and Khoisan.

Table 64: Crown height of the of the mandibular 1st molars

Population groups	Crown Height			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	5.63	0.11	5.49-5.74	4
Khoisan females	5.39	0.13	5.23-5.52	4
Tswana males	7.40	0.50	6.39-8.30	42
Tswana females	6.89	0.57	5.93-8.00	35
Zulu males	7.33	0.53	6.37-8.29	68
Zulu females	6.9	0.54	5.80-7.90	45
European males	6.65	0.63	5.71-7.65	33
European females	6.46	0.64	5.63-7.46	20

No Palauans were available for comparison with the modern human populations. The Khoisan population was the least represented, with only eight individuals. Tswana males have the highest mean of all the modern human populations measured, whereas Khoisan females have the lowest mean. Modern human femalesc are smaller than their male counterparts. Europeans are larger than the Khoisan, but smaller than Tswanas and Zulus.

The standard deviations of all the groups studied are low, illustrating the clustering of primary data around the means of the different groups. Tswana males range from 6.39-8.3 mm, and Khoisan females from 5.23-5.52 mm. These ranges indicate that the normal range of the crown height of modern humans is broad.

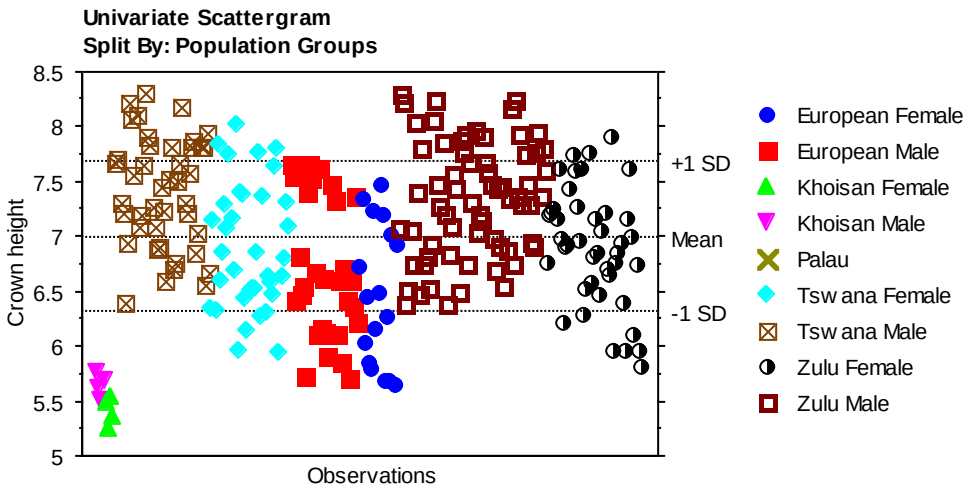

Figure 202: Univariate plot of the crown height of the mandibular 1st molars.

No Palauans were available to be compared with the modern human samples. Tswana and Zulu males are similar, and so are the females of these two groups. Khoisan population groups are clustered among the smallest of the modern humans measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in Europeans and Khoisan. These are indicated by the sample minumum and maximum of different groups. For example, Zulu males and females range from 6.37-8.29 mm and 5.8-7.9 mm, while European males and females from 5.71-7.65 mm and mm 5.63-7.46 respectively.

Table 65: MD (cej) diameters of the mandibular 1st molars

Population groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	9.79	0.96	8.20-11.20	7
Khoisan males	9.12	0.34	8.86-9.59	4
Khoisan females	8.63	0.26	8.42-9.01	4
Tswana males	10.07	0.63	9.26-11.58	45
Tswana females	9.73	0.57	8.96-10.81	35
Zulu males	10.08	0.57	9.25-11.20	65
Zulu females	9.69	0.57	8.91-10.88	44
European males	9.59	0.57	8.57-10.46	34
European females	9.42	0.59	8.36-10.33	20

Seven Palauan mandibular 1st molars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD (cej) diameters of the Palau population is smaller than the means of the Tswana and Zulu males, but larger than those of the remaining modern human population groups. Khoisan females have the smallest mean of all the populations measured. The females of the modern human sample are smaller than the males of their similar groups.

The standard deviations of all the groups measured are low, indicating the clustering of primary data around the means of the different groups. The Palauans range from 8.2-11.2 mm. Tswana males and Khoisan females range from 9.26-11.58 mm and 8.42-9.01 mm respectively. These ranges indicate that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

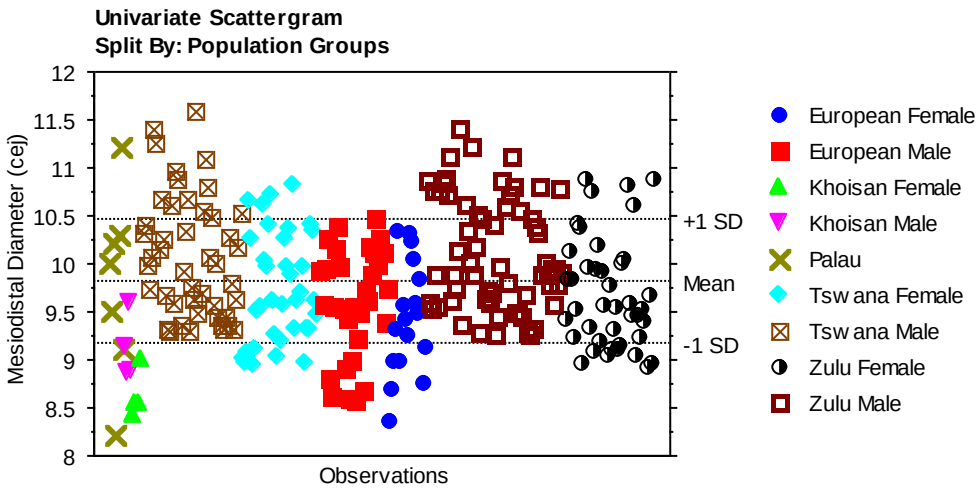

Figure 203: Univariate plot of the MD (cej) diameters of the mandibular 1st molars.

The MD (cej) diameter of the Palau population is equal to those of the modern human populations. Only one is smaller than the entire modern human sample. Tswana and Zulu males are similar to each other, and so are the females of these two groups. European population groups are larger than the Khoisan, but smaller than the Palauans, Tswanas and Zulus. Khoisan population groups are among the smallest of the modern humans measured. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in the Europeans and Khoisan.

Table 66: BL (cej) diameters of the mandibular 1st molars

Population groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	9.74	0.95	8.80-11.30	7
Khoisan males	9.67	0.14	9.51-9.82	4
Khoisan females	9.46	0.24	9.30-9.73	4
Tswana males	10.87	0.58	9.97-12.05	43
Tswana females	10.31	0.42	9.52-10.98	33
Zulu males	10.80	0.58	9.96-12.02	60
Zulu females	10.37	0.37	9.57-10.98	42
European males	10.25	0.44	9.31-10.83	35
European females	10.08	0.33	9.67-10.61	17

Seven Palauan mandibular 1st molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only eight individuals. The mean of the Palau population is smaller than those of Tswana and Zulu males, but larger than the remaining modern human population groups. Tswana males have the highest mean of all the populations measured, whereas Khoisan females have the lowest.

The standard deviations of all the populations measured are small, indicating the clustering of primary data around the means of the different groups. The BL (cej) diameter of the Palauans ranges from 8.8-11.3 mm. Tswana males and Khoisan females range from 9.97-12.05 mm and 9.3-9.73 mm respectively. These ranges indicate that the BL (cej) diameter of the Palauans falls below and within the normal range of modern human variation.

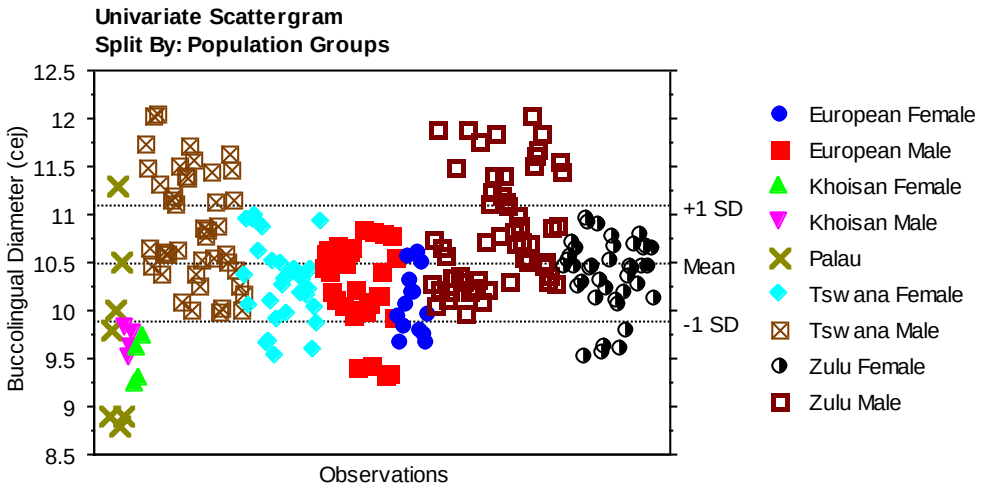

Figure 204: Univariate plot of the BL (cej) diameters of the mandibular 1st molars.

The BL (cej) diameter of the Palau population is equal to those of the modern human populations. A few are smaller than the entire sample of modern humans. Tswana and Zulu

males are equal to each other, and so are the females of these two groups. European population groups are smaller than the Palauans, Tswanas and Zulus, but larger than the Khoisan. Khoisan population groups are among the smallest of the modern humans measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 67: Total root length of the mandibular 1st molars.

Population groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau				
Tswana females	11.86	0.96	11.18-12.54	2
Zulu males	11.02	0.99	10.27-12.72	5

No Palauans were available for comparison with the modern human sample, which comprised only Tswana females and Zulu males. The mean of the total root length of the Tswana females is greater than those of the Zulu males. Tswana females range from 11.18-12.54 mm, while Zulu males range from 10.27-12.72 mm. Based on the small sample size, these ranges might not represent the normal range of the total root lengths of modern human variation.

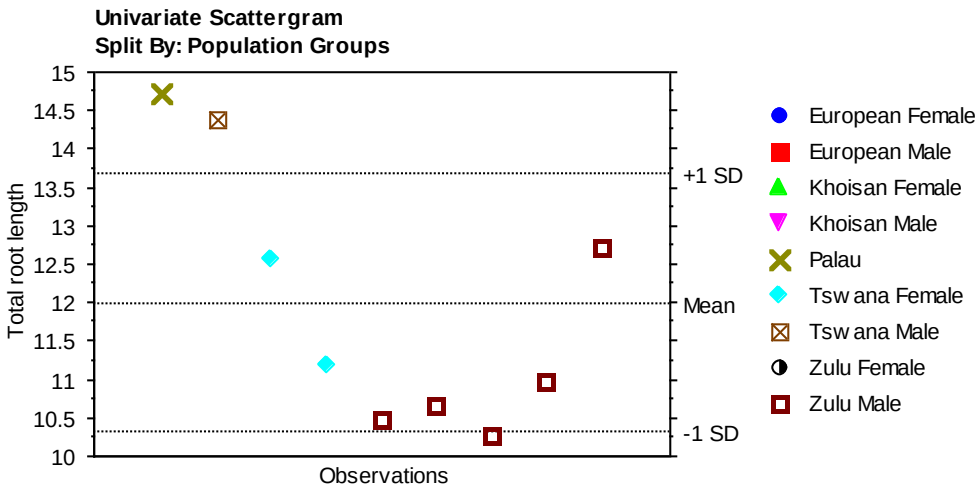

Figure 205: Univariate plot of the total root length of the mandibular 1st molars.

The total root length of the Palau population is greater than those of the modern human populations. Zulu males have the smallest roots, followed by the Tswana females and then Tswana males.

Bivariate plot

The first variables compared were the crown measurements, the MD and BL of the mandibular 1st molars.

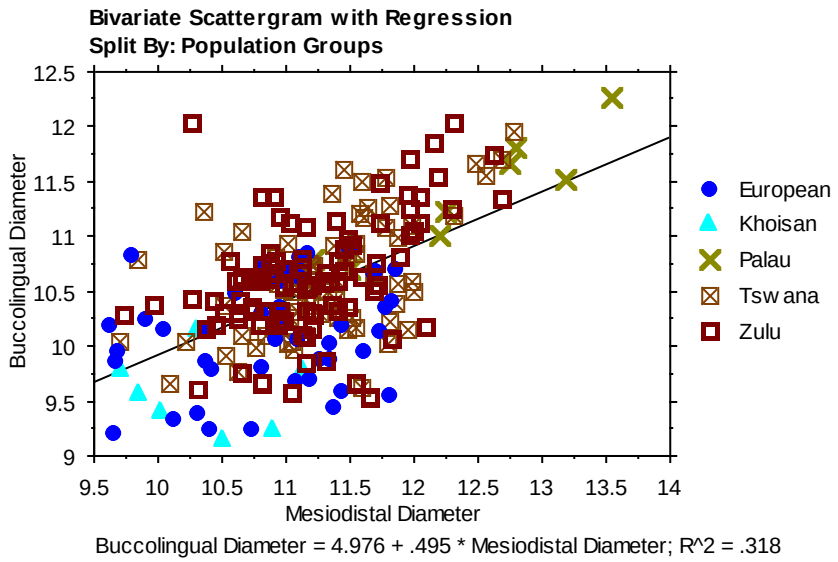

Figure 206: Bivariate plot of the MD and the BL diameters of the mandibular 1st molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. Two are greater than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation, while the Khoisan is at the lower end. This makes the difference between the Palau population and the Khoisan the greatest.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the European and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured, thus making the difference between them and the Palau population the greatest. There is a moderate positive correlation between the MD and the BL diameter ($r= 0.56$, $n= 230$, $p<$

0.0001, 95% CI 0.469-646). The correlation between these two variables is statistically significant.

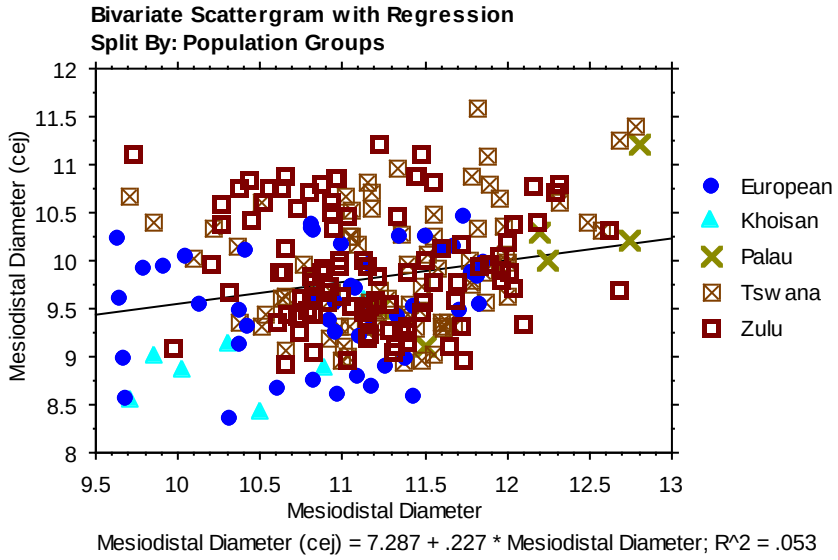

Figure 207: Bivariate plot of the MD and the MD (cej) diameters of the mandibular 1st molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is at the lower end of the range, and this makes the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. One is at the lower end of the range of modern human variation, while the other is at the upper end. The Tswana and the Zulu populations are similar to each other, and are clustered on the upper end of the range of modern human variation. The Europeans are clustered in the middle of the range of modern human variation, whereas the Khoisan are clustered on the lower end of the

range. There is a little difference between the Palau population and the modern humans because the Palauans are distributed along the range of modern human variation. There is a low positive correlation between the MD and the MD (cej) diameter, (r= 0.23, 239, p< 0.0001, 95% CI 0.106-0.347). The correlation between these two variables is statistically significant.

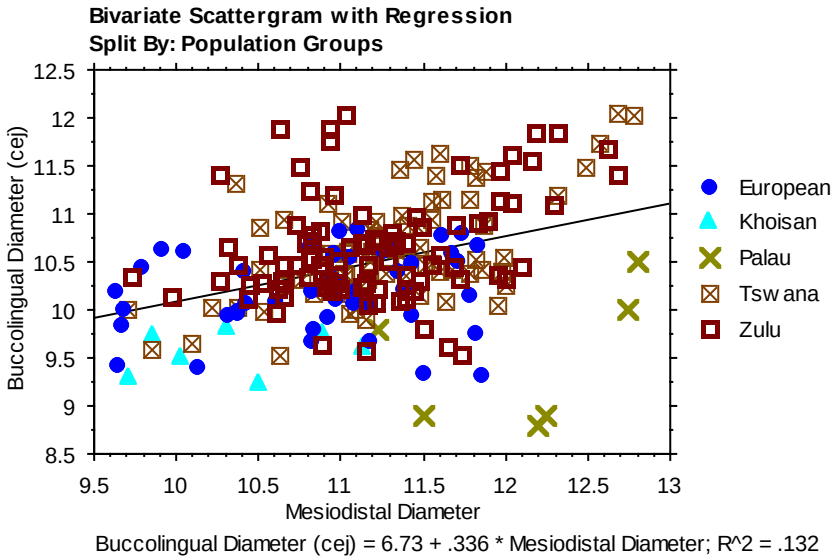

Figure 208: Bivariate plot of the MD and the BL (cej) diameters of the mandibular 1st molars.

The MD diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation, while the Khoisan is at the lower end. The difference between the Palau population and the Khoisan is the greatest compared to the other modern human populations.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those on the lower end and in the middle of the range. It is below the expected

slope of variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the MD and the BL (cej) diameter, (r= 0.36, n= 226, p< 0.0001, 95% CI 0.245-0.472). The correlation between these two variables is statistically significant.

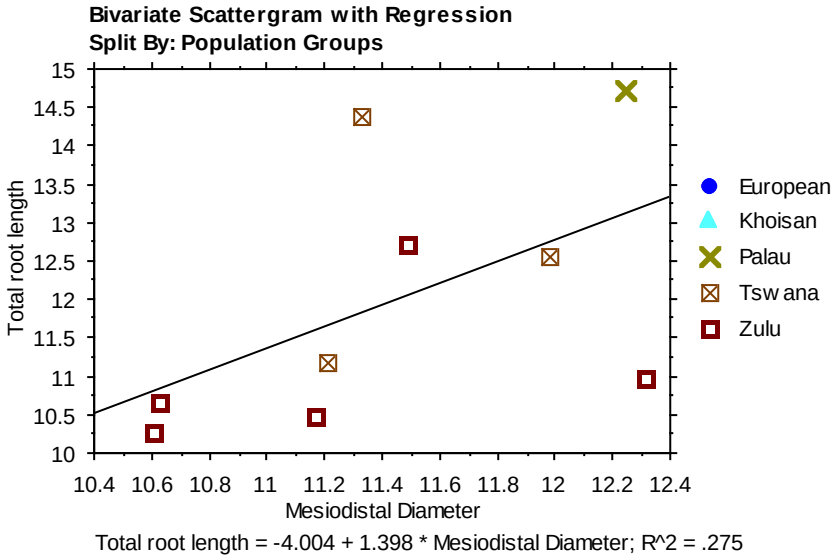

Figure 209: Bivariate plot of the MD diameters and the TRL of the mandibular 1st molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. It is somewhat equal to the Tswana and the Zulu populations. The Tswana and the Zulu populations are similar to each other, though the sample minimum of the Zulu is about a millimetre samller than that of the Tswana.

The total root length of the Palau population falls at the upper end of the range of modern human variation. Few of the total root lengths of the Zulu population are smaller than those of the

Tswana and the Palau population. There is a moderate positive correlation between the MD diameter and the total root length, (r= 0.53, n= 9, p= 0.1534, 95% CI -0.214-0.882). The correlation between these two variables is not statistically significant.

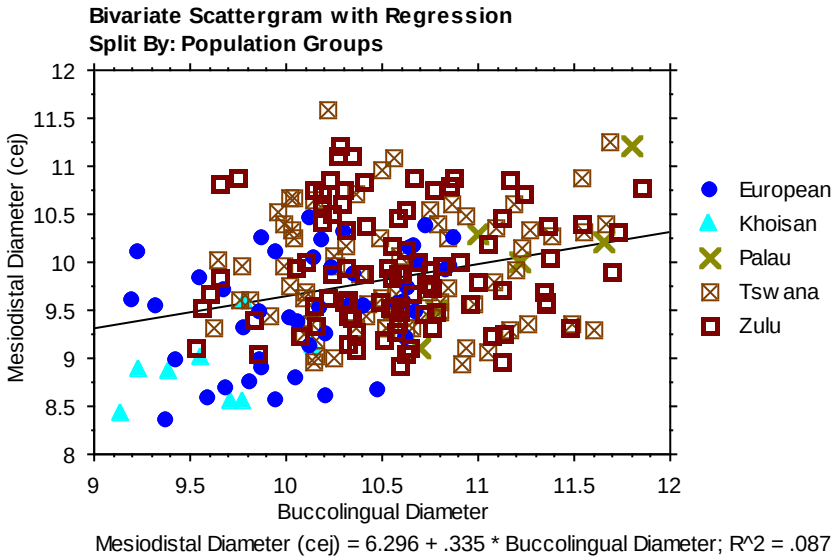

Figure 210: Bivariate plot of the BL and the MD (cej) diameters of the mandibular 1st molars.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European is in the middle of the range of modern human variation. The Khoisan population is clustered in the lower end of the range, thus making the difference between the Khoisan and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans

measured. There is a low positive correlation between the BL and the MD (cej) diameter, (r= 0.30, n= 226, p< 0.0001, 95% CI 0.172-0.410). The correlation between these two variables is statistically significant.

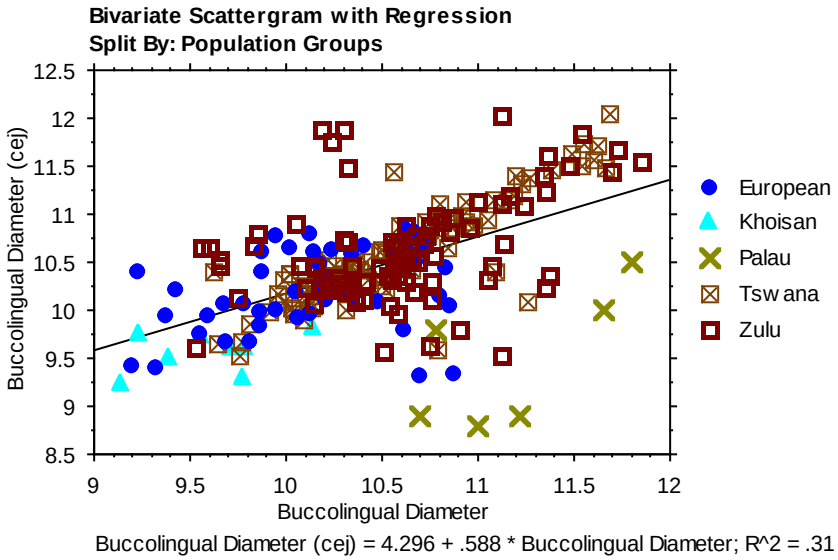

Figure 211: Bivariate plot of the BL and the BL (cej) diameters of the mandibular 1st molars.

The BL diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and at the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European is in the middle of the range of modern human variation. The Khoisan are at the lower end of the range of modern human variation, thus making the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and at the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The

European population ranges from the lower to the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the BL and the BL (cej) diameter, (r= 0.56, n= 229, p< 0.0001, 95% CI 0.461-0.641). The correlation between these two variables is statistically significant.

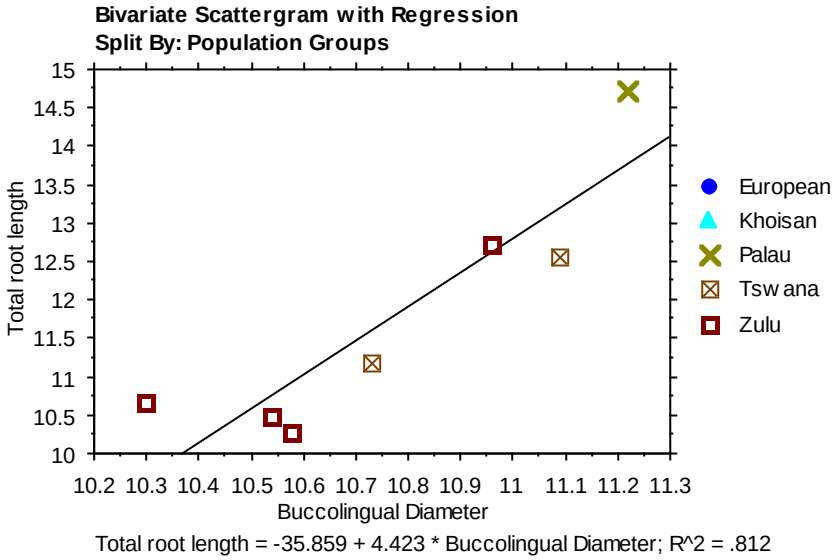

Figure 212: Bivariate plot of the BL diameters and the TRL of the mandibular 1st molars.

The BL diameter of the Palau population falls above the range of modern human variation, and is greater than the Tswana and the Zulu populations. The Tswana and the Zulu populations are similar to each other, though the sample minimum of the Zulus is smaller than that of the Tswanas.

The total root length of the Palau population falls above the range of modern human variation. Three of the four available Zulu population are smaller than the Tswanas. There is a high

positive correlation between the BL diameter and the total root length, (r= 0.90, n= 7, p= 0.0031, 95% CI 0.461-0.985). The correlation between these two variables is statistically significant.

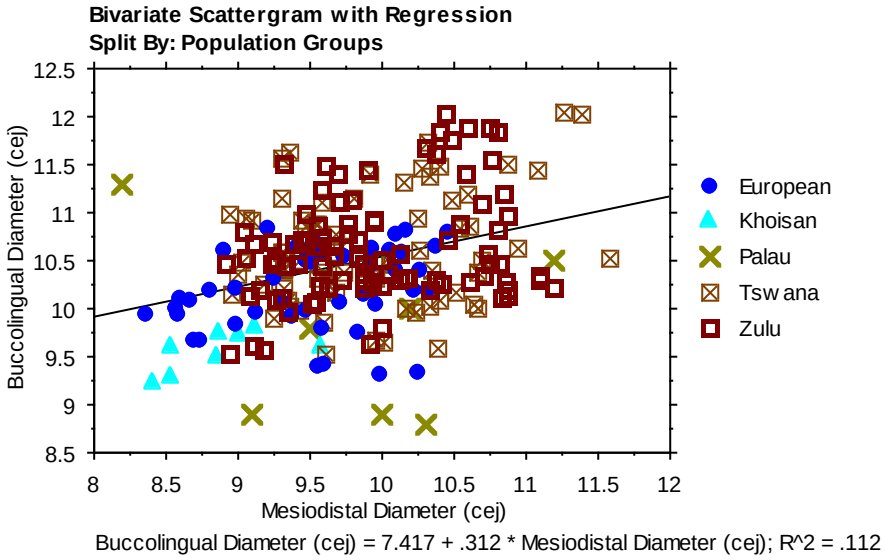

Figure 213: Bivariate plot of the MD (cej) and the BL (cej) diameters of the mandibular 1st molars.

The MD diameter of the Palau population falls within the range of modern human variation. One is smaller than the entire modern human sample, while one is at the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are larger than the Europeans and the Khoisan. The European population is in the middle of the range of modern human variation, while the Khoisan is at the lower end of the range.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. One is at the upper end of the range of modern human variation, while three are at the lower end of the range. The Tswana and the Zulu populations are similar to each other, and are larger than the European and the Khoisan. The Europeans are clustered in the middle of the range of modern

human variation, while the Khoisan are at the lower end. There is a low positive correlation between the MD (cej) and the BL (cej) diameter (r= 0.34, n= 230, p< 0.0001, 95% CI 0.215-0.445). The correlation between these two variables is statistically significant.

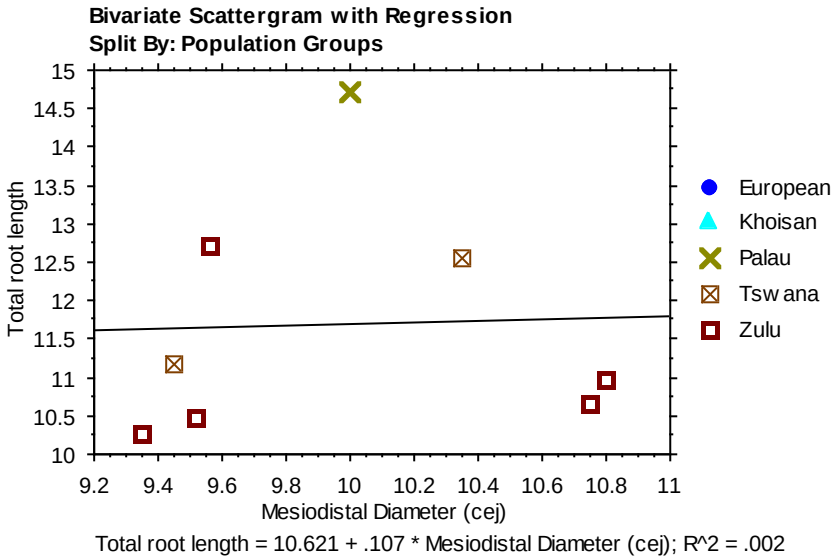

Figure 214: Bivariate plot of the MD (cej) diameters and the TRL of the mandibular 1st molars.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is plotted in the middle of the range. The Tswana and the Zulu populations are similar to each other.

The total root length of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other. There is a low positive correlation between the MD (cej) diameter and the total root length (r= 0.04, n= 8, p= 0. 9257, 95% CI 0.683-0.725). The correlation between these two variables is not statistically significant.

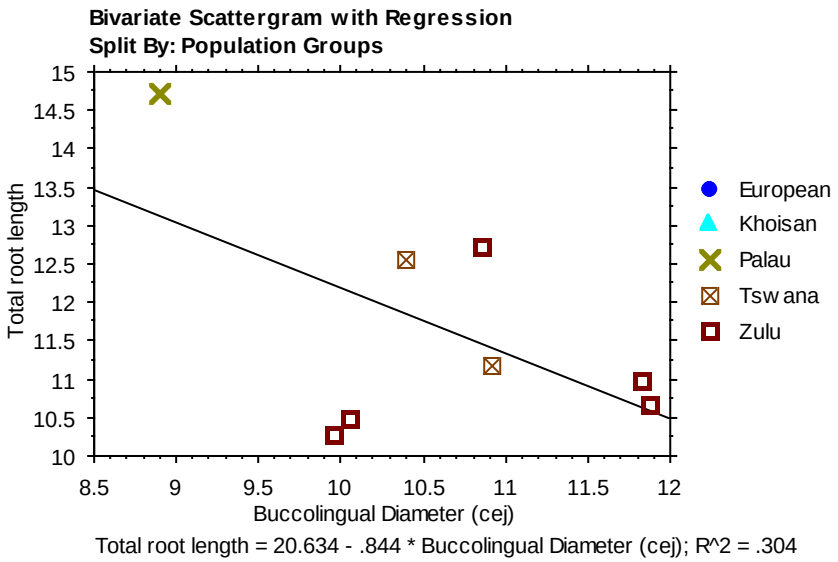

Figure 215: Bivariate plot of the BL (cej) diameters and the TRL of the mandibular 1st molars.

The BL (cej) diameter of the Palau population falls below the range of modern human variation. It is smaller than the entire modern human sample. The Tswana and the Zulu populations are similar to each other.

The total root length of the Palau population falls above the range of modern human variation. It is larger than the entire human sample measured. The Tswana and the Zulu populations are very similar to each other. There is a moderate negative correlation between the BL (cej) diameter and the total root length (r= -0.55, n= 8, p= 0.1654, 95% CI -0.905-0.251). The correlation between these two variables is not statistically significant.

Maxillary 1st molars

The size of maxillary 1st molars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of maxillary 1st molars. In addition, a univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 68: MD diameters of the maxillary 1st molars

Population groups	**MD Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	11.43	1.09	10.07-12.60	5
Khoisan males	9.72	0.28	9.33-10.10	6
Khoisan females	9.34	0.30	9.12-9.55	2
Tswana males	10.66	0.61	9.79-12.10	50
Tswana females	10.20	0.46	9.35-11.26	33
Zulu males	10.61	0.56	9.73-12.02	66
Zulu females	10.24	0.48	9.30-11.20	58
European males	10.17	0.50	9.23-11.05	48
European females	10.02	0.46	9.14-10.51	23

Five Palauan maxillary 1st molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only eight individuals. The mean of the MD diameters of the Palau population is greater than the mean of all the modern human populations. It is followed by Tswana males. Khoisan females have the lowest mean of all the populations measured. European population groups are larger than the Khoisan, but smaller than the remaining human populations. The females of the modern human sample are smaller than the males of their similar groups.

The standard deviations of the Palau population are larger than those of the modern human populations. The smaller standard deviations of the modern human population groups indicate that their primary data are clustered around the means of their different groups. The Palauans range from 10.07-12.60 mm. Tswana males and Khoisan females range from 9.79-12.1 mm and 9.12-9.55 mm respectively. These ranges indicate that the MD diameter of the Palau population falls above the normal range of modern human variation.

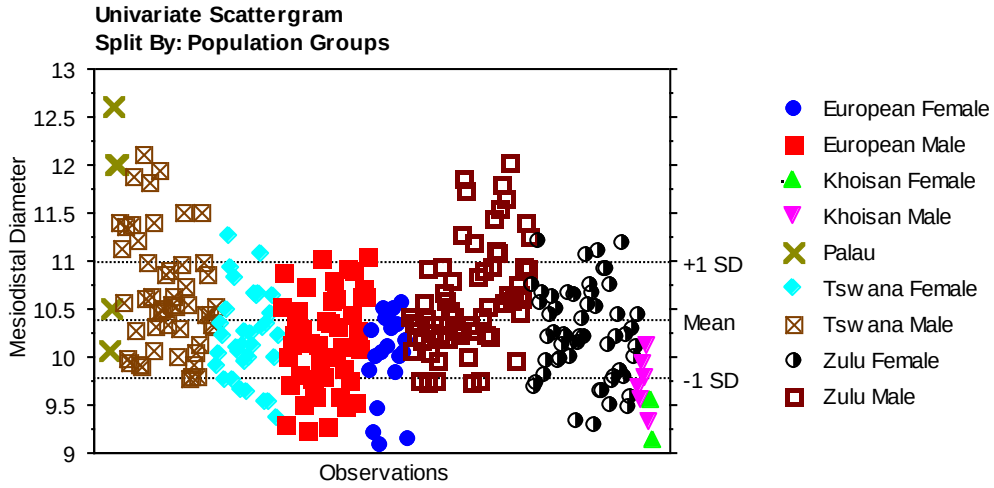

Figure 216: Univariate plot of the MD diameters of the maxillary 1st molars.

The MD diameter of the Palau population is greater and sometimes equal to those of the modern human populations. Tswana and Zulu males are similar to each other, and so are the females of these two groups. European population groups are larger than the Khoisan, but smaller than the other human populations. Khoisan population groups are equal to the smallest of the modern humans measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 69: BL diameters of the mandibular 1st molars

Population groups	BL Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	12.61	0.98	11.06-13.40	5
Khoisan males	9.85	0.33	9.43-10.25	6
Khoisan females	9.58	0.05	9.54-9.61	2
Tswana males	11.09	0.62	9.85-12.45	50
Tswana females	10.91	0.48	10.03-11.86	35
Zulu males	11.14	0.63	9.67-12.40	67
Zulu females	10.87	0.59	9.88-12.01	58
European males	10.69	0.54	9.65-11.50	49
European females	10.47	0.50	9.53-11.16	23

Five Palauan maxillary 1st molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only eight individuals. The mean of the BL diameters of the Palau population is greater than those of the entire modern human sample. It is followed by Zulu males. Khoisan females have the lowest mean of all the populations measured. European population groups are larger than the Khoisan, but smaller than the remaining human populations. The females of the modern humans are smaller than their male counterparts.

The standard deviations of the population groups measured are small, indicating the clustering of primary data around the means of the different groups. The BL diameter of the Palauans ranges from 11.06-13.4 mm. Zulu males and Khoisan females range from 9.67-12.40 mm and 9.54-9.61 mm respectively. These ranges indicate that the BL diameter of the Palau population falls above the normal range of modern human variation.

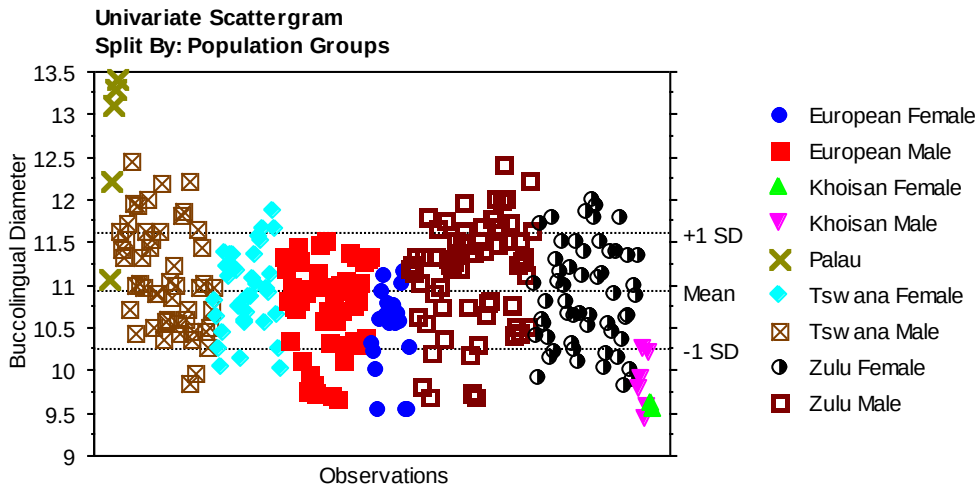

Figure 217: Univariate plot of the BL diameters of the maxillary 1st molars.

The BL diameter of the Palau population is greater than those of the modern human populations. Two of the Palauans are equal to the modern human population groups, especially those on the upper end of the range of modern human variation. Tswana and Zulu males are similar to each other, and so are the females of these two groups. European population groups are larger than the Khoisan, but smaller than the remaining human populations. Khoisan population groups are clustered among the smallest of the modern humans measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 70: Crown height of the of the maxillary 1st molar

Population groups	Crown Height			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	5.49	0.33	5.14-5.99	6
Khoisan females	5.41	0.18	5.28-5.53	2
Tswana males	7.3	0.64	6.18-8.67	44
Tswana females	6.92	0.61	5.95-8.09	35
Zulu males	7.24	0.67	6.22-8.85	66
Zulu females	6.95	0.54	5.88-8.01	58
European males	6.77	0.63	5.85-7.68	49
European females	6.54	0.59	5.51-7.35	23

No Palauans were available for comparison with the modern human sample. The Khoisan population was the least represented, with only eight individuals. Tswana males have the highest mean of all the modern humans measured. They are followed by Zulu males. Khoisan females have the lowest mean of the entire modern human sample. Europeans are larger than the Khoisan, but smaller than the Tswanas and Europeans. The females of the modern humans are smaller than the males of their similar groups.

The standard deviations of all the modern human populations measured are small, indicating the clustering of primary data around the means of the different groups. The crown heights of Tswana males and Khoisan females range from 6.18-8.67 mm and 5.28-5.53 mm respectively. These ranges indicate that the crown heights of the maxillary 1st molar in modern humans have a wide range of variation.

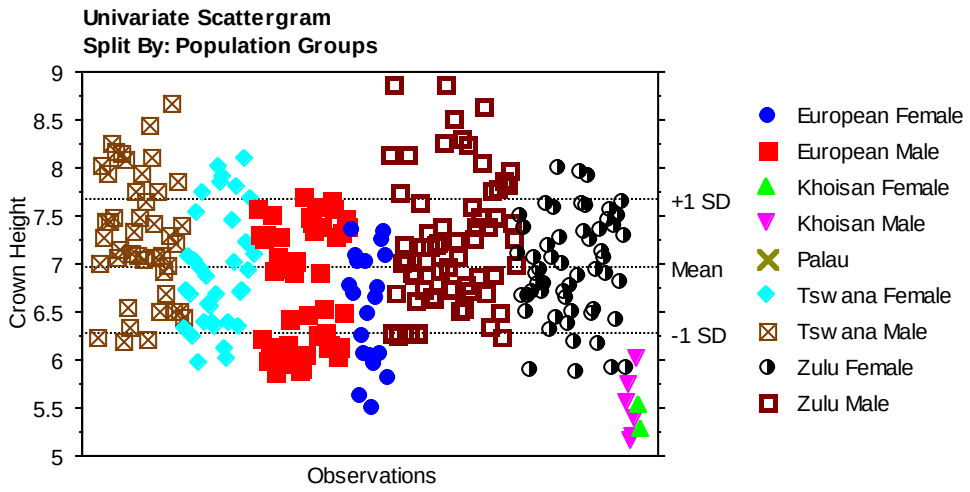

Figure 218: Univariate plot of the crown height of the maxillary 1st molars.

No Palauans were available for comparison with the modern human sample. Tswana and Zulu males are similar to each other, as are the females of these two groups. European populations are smaller than the Tswanas and Zulus, but larger than the Khoisan population. Khoisan population groups are among the smallest of the modern humans measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 71: MD (cej) diameters of the maxillary 1st molars

Population groups	**MD (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	9.33	0.46	8.80-9.60	3
Khoisan males	7.8	0.47	7.14-8.27	6
Khoisan females	7.53	0.15	7.42-7.63	2
Tswana males	9.22	0.70	7.82-10.49	50
Tswana females	8.47	0.54	7.58-9.32	36
Zulu males	9.16	0.88	7.83-10.69	66
Zulu females	8.41	0.55	7.52-9.47	55
European males	8.34	0.55	7.40-9.28	48
European females	8.3	0.47	7.41-9.03	23

Three Palauan maxillary 1st molars were available for comparison with the modern human sample. Out of 400 modern humans studied, the Khoisan population was the least represented. The mean of the MD (cej) diameters of the Palau population is greater than all of the modern human populations. It is followed by Tswana males. Khoisan females have the smallest mean of all the populations studied. The females of the modern human sample have means that are smaller than the means of their male counterparts. The standard deviations of all the population groups studied are very low, indicating the clustering of primary data around the means of the different groups.

The MD (cej) diameter of the Palauans ranges from 8.8-9.6 mm. Tswana males and Khoisan females range from 7.82-10.49 mm and 7.42-7.63 mm respectively. These ranges indicate that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

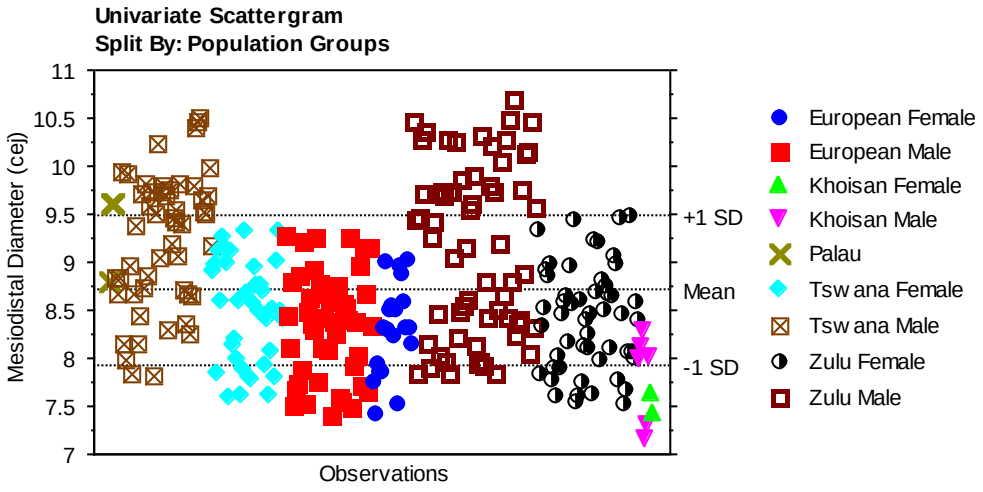

Figure 219: Univariate plot of the MD (cej) diameters of the maxillary 1st molars.

The MD (cej) diameter of the Palau population is equal to most of the MD (cej) diameters of the modern human population groups; especially those slightly on the upper end of the range of modern human variation. A few of the Tswana and Zulu males have greater MD (cej) diameters than the Palauans. Tswana and Zulu males are similar to each other, and so are the females of these groups; which happen to be comparable with European males. Europeans are smaller than the Palauans, Tswanas and Zulus, but are larger than the Khoisan. Khoisan population groups are among the smallest of the modern human populations measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 72: BL (cej) diameters of the maxillary 1st molars

Population groups	**BL (cej) Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	12.1	0.64	11.20-12.70	4
Khoisan males	10.04	0.19	9.87-10.35	6
Khoisan females	10.03	0.16	9.91-10.14	2
Tswana males	11.26	0.55	9.95-12.41	50
Tswana females	11.09	0.48	10.13-11.90	36
Zulu males	11.31	0.65	9.92-12.43	68
Zulu females	11.05	0.52	10.00-11.96	56
European males	10.88	0.60	9.69-11.77	49
European females	10.78	0.56	9.87-11.52	23

Four Palauan maxillary 1st molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only eight individuals. The mean of the BL (cej) diameters of the Palau population is greater than those of the moern human populations. It is followed by European males. The Khoisan females are the smallest of all the populations measured. The females of the modern human sample are smaller than the males of similar groups. The standard deviations of all the populations, excluding the Zulu females are low.

The range of the BL (cej) diameters of the Palau population is larger than the ones of the Khoisan females, and smaller than those of the remaining human populations. It ranges from 11.2-12.7 mm. The Khoisan females range from 9.91-10.14 mm. The Zulu males have the highest range of the human sample, from 9.55-12.41 mm. The BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

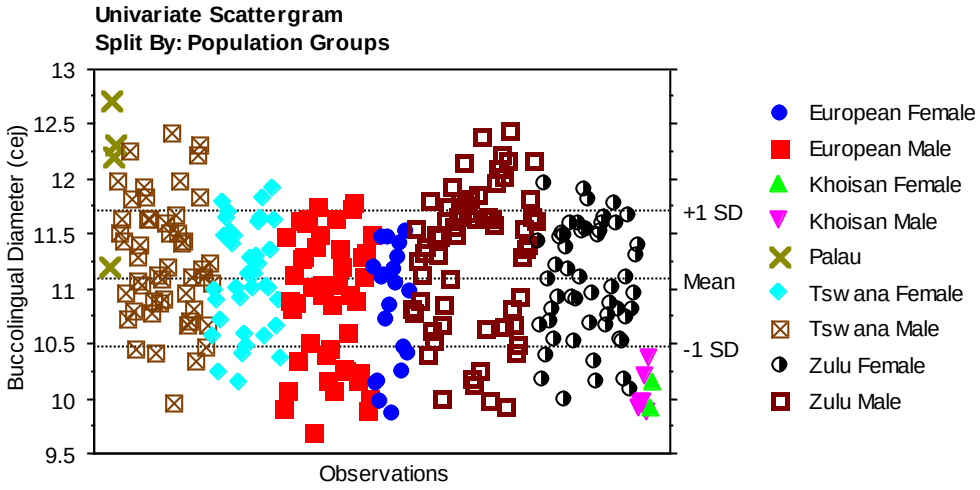

Figure 220: Univariate plot of the BL (cej) diameters of the maxillary 1st molars.

The BL (cej) diameter of the Palau population is equal to those of the modern human populations. Only one of the BL (cej) diameters of the Palauans is greater than those of the modern humans. Tswana and Zulu males are similar; and so are the females of these two groups. European population groups are larger than the Khoisan, but smaller than the remaining human populations. Khoisan population groups are clustered among the smallest of the modern humans measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 73: Total root length of the maxillary 1st molars

Population groups	Total Root Length			
	Mean	***Std dev***	***Range***	***N***
Palau				
Tswana males	13.35	1.65	10.76-15.12	6
Tswana females	11.13	0.98	10.00-12.44	5
Zulu males	13.13	1.35	11.46-15.27	19
Zulu females	11.82	1.05	10.77-12.99	9

No Palauans were available for comparison with the modern human sample. Only two groups; the Tswanas and the Zulus were available for comparison. Tswana males have the highest mean of all the groups measured, followed by Zulu males. Tswana females have the smallest mean. All the groups measured have very high standard deviations, indicating the scattering of primary data around the means of different groups. Tswana males and females range from 10.76-15.12 mm and 10.12-12.44 mm respectively.

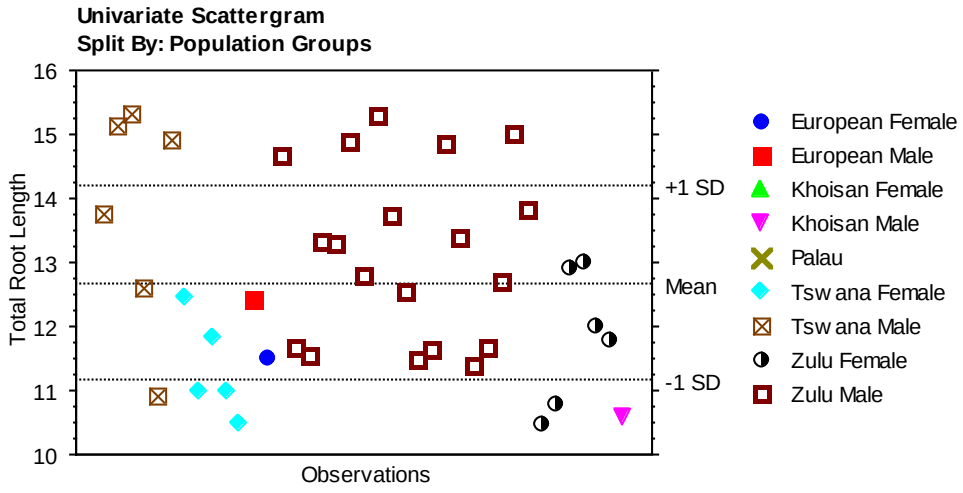

Figure 221: Univariate plot of the total root length of the maxillary 1st molars.

No Palauans were available for comparison with the modern human sample. Tswana and Zulu males are similar to each other, and their range is wide. The females of these two groups are also similar, but do not cover a wide range.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the maxillary 1st molars.

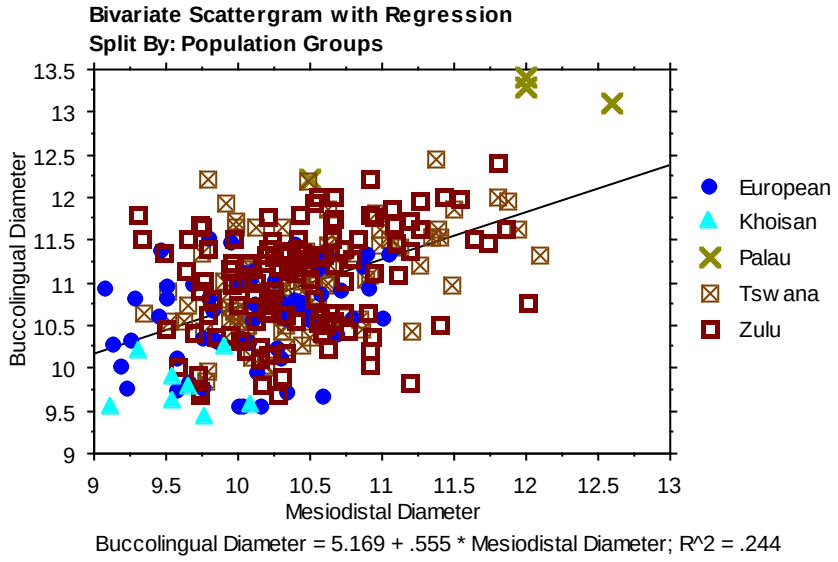

Figure 222: Bivariate plot of the MD and the BL diameters of the maxillary 1st molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. One is equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, and they are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is clustered in the lower end of the range of modern human variation, thus making the difference between them and the Palau population the greatest.

The BL diameter of the Palau population falls above the range of modern human variation. One is equal to those at the upper end of the range. The sample minimums of the Tswana, Zulu and the European populations are similar to one another, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is among the smallest of the modern humans measured, thus making the difference between them and the Palau population the greatest. There is a low positive correlation between the MD and BL diameter (r= 0.49, n= 279, p< 0.0001, 95% CI 0.400-0.578). The correlation between these two variables is statistically significant.

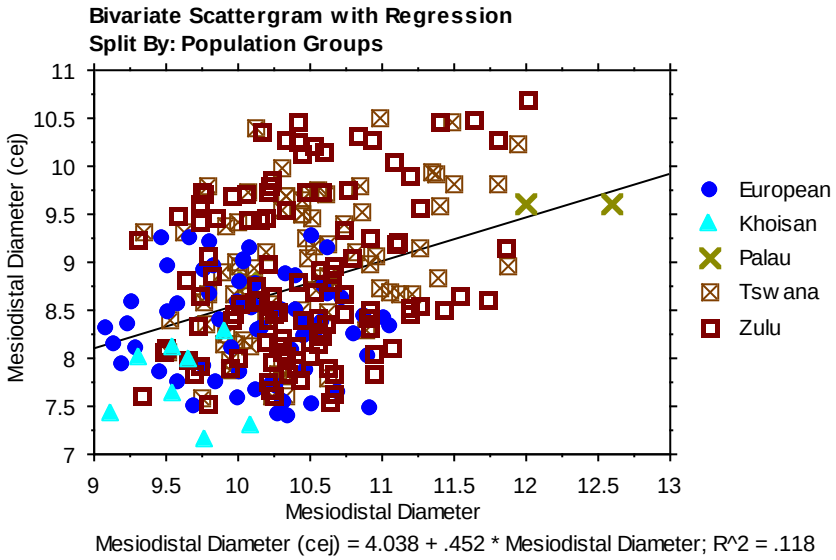

Figure 223: Bivariate plot of the MD and the MD (cej) diameters of the maxillary 1st molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. One is larger than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European is in the middle of the range of modern human variation, while the Khoisan is at the lower end. Therefore the difference between the Palau population and the Khoisan is the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, and most are greater than the Europeans and the Khoisan. The European population is clustered from the lower end to the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured, and all are plotted below the regression line. There is a low positive correlation between the MD diameter and the MD (cej diameter (r= 0.34, n= 271, p< 0.0001, 95% CI 0.233-0.444). The correlation between these two variables is statistically significant.

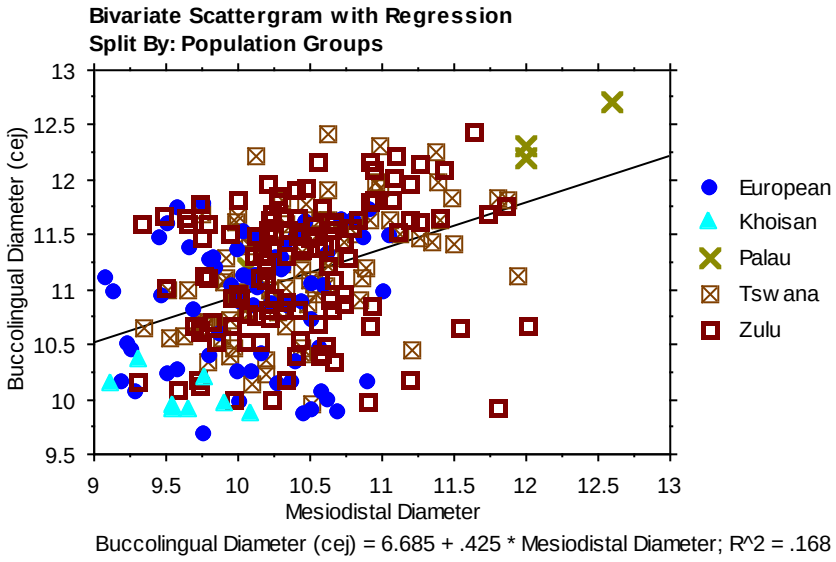

Figure 224: Bivariate plot of the MD and the BL (cej) diameters of the maxillary 1st molars.

The MD diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European and the Khoisan populations are clustered in the middle and the lower end of the range of modern human variation respectively.

The BL (cej) diameter of the Palau population falls at the upper end of the range of modern human variation. The BL (cej) diameter of the Tswana, Zulu and the European populations are similar to one another, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is clustered at the lower end of the range of modern human variation. There is a low positive correlation between the MD and the BL (cej) diameter (r= 0.41, n= 275, p< 0.0001, 95% CI 0.307-0.504). The correlation between these two variables is statistically significant.

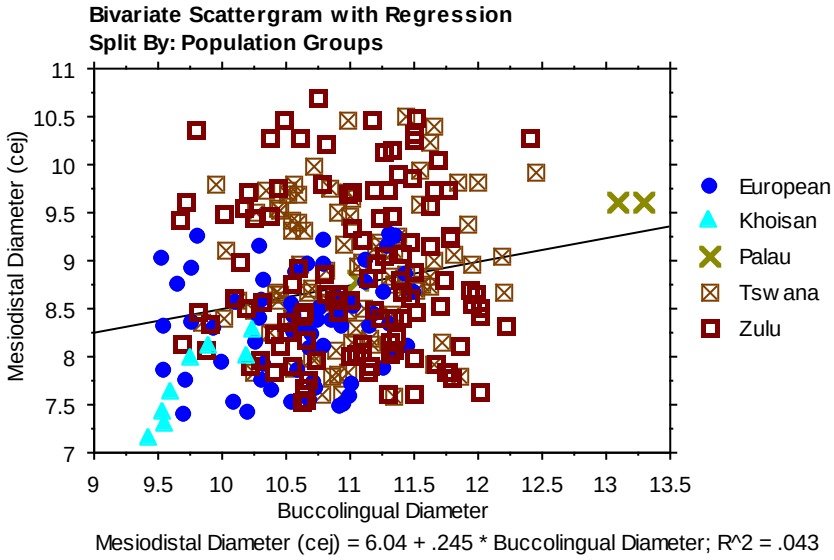

Figure 225: Bivariate plot of the BL and the MD (cej) diameters of the maxillary 1st molars.

The BL diameter of Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is clustered among the smallest of the modern humans measured, and this makes the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those at the upper end of the range. It is above the expected slope of variation. The Tswana and the Zulu populations are similar to each other, and they shift towards the upper end of the range. The Europeans are clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the BL and the MD (cej) diameter (r= 0.21, n= 275, p= 0.0005, 95% CI 0.091-0.318). The correlation between these two variables is statistically significant.

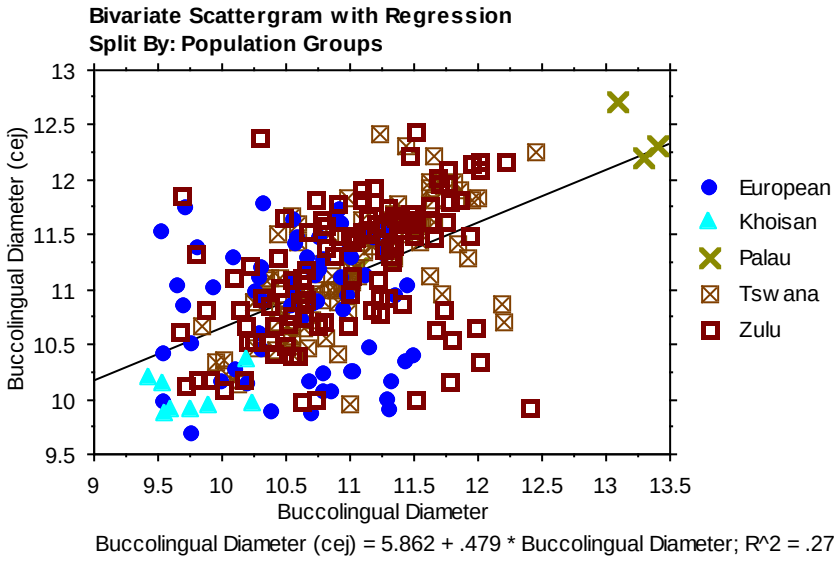

Figure 226: Bivariate plot of the BL and the BL (cej) diameters of the maxillary 1st molars.

The BL diameter of the Palau population falls above the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured, thus making the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana, Zulu and the European population are similar to each other, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is among the smallest of the human populations measured. There is a moderate correlation between the BL and the BL (cej) diameter (r= 0.52, n= 280, p< 0.0001, 95% CI 0.429-0.601). The correlation between these two variables is statistically significant.

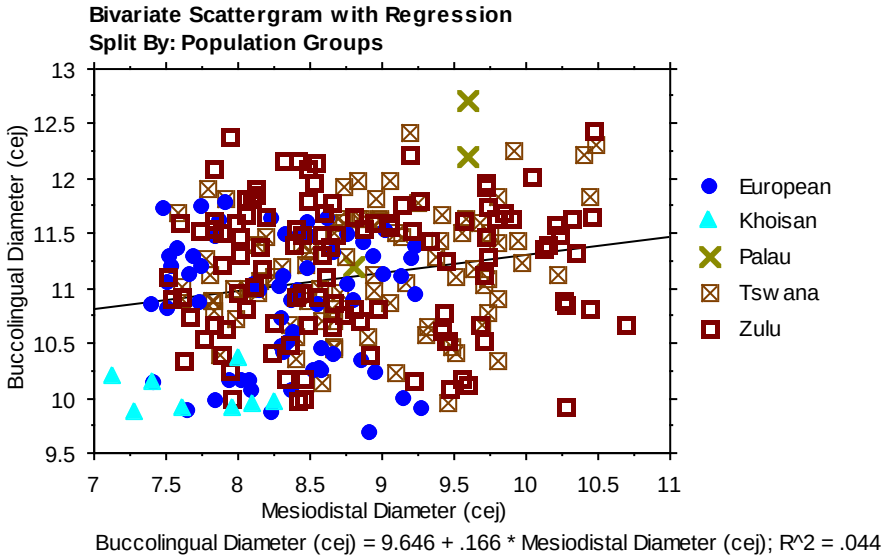

Figure 227: Bivariate plot of the MD (cej) and the BL (cej) diameters of the maxillary 1st molars.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and are equal to those in the middle of the range. Majority of the MD (cej) diameter of the Tswana and the Zulu populations are similar to each other and are greater than the Europeans, the Khoisan and the Palau population. The European population is clustered in the middle of the range of modern human variation, while the Khoisan population is at the lower end.

The BL (cej) diameter of the Palau population falls at the upper end of the range of modern human variation. One is equal to those in the middle of the range. The sample minimums of the Tswana, Zulu and the European populations are similar to one another, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the MD (cej) and the BL (cej) diameter (r= 0.21, n= 277, p= 0.0005, 95% CI 0.093-0.319). The correlation between these two variables is statistically significant.

Mandibular 2nd molars

The size of mandibular 2nd molars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of mandibular 2nd molars. In addition, a univariate plot for each measurement is presented to further illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 74: MD diameters of the mandibular 2nd molars

Population groups	MD Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	11.60	0.73	10.85-12.69	7
Khoisan males	10.28	0.38	9.85-10.58	3
Tswana males	10.72	0.79	9.12-12.90	49
Tswana females	10.51	0.61	9.49-11.71	38
Zulu males	10.84	0.73	9.00-12.13	62
Zulu females	10.57	0.55	9.47-11.78	43
European males	10.45	0.51	9.63-11.42	34
European females	10.33	0.65	9.13-11.41	20

Six Palauan mandibular 2nd molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only three Khoisan males. The mean of the MD diameters of the Palau population is greater than the means of the modern human populations. It is followed by Zulu and Tswana males respectively. The means of the males of the modern human sample are greater than the means of the females of their similar groups. Khoisan males have the lowest mean of all the populations measured. European population groups are larger than the Khoisan males, but smaller than the rest of the human populations. All of the human population groups have low standard deviations, indicating the clustering of the primary data around the means of the different groups.

The Palauans range from 10.85-12.69 mm, while Zulu and Khoisan males range from 9.47-11.78 mm and 9.85-10.58 mm respectively. These ranges indicate that the MD diameter of the Palau population falls above the normal range of modern human variation.

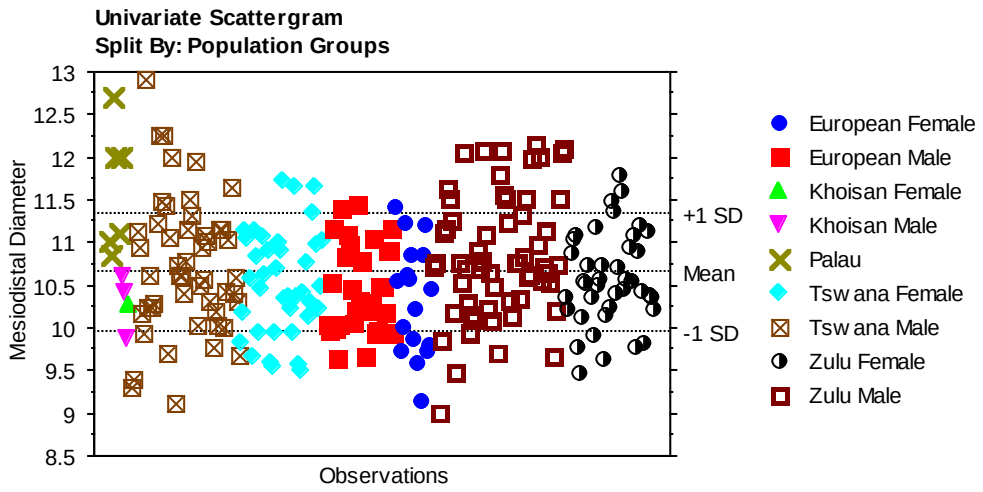

Figure 228: Univariate plot of the MD diameters of the mandibular 2nd molars.

The MD diameter of the Palau population is greater and sometimes equal to those of the modern human populations. Tswana and Zulu males are similar to each other. The same applies to the females of these two groups. The Khoisan population groups are among the smallest of the human populations measured.

Table 75: BL diameters of the mandibular 2nd molars

Population groups	**BL Diameters**			
	Mean	***Std dev***	***Range***	***N***
Palau	10.98	0.78	10.20-12.34	7
Khoisan males	9.68	0.06	9.64-9.72	2
Tswana males	10.51	0.56	9.64-11.60	50
Tswana females	10.27	0.43	9.56-11.28	40
Zulu males	10.61	0.52	9.61-11.57	62
Zulu females	10.33	0.41	9.52-11.07	43
European males	10.20	0.56	9.35-11.04	35
European females	10.06	0.44	9.40-10.79	24

Seven Palauan mandibular 2nd molars were available for comparison with the modern human sample. Out of the 400 modern humans studied, the Khoisan population was the least represented. The mean of the BL diameters of the Palau population is greater than the means of all the groups measured. It is followed by the means of Zulu and Tswana males respectively. Khoisan males have the lowest mean of all the population groups measured. Europeans are larger than Khoisan males, but smaller than the remaining human sample. The females of the modern human population groups are smaller than the males of their respective groups. The standard deviation of the Palau population is the highest of the groups studied. The rest of the population groups have very small standard deviations, illustrating the clustering of the primary data around the means of the different groups.

The Palauans range from 10.20-12.34 mm, while Zulu males range from 9.61-11.57 mm, and Khoisan males from 9.64-9.72 mm. These ranges indicate that the BL diameter of the Palau population falls above the normal range of modern human variation.

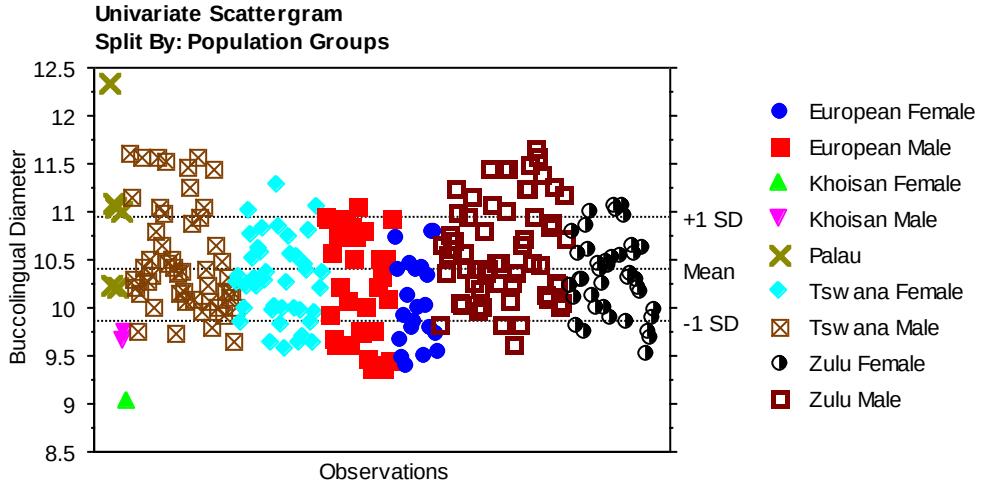

Figure 229: Univariate plot of the BL diameters of the mandibular 2nd molars.

The BL diameter of the Palau population is equal to the BL diameters of the modern human populations. Only one of the BL diameters of the Palauans is exceptionally large when compared to the modern humans. Tswana and Zulu males are equal to each other, and so are the females of these two groups. European population groups are larger than the Khoisan, but smaller than the remaining human populations. Khoisan population groups are clustered among the smallest of the modern humans measured. Sexual dimorphism is extensive in Tswanas and Zulus, but moderate in Europeans.

Table 76: Crown height of the of the mandibular 2nd molars

Population groups	**Crown Height**			
	Mean	***Std dev***	***Range***	***N***
Palau				
Khoisan males	6.05	0.15	5.88-6.16	3
Tswana males	7.64	0.56	6.70-8.79	43
Tswana females	7.31	0.55	6.36-8.24	40
Zulu males	7.55	0.54	6.60-8.54	63
Zulu females	7.32	0.48	6.27-8.24	43
European males	7.23	0.63	5.91-8.15	34
European females	7.13	0.56	6.18-8.10	24

Only one Palauan was available for comparison with the modern human sample, and it is plotted on the univariate graph below. Khoisan females were not available for comparison. Tswana males have the highest mean of all the modern human populations measured, while Khoisan males have the lowest. The means of the crown heights of modern human populations are greater than those of their female counterparts. Europeans are smaller than the Tswanas and Zulus, but larger than Khoisan males.

The standard deviations of all the groups measured are low, indicating the clustering of primary data around the means of the different groups. The Khoisan males range from 5.88-6.16 mm, and Tswana males from 6.70-8.79 mm. The crown height of the only available Palauan is 15.41 mm, well exceeding the normal range of modern human variation.

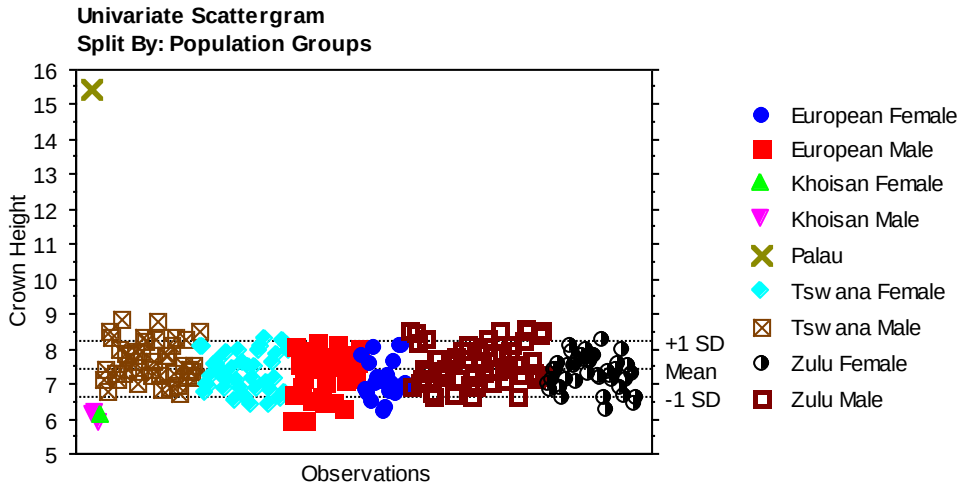

Figure 230: Univariate plot of the crown height of the mandibular 2nd molars.

The crown height of the Palau population is greater than the crown heights of the modern human populations. Tswana and Zulu males are comparable, and so are the females of these groups. Khoisan population groups are among the smallest of the modern humans measured. Sexual dimorphism is extensive in the Tswana and Zulu population groups, but moderate in the Europeans.

Table 77: MD (cej) diameters of the mandibular 2nd molars

Population groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	9.78	0.75	8.90-10.70	5
Khoisan males	8.55	0.33	8.23-8.90	3
Tswana males	9.77	0.60	8.54-11.15	50
Tswana females	9.51	0.59	8.37-10.54	40
Zulu males	9.70	0.70	8.66-11.29	63
Zulu females	9.58	0.51	8.40-10.51	42
European males	9.39	0.52	8.43-10.36	36
European females	9.31	0.49	8.47-10.28	23

Five Palauan mandibular 2nd molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only three individuals. The mean of the MD (cej) diameters of the Palau population is greater than the means of the modern human populations. It is followed by those of Tswana males. The mean of the Khoisan males is the smallest of all the populations measured. European population groups are larger than the Khoisan males, but smaller than the remaining human population groups measured. Modern human females have means that are smaller than those of the males of their similar groups. The standard deviations of all the groups measured are low, with the Khoisan males having the lowest. These small standard deviations indicate that the primary data are clustered around the means of the different groups.

Palauans range from 8.9-10.7 mm. Khoisan males range from 8.23-8.90 mm, while Tswana males range from 8.24-11.15 mm. These ranges indicate that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

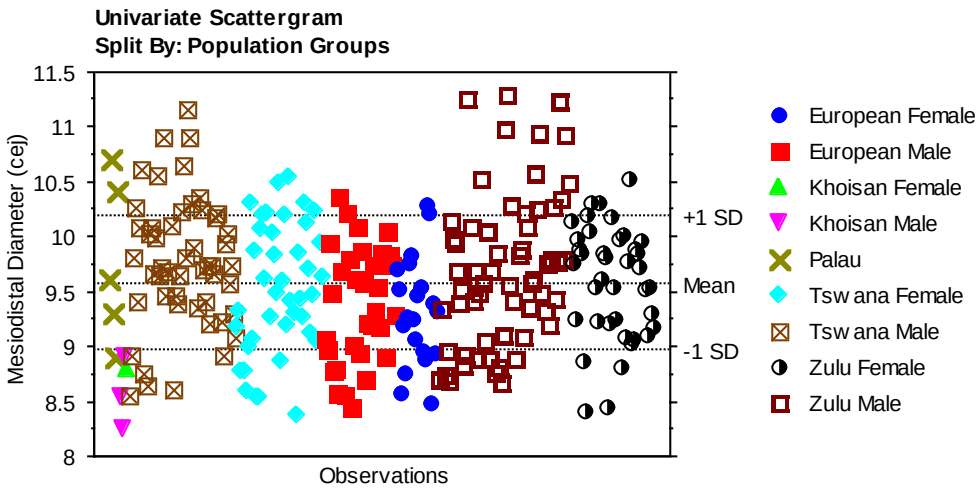

Figure 231: Univariate plot of the MD (cej) diameters of the mandibular 2nd molars.

The MD (cej) diameter of the Palau population is equal to most of the MD (cej) diameters of the modern human populations. There is little difference between the MD (cej) diameters of the modern human population groups. Tswana and Zulu males are equal to each other, and the same applies to the females of these groups. The Khoisan population groups are clustered among the smallest of the human populations measured. Sexual dimorphism is extensive in Zulu and Tswanas, but moderate in Europeans. This is indicated by the sample minimum and maximum of these different groups.

Table 78: BL (cej) diameters of the mandibular 2nd molars

Population groups	BL (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	9.18	0.28	8.90-9.60	5
Khoisan males	9.55	0.23	9.33-9.78	3
Tswana males	10.54	0.53	9.72-11.65	50
Tswana females	10.19	0.43	9.49-10.89	40
Zulu males	10.59	0.50	9.61-11.63	62
Zulu females	10.25	0.48	9.32-10.96	43
European males	10.12	0.40	9.32-10.72	35
European females	10.03	0.39	9.39-10.63	23

Five Palauan mandibular 2nd molars were available for comparison with the modern human sample. Out of the 400 modern humans studied the Khoisan population was the least represented. The mean of the BL (cej) diameters of the Palau population is lower than the means of the entire modern human sample. Zulu males have the highest mean of all the populations measured. It is followed by the mean of the Tswana males. Khoisan males have the lowest mean of the modern human sample. The females of the modern human sample are smaller than the males of their similar groups. All the groups studied have a low standard deviation, indicating the clustering of primary data around the means of the different groups.

The Palau population ranges from 8.9-9.6 mm. Zulu and Khoisan males range from and 9.61-11-63 mm and 9.33-9.78 mm respectively. These ranges indicate that the BL (cej) diameter of the Palau population falls below the normal range of modern human variation.

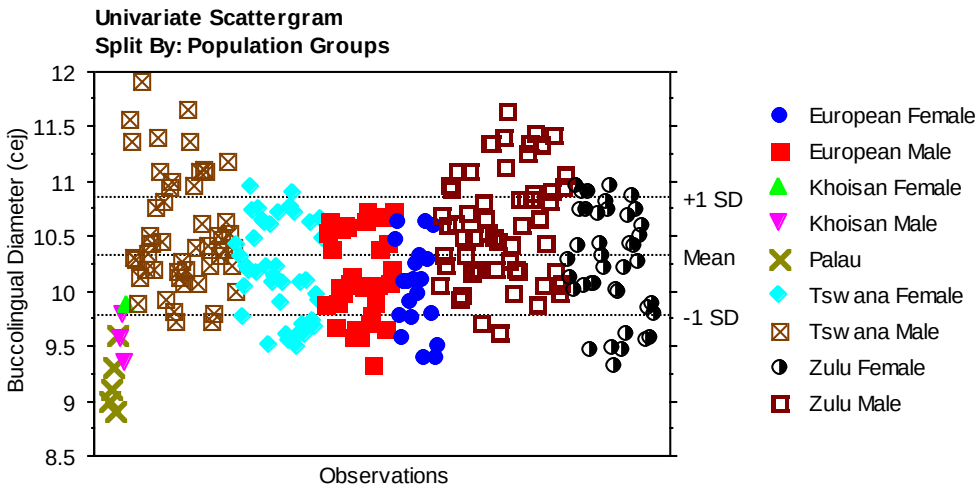

Figure 232: Univariate plot of the BL (cej) diameters of the mandibular 2nd molars.

The BL (cej) diameter of the Palau population is smaller than the majority of modern humans, even smaller than the BL (cej) diameters of the Khoisan population. Tswana and Zulu Males are similar to each other, and so are the females of these groups. Khoisan population groups are among the smallest of the modern human populations. Sexual dimorphism is extensive in the Tswana and the Zulu populations, but minimal in Europeans. The sample minimum and maximum of the European population groups are somewhat different from each other.

Table 79: Total root length of the mandibular 2nd molars

Population groups	**Total Root Length**			
	Mean	***Std dev***	***Range***	***N***
Palau	11.43	0.74	10.90-11.95	2

Two Palauan mandibular 2nd molars were available for comparison with modern humans, however, no comparison was possible because the means, standard deviations and ranges could

not be obtained from the available modern humans. Tswana and Zulu males were represented by only one individual each, plotted on the univariate graph below.

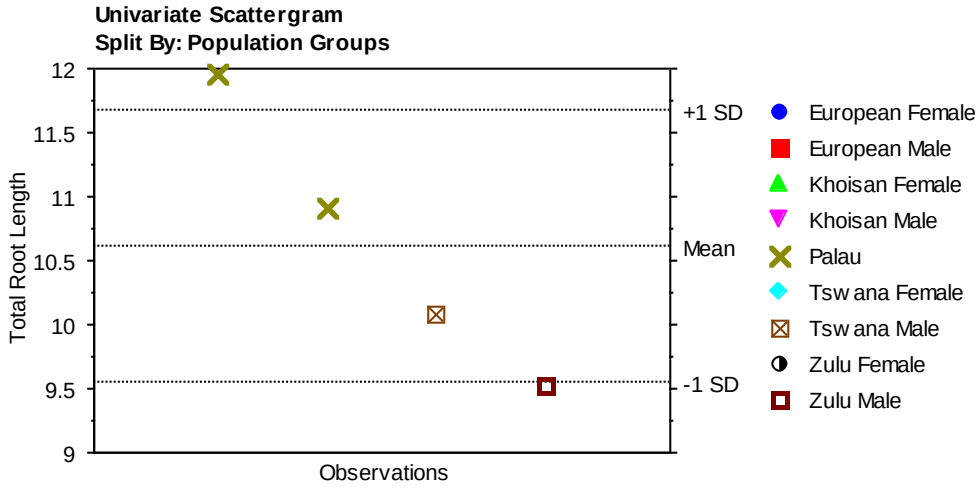

Figure 233: Univariate plot of the total root length of the mandibular 2nd molars.

The total root length of the Palau population is greater than those of the modern humans represented. The primary data of the Tswana and Zulu males available were 10.08 mm and 9.51 mm respectively, and are smaller than the two Palauans present.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the mandibular 2nd molars.

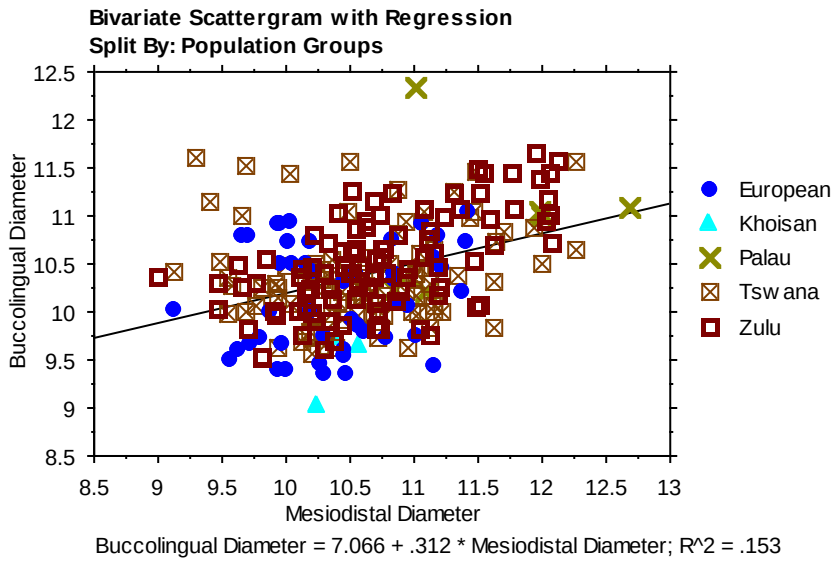

Figure 234: Bivariate plot of the MD and the BL diameters of the mandibular 2nd molars.

The MD diameter of the Palau population falls within and above the range of modern human variation. One is greater than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and their sample maximums are greater than those of the Europeans and Khoisan. The European and the Khoisan populations are clustered in the middle of the range of modern human variation.

The BL diameter of the Palau population falls within and above the range of modern human variation. One is greater than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are larger than most of the European population. The Khoisan population is clustered at the lower end of the range of modern human variation, thus making the difference between them and the Palau population the greatest. There is a low positive correlation between the MD and the BL diameter ($r= 0.39$, $n= 240$, $p< 0.0001$, 95% CI 0.278-0.493). The correlation between these two variables is statistically significant.

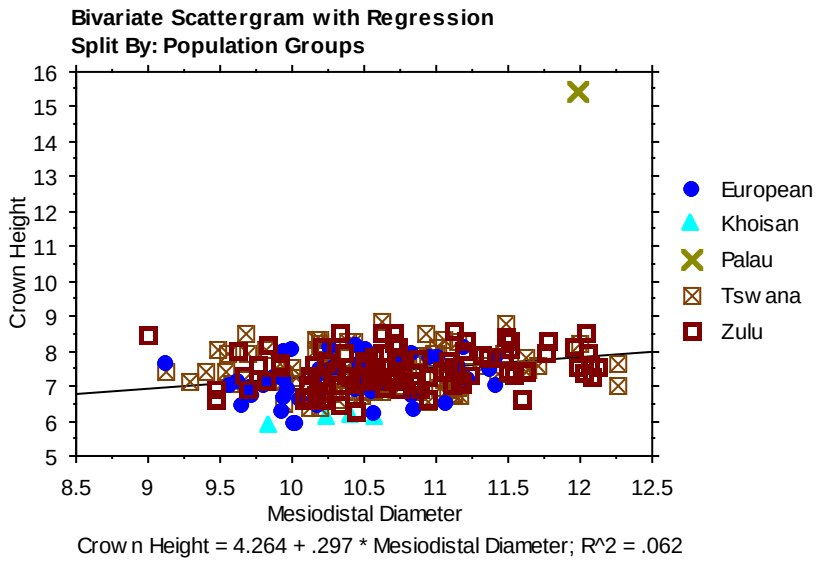

Figure 235: Bivariate plot of the MD diameters and the CH of the mandibular 2nd molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and their sample maximums are greater than those of the Europeans and the Khoisan. The European and the Khoisan are clustered in the middle of the range of modern human variation, though one of the European is among the smallest of the modern humans.

The crown height of the Palau populations falls above the range of modern human variation. It is 7.00 mm greater than the entire modern human sample. The Tswana, Zulu and the European populations are similar to one another, and are clustered on the 6.00-8.00 mm mark. The Khoisan population is at the lower end of the range of modern human variation. There is a low positive correlation between the MD diameter and the crown height ($r= 0.25$, $n= 229$, $p< 0.0001$, 95% CI 0.123-0.366). The correlation between these two variables is statistically significant.

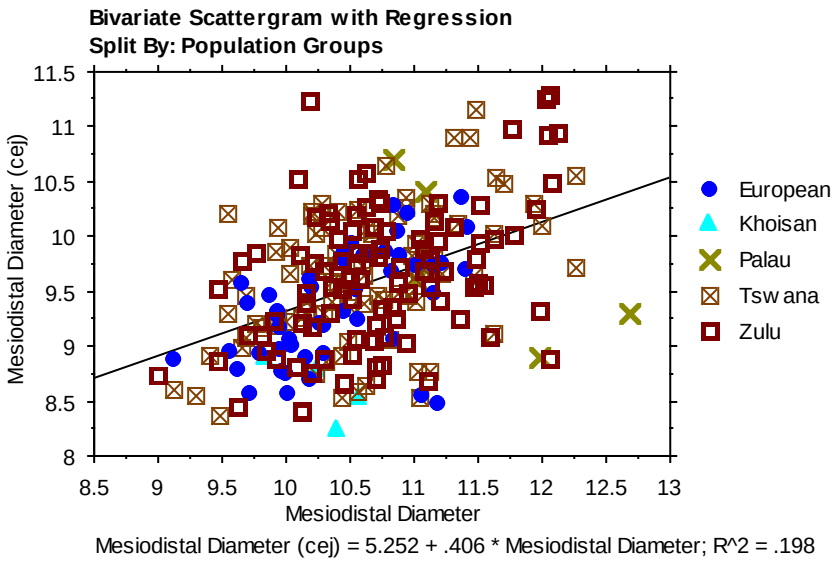

Figure 236: Bivariate plot of the MD and MD (cej) diameters of the mandibular 2nd molars.

The MD diameter of the Palau population falls within and above the range of modern human variation. One is greater than the entire modern human sample, whereas two are equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, are are widely spread. The Europeans and the Khoisan are in the middle of the range of modern human variation.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Two are equal to those on the upper end of the range, while two to those on the lower end. The Tswana and the Zulu populations are similar to each other, and are widely spread. They are evenly distributed along the range of modern human variation. The European population is clustered in the middle of the range of modern human variation, while the Khoisan is at the lower end. There is a low positive correlation between the MD and the MD (cej) diameter ($r= 0.45$, $n= 241$, $p< 0.0001$, 95% CI 0.338-0.541). The correlation between these two variables is statistically significant.

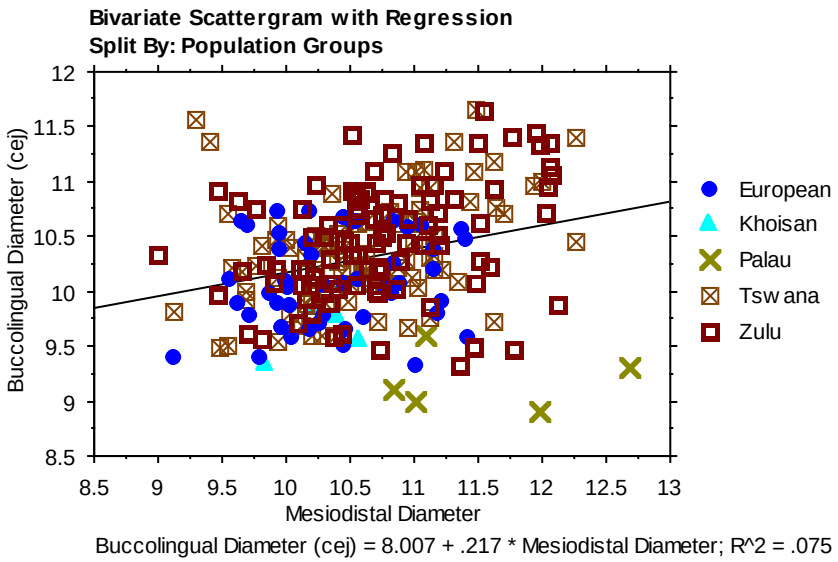

Figure 237: Bivariate plot of the MD and the BL (cej) diameters of the mandibular 2nd molars.

The MD diameter of the Palau population falls within and above the range of modern human variation. The Tswana, Zulu and the European populations are similar to one another, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is in the middle end of the range of modern human variation.

The BL (cej) diameter of the Palau population falls below and at the lower end of the range of modern human variation. Four are smaller than the entire modern human sample. The Tswana, Zulu and the European populations are similar to each other, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is at the lower end of the range of modern human variation. There is a low positive correlation between the MD and the BL (cej) diameter ($r= 0.27$, $n= 240$, $p< 0.0001$, 95% CI 0.153-0.387). The correlation between these two variables is statistically significant.

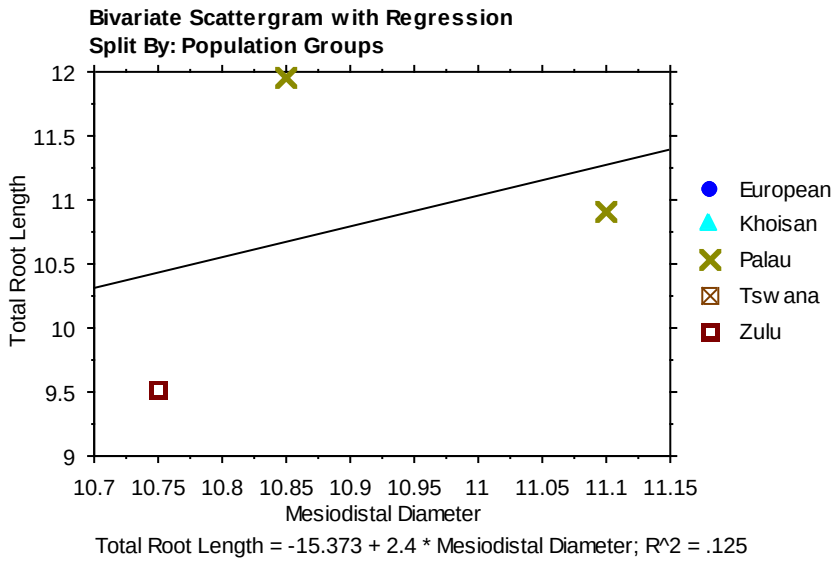

Figure 238: Bivariate plot of the MD diameters and the TRL of the mandibular 2nd molars.

The MD diameter of the Palau population falls above the range of modern human variation. It is larger than the only available Zulu population.

The total root length of the Palau population falls above the range of modern human variation. It is larger than the only available Zulu population. There is a low correlation between MD diameter and the total root length (r= 0.35, n= 3, p> 0.9999, 95% CI 0-1.000). The correlation between these two variables is not statistically significant.

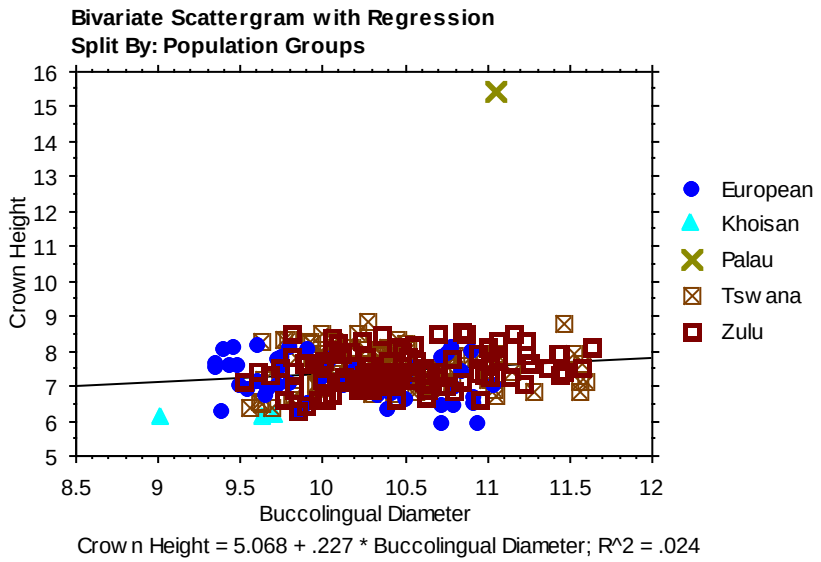

Figure 239: Bivariate plot of the BL diameters and the CH of the mandibular 2nd molars.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population are in the middle of the range of modern human variation, while the Khoisan is at the lower end.

The crown height of the Palau population falls above the range of modern human variation. The Tswana, Zulu and the European populations are similar to each other, but the sample maximums of the former two are some what greater than that of the latter. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the BL diameter and the crown height (r= 0.15, n= 238, p= 0.0173, 95% CI 0.027-0.276). The correlation between these two variables is statistically significant.

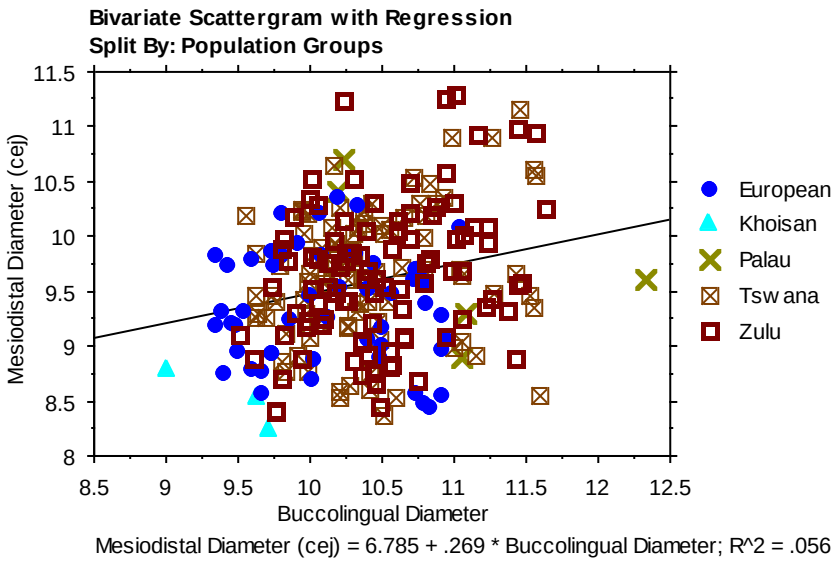

Figure 240: Bivariate plot of the BL and the MD (cej) diameters of the mandibular 2nd molars.

The BL diameter of the Palau population falls within and at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is among the smallest of the modern humans measured.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. Tw are equal to those at the upper end of the range, while two are at the lower end. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is in the middle of the range of modern human variation, while the Khoisan are at the lower end. There is a low positive correlation between the BL and the MD (cej) diameter (r= 0.24, n= 248, p= 0.0002, 95% CI 0.116-0.352). The correlation between these two variables is statistically significant.

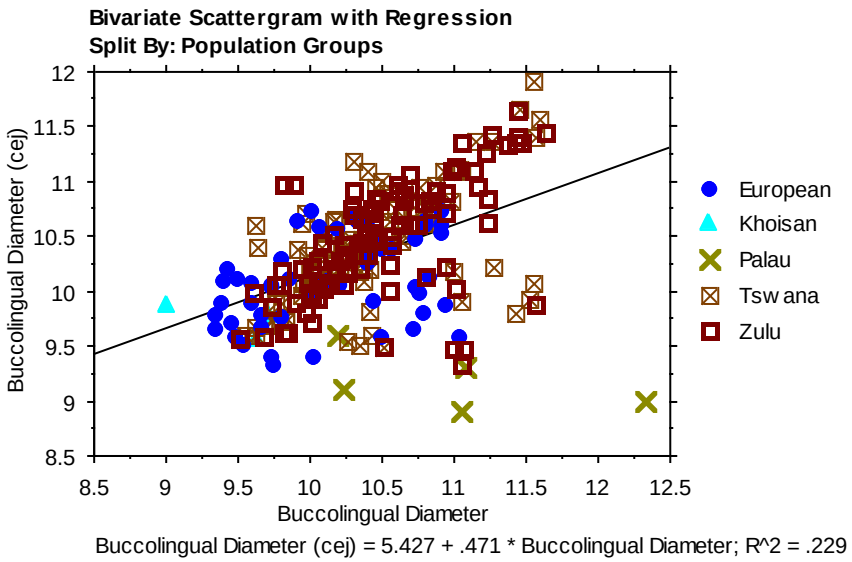

Figure 241: Bivariate plot of the BL and the BL (cej) diameters of the mandibular 2nd molars.

The BL diameter of the Palau population falls within and above the range of modern human variation. One is larger than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European is clustered in the middle of the range of modern human variation, while the Khoisan is at the lower end. This makes the difference between the Khoisan and the Palau population the greatest.

The BL (cej) diameter of the Palau population falls within and below the range of modern human variation. Three are smaller than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation, while the Khoisan is at the lower end. The difference between the Palau population and the Khoisan is the greatest. There is a low positive correlation between the BL and the BL (cej) diameter (r=

0.48, n= 249, p< 0.0001, 95% CI 0.377-0.569). The correlation between these two variables is statistically significant.

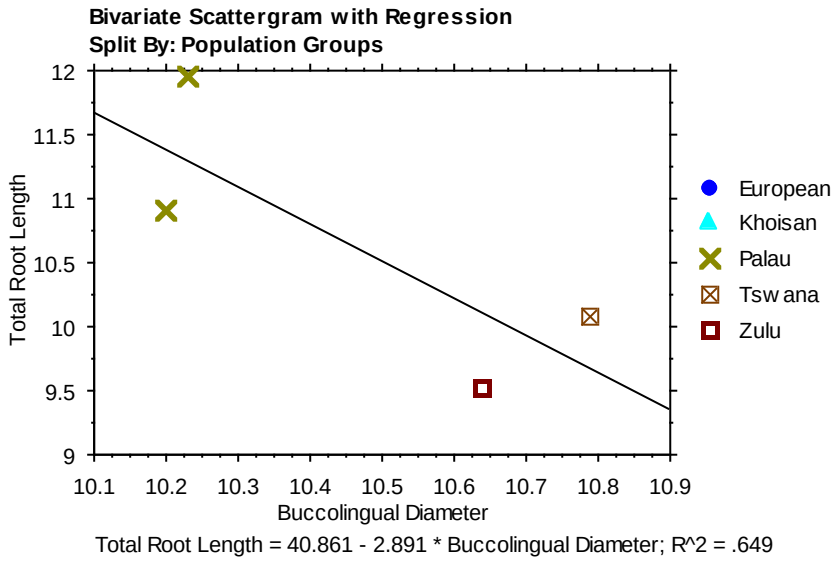

Figure 242: Bivariate plot of the BL diameters and the TRL of the mandibular 2nd molars.

The BL diameter of the Palau population falls below the range of modern human variation. It is smaller than the Tswana and the Zulu populations. The Tswana population is 0.2 mm larger than the Zulu population.

The total root length of the Palau population falls above the range of modern human variation. The only available Tswana population is greater than the Zulu. There is a high negative correlation between the BL diameter and the total root length (r= -0.81, n=4, p= 0.2653, 95% CI -0.996-0.689). The correlation between these two variables is not statistically significant.

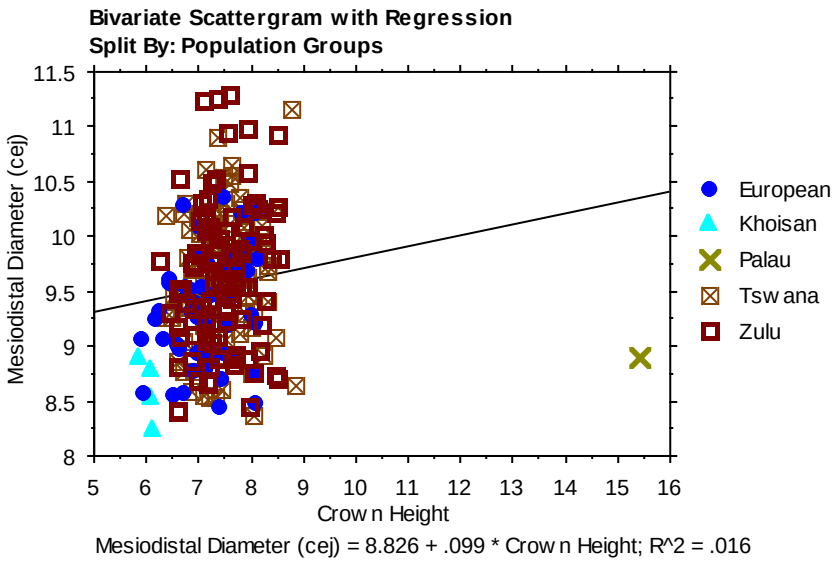

Figure 243: Bivariate plot of the CH and the MD (cej) diameters of the mandibular 2nd molars.

The crown height of the Palau population falls above the range of modern human variation. The Tswana, Zulu and the European populations are similar to one another, and are clustered around the 6.00-9.00 mm mark. The Khoisan population is among the smallest of the modern humans measured.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European is in the middle of the range of modern human variation, while the Khoisan is at the lower end. There is a low positive correlation between the crown height and the MD (cej) diameter (r= 0.13, n= 238, p= 0.0520, 95% CI -0.001-0.249). The correlation between these two variables is not statistically significant.

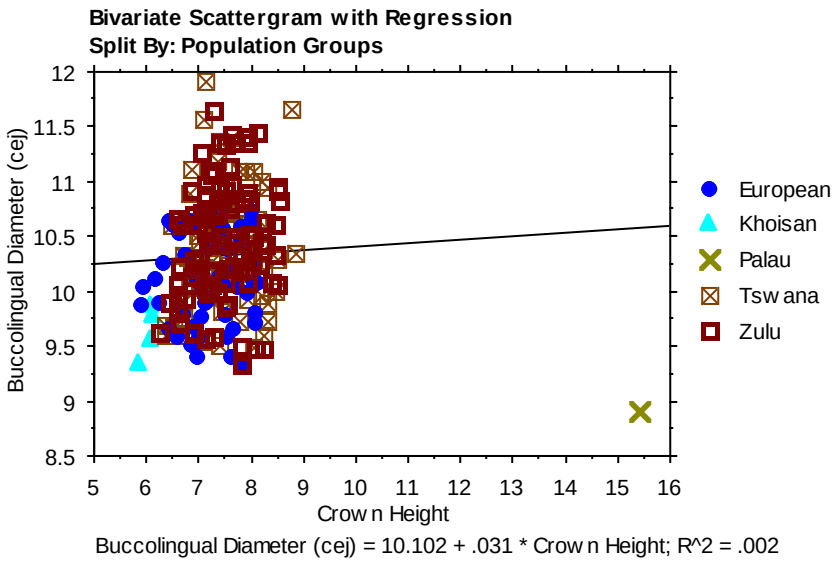

Figure 244: Bivariate plot of the CH and the BL (cej) diameters of the mandibular 2nd molars.

The crown height of the Palau population falls above the range of modern human variation. The Tswana, Zulu and the European population are similar to one another, and are clustered around the 6.00-8.50 mm mark. The Khoisan population is among the smallest of the modern humans measured. The difference between the Palauans and the modern humans is huge.

The BL (cej) diameters of the Palau population falls below the range of modern human variation. It is smaller than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the crown height and the BL (cej) diameter (r= 0.05, n= 238, p= 0.4746, 95% CI -0.081-0.173). The correlation between these two variables is not statistically significant.

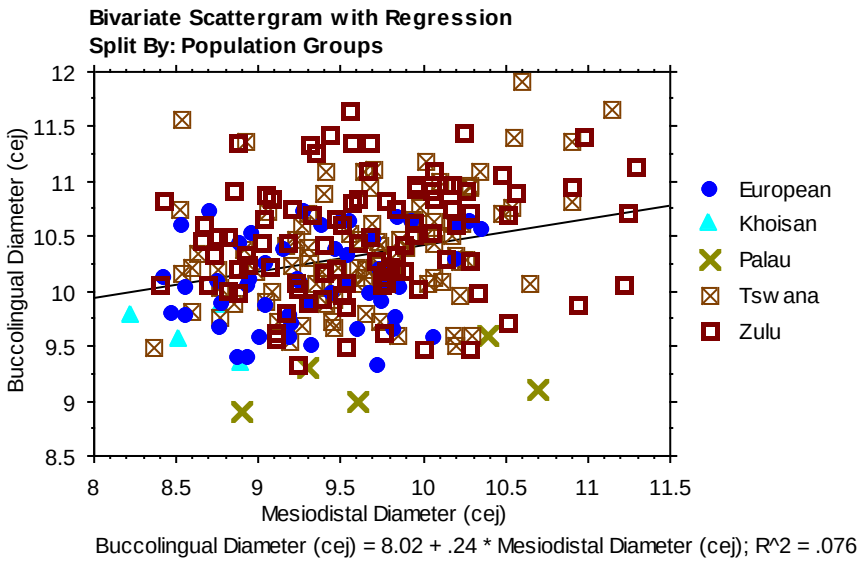

Figure 245: Bivariate plot of the MD (cej) and the BL (cej) diameters of the mandibular 2nd molars.

The MD (cej) diameter of the Palau population falls within the range of modern human variation, and is equal to those in the middle and on the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European is in the middle of the range of modern human variation. The Khoisan population is at the lower end of the range of modern human variation.

The BL (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. Three are smaller than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The Khoisan is at the lower end of the range of modern human variation. There is a low correlation between the MD (cej) and the BL (cej) diameter ($r= 0.28$, $n= 249$, $p< 0.0001$, 95% CI 0.156-0.386). The correlation between these two variables is statistically significant.

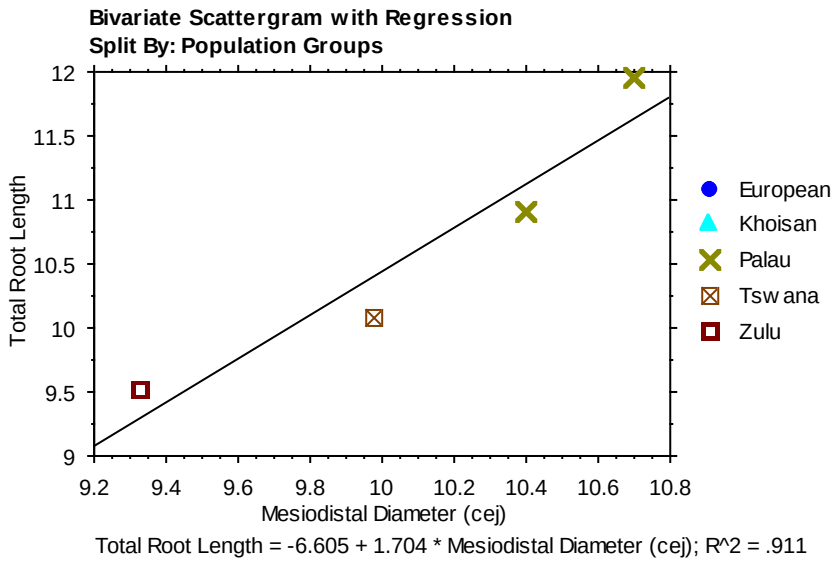

Figure 246: Bivariate plot of the MD (cej) diameters and the TRL of the mandibular 2nd molars.

The MD (cej) diameter of the Palau population falls above the range of modern human variation. The only available Tswana is larger than the Zulu. This makes the difference between the Zulu and the Palau population the greatest.

The total root length of the Palau population falls above the range of modern human variation. The Tswana population is greater than the Zulu population. There is a high positive correlation between the MD (cej) diameter and the total root length (r= 0.95, N= 4, P= 0.0603, 95% CI -0.081-0.999). The correlation between these two variables is not statistically significant.

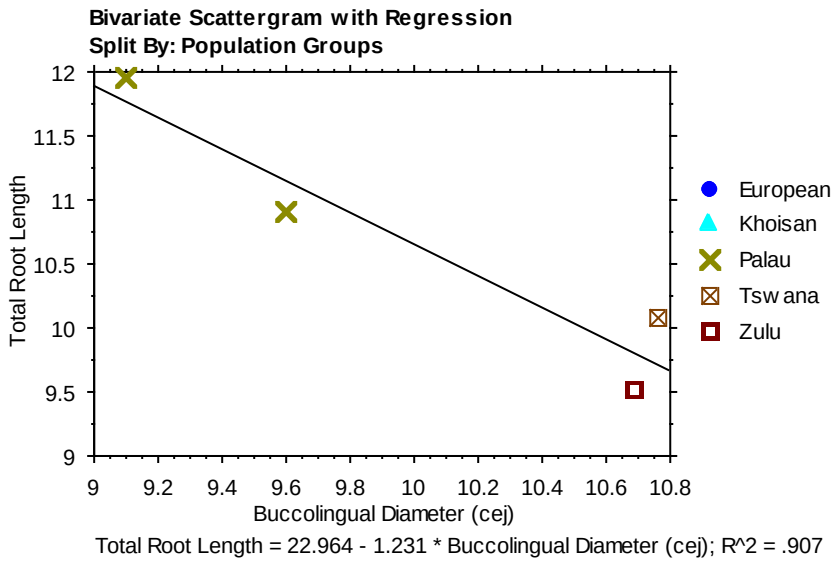

Figure 247: Bivariate plot of the BL (cej) diameters and the TRL of the mandibular 2nd molars.

The BL (cej) diameter of the Palau population falls below the range of modern human variation. It is smaller than the Tswana and the Zulu populations available. The Tswana and the Zulu populations are equal to each other.

The total root length of the Palau population falls above the range of modern human variation. The Tswana population is a little larger than the Zulu. There is a high negative correlation between the BL (cej) diameter and the total root length (r= -0.95, n= 4, p= 0.0634, 95% CI -0.999-0.103). The correlation between these two variables is not statistically significant.

Maxillary 2nd molars

The size of maxillary 2nd molars was examined using six measurements described in detail in Chapter 2. The total number of specimens, ranges, means and standard deviations are given in the following tables for each population group for comparison with the Palauan sample of maxillary 2nd molars. In addition, a univariate plot for each measurement is presented to further

illustrate the difference between the groups. Each table is followed by a univariate analysis of the same measurement.

Table 80: MD diameters of the maxillary 2nd molars

Population groups	MD Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	10.41	1.01	8.80-11.70	5
Khoisan males	8.77	0.12	8.65-8.90	3
Tswana males	10.15	0.70	8.84-12.04	50
Tswana females	9.87	0.65	8.79-11.38	42
Zulu males	10.12	0.71	8.87-11.98	67
Zulu females	9.96	0.69	8.79-11.28	50
European males	9.78	0.76	8.55-11.14	47
European females	9.64	0.65	8.55-10.91	17

Five Palauan maxillary 2nd molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only three individuals present. The mean of the MD diameters of the Palau population is greater than the means of all the modern human populations. It is followed by the mean of Tswana males. Khoisan males have the lowest mean of all the populations measured. European population groups have means that are greater than Khoisan males, but smaller than the remaining human population groups. The females of the modern humans have means that are smaller than the means of the males of their respective groups.

Khoisan males have the lowest standard deviation, whereas Palauans have the highest. The other groups have lower standard deviations, which indicate the clustering of primary data around the means of the different groups. The MD diameter of the Palau population ranges from 8.8-11.7 mm, while Tswana and Khoisan males range from 8.84-12.04 mm and 8.65-8.90 mm

respectively. These ranges indicate that the MD diameter of the Palau population falls within the normal range of modern human variation.

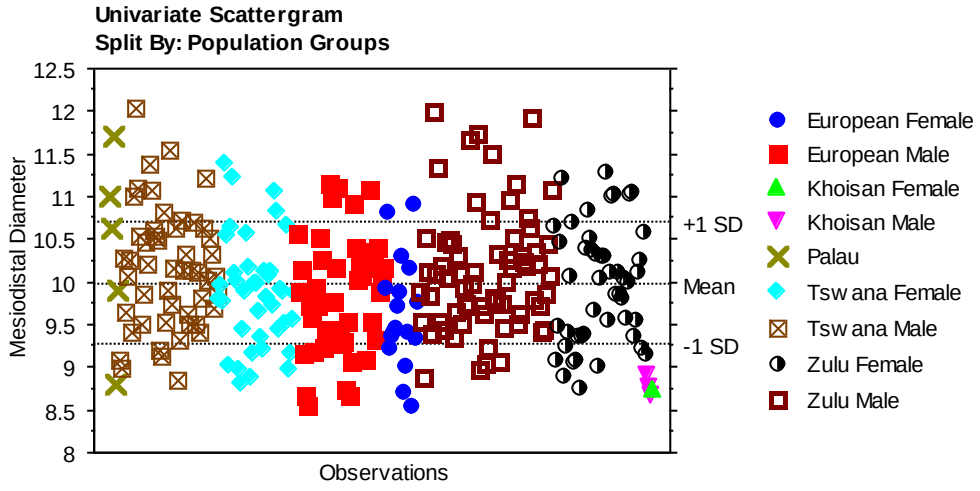

Figure 248: Univariate plot of the MD diameters of the maxillary 2nd molars.

The MD diameter of the Palau population is equal to those of the modern human populations.

The MD diameter of the Tswana and Zulu males are similar to each other, and are slightly larger than those of their female counterparts. Khoisan population groups are clustered among the smallest of the modern human populations. European population groups are smaller than the Khoisan, and most of the Palauans, Tswanas and Zulus. Sexual dimorphism is extensive in the Tswana and Zulu population groups, but moderate in the Europeans and Khoisan.

Table 81: BL diameters of the maxillary 2nd molars

Population groups	BL Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	12.29	1.09	10.9-13.49	5
Khoisan males	9.42	0.11	9.30-9.50	3
Tswana males	11.36	0.76	10.23-13.02	51
Tswana females	10.99	0.53	9.90-11.99	43
Zulu males	11.41	0.62	10.12-12.99	67
Zulu females	10.96	0.47	10.14-11.83	50
European males	10.80	0.59	9.73-11.74	47
European females	10.77	0.63	9.62-11.53	17

Five Palauan maxillary 2nd molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only three individuals. The mean of the BL diameters of the Palau population is greater than the means of all the modern human populations. It is followed by the mean of the Tswana males. Khoisan males have the lowest mean of all the populations measured. The means of the Europeans are greater than the the Khoisan, but smaller than those of the other human populations. The means of the females of the modern human sample are lower than those of the males of their similar groups. The modern human populations have the lowest standard deviations, while the Palauans have a slightly higher one. The BL diameters of the Palauans range from 10.90-13.49 mm. Tswana males and Khoisan males range from 10.23-13.02 mm and 9.3-9.5 mm respectively. These ranges indicate that the BL diameters of the Palau population fall above the normal range of modern human variation.

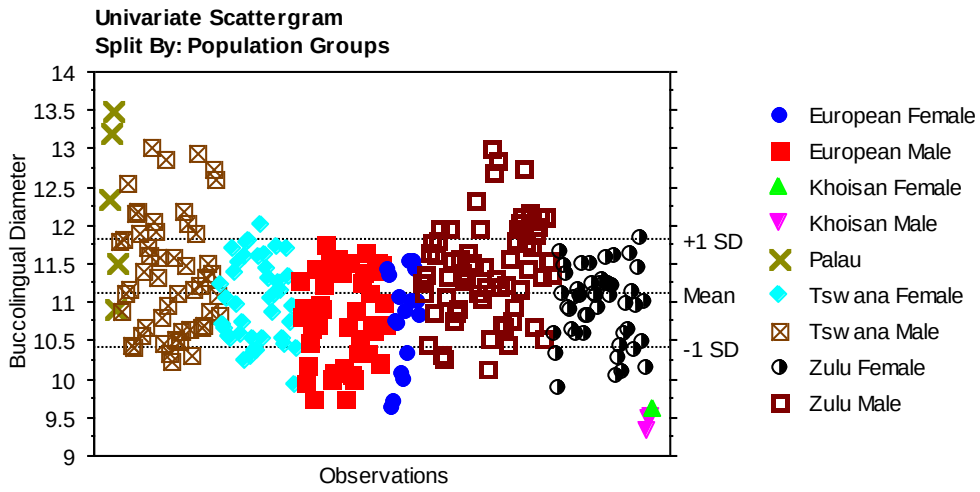

Figure 249: Univariate plot of the BL diameters of the maxillary 2nd molars.

A few of the BL diameters of the Palau population are larger than the BL diameters of the modern human populations, while some are equal to those of the modern humans. Tswana and Zulu males are very similar, and so are the females of these two groups. Khoisan populations are clustered on the lower end of the range of modern human variation. Sexual dimorphism is extensive in the Tswanas and Zulus, but moderate in Europeans and Khoisan.

Table 82: MD (cej) diameters of the maxillary 2nd molars

Population groups	MD (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	7.75	1.09	6.50-9.10	4
Khoisan males	7.8	0.30	7.49-8.08	3
Tswana males	8.83	0.68	7.71-10.43	51
Tswana females	8.77	0.68	7.44-10.15	43
Zulu males	8.83	0.64	7.70-10.35	67
Zulu females	8.72	0.64	7.43-10.17	49
European males	8.54	0.63	7.26-9.72	47
European females	8.42	0.36	7.70-9.00	17

Four Palauan maxillary 2nd molars were available for comparison with the modern human sample. Out of the 400 modern humans studied; the Khoisan population was the least represented, with only four individuals. The mean of the MD (cej) diameters of the Palau population is lower than the means of the entire modern human sample. Tswana and Zulu males have the highest means of all the populations measured, while Khoisan males have the lowest. Europeans have means that are lower than those of Tswanas and Zulus, but greater than those of the Khoisan. Modern human females have means that are lower than those of their male counterparts.

Palauans have the highest standard deviation of all the populations measured. Those of modern humans are small, indicating the clustering of the primary data around the means of the different groups. The MD (cej) diameters of the Palauans range from 6.5-9.1 mm. Tswana males and Khoisan males range from 7.71-10.43 mm and 7.49-8.08 mm respectively. These ranges indicate

that the MD (cej) diameter of the Palau population falls within the normal range of modern human variation.

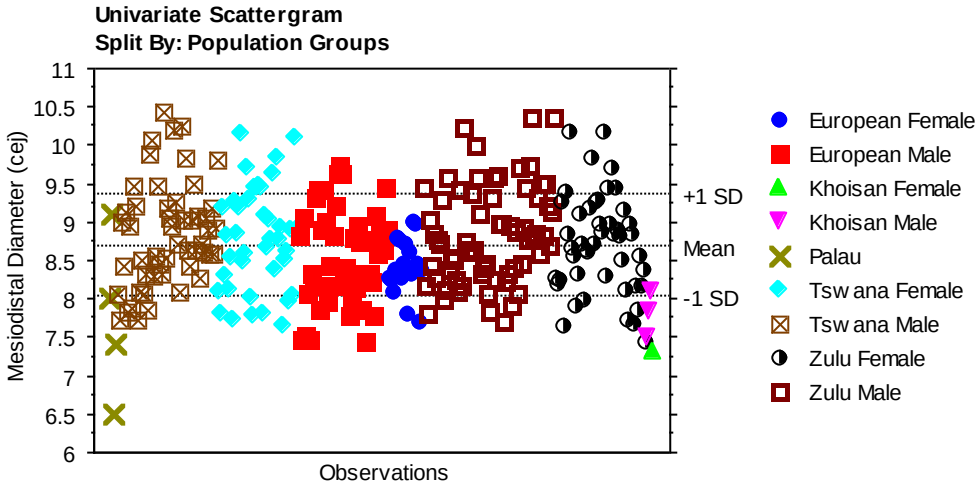

Figure 250: Univariate plot of the MD (cej) diameters of the maxillary 2nd molars.

Two of the MD (cej) diameters of the Palau population are equal to those of the modern human populations. One is equal to the lowest MD (cej) diameter of the modern humans recorded, while one is lower. Males and females of the Tswana and Zulu population groups are comparable with each other. Khoisan population groups are clustered among the smallest of the modern humans measured. Moderate sexual dimorphism is evident in the MD (cej) diameters of the modern humans studied.

Table 83: BL (cej) diameters of the maxillary 2nd molars

Population groups	BL (cej) Diameters			
	Mean	***Std dev***	***Range***	***N***
Palau	11.35	1.24	9.80-12.40	4
Khoisan males	9.9	0.28	9.71-10.22	3
Tswana males	11.58	0.58	10.42-12.98	51
Tswana females	11.16	0.54	10.22-12.22	43
Zulu males	11.63	0.65	10.43-12.92	67
Zulu females	11.20	0.57	10.27-12.29	49
European males	11.12	0.69	9.84-12.10	47
European females	10.86	0.65	9.69-11.64	17

Four Palauan maxillary 2nd molars were available for comparison with the modern human sample. The Khoisan population was the least represented, with only four individuals. The mean of the BL (cej) diameters of the Palau population is lower than the means of Tswana and Zulu males. Zulu males have the highest mean of all the populations measured, whereas Khoisan males have the lowest. European population groups are larger than the Khoisan, but smaller than the remaining human populations studied. Modern human females have means that are smaller than their male counterparts.

Palauans have a higher standard deviation compared to modern humans. The low standard deviations observed in the modern humans indicate the clustering of primary data around the means of the different groups. The Palauans range from 9.8-12.4 mm. Zulu and Khoisan males range from 10.43-12.92 mm and 9.71-10.22 mm respectively. These ranges indicate that the BL (cej) diameter of the Palau population falls within the normal range of modern human variation.

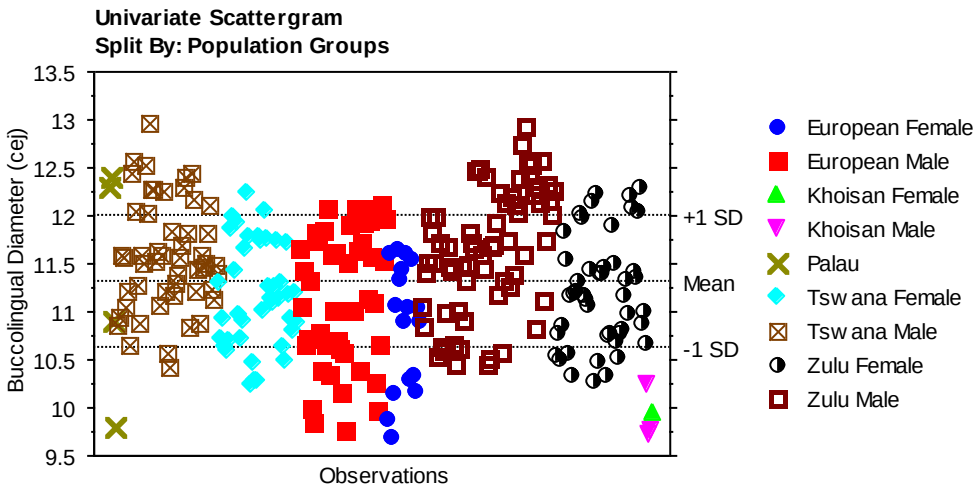

Figure 251: Univariate plot of the BL (cej) diameters of the maxillary 2nd molars.

The BL (cej) diameter of the Palau population is equal to that of modern human populations. Only one is equal to the smallest of the European and Khoisan populations. Tswana and Zulu males are equal to each other, and so are the females of these two groups. European males are comparable to Tswana and Zulu females. The Khoisan population groups are among the smallest of the modern humans measured. Sexual dimorphism is extensive in all the groups measured.

Bivariate Analysis

The first variables compared were the crown measurements, the MD and BL of the maxillary 2nd molars.

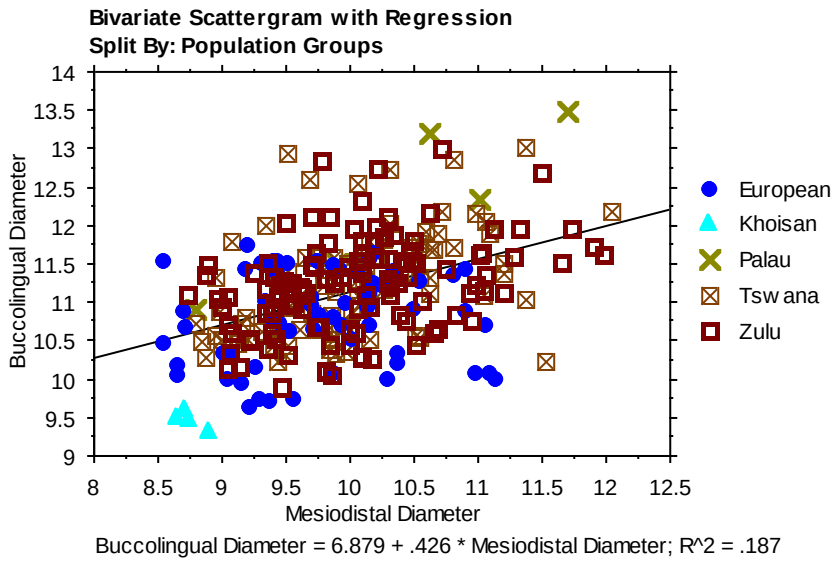

Figure 252: Bivariate plot of the MD and the BL diameters of the maxillary 2nd molars.

The MD diameter of the Palau population falls at the upper end of the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is in the middle of the range of modern human variation. The Khoisan population is clustered in the lower end of the range of modern variation, thus makes the difference between them and the Palau population the greatest.

The BL diameter of the Palau population falls at the upper end of the range of modern human variation. Two are larger than the entire modern human sample. The Tswana and the Zulu populations are similar to each other, and their sample maximums are greater than that of the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation. The Khoisan population is at the lower end of the range of modern human variation, thus making the difference between them and the Palau population the greatest. There is a low positive correlation between the MD and the BL diameter ($r= 0.43$, $n= 273$, $p< 0.0001$, 95% CI 0.330-0.524). The correlation between these two variables is statistically significant.

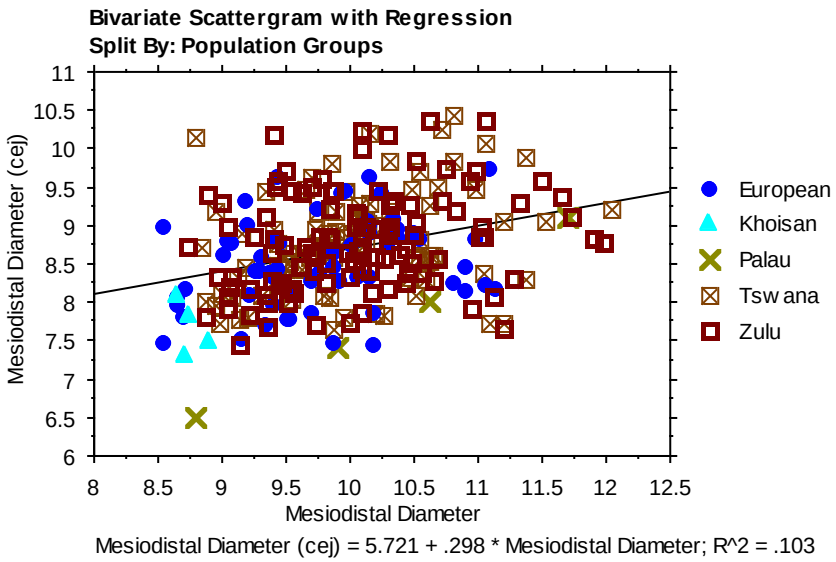

Figure 253: Bivariate plot of the MD and the MD (cej) diameters of the maxillary 2nd molars.

The MD diameter of the Palau population falls within the range of modern human variation. One is equal to those at the lower end of the range, whereas two are equal to those in the middle of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is in the middle of the range of modern human variation, though few are at the upper end. The Khoisan population is at the lower end of the range of modern human variation, thus making the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls at the lower end of the range of modern human variation. One is smaller than the entire modern human variation. The Tswana, Zulu and the European population are similar to one another, though the sample maximums of the former two are larger than that of the latter. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the MD and the BL (cej)

diameter (r= 0.32, n= 270, p< 0.0001, 95% CI 0.209-0.424). The correlation between these two variables is statistically significant.

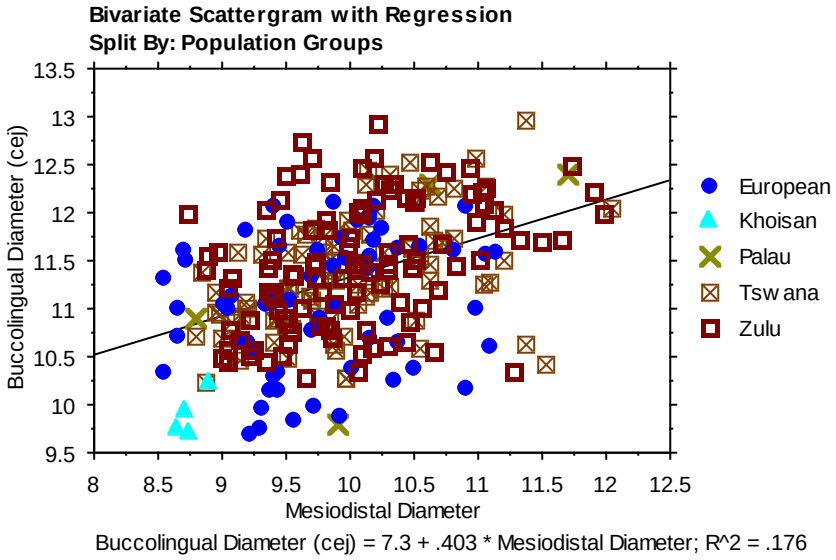

Figure 254: Bivariate plot of the MD and BL (cej) diameters of the maxillary 2nd molars.

The MD diameter of the Palau population falls within the range of modern human variation. One is equal to those at the upper end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is clustered in the middle of the range of modern human variation, while few are at the upper end. The Khoisan population is clustered at the lower end of the range of modern human variation.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. One is equal to those at the lower end of the range. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The European population is in the middle of the range of modern human variation. The Khoisan is among the smallest of the modern humans measured. There is a low positive correlation between the MD

and the BL (cej) diameter (r= 0.42, n= 271, p< 0.0001, 95% CI 0.317-0.513). The correlation between these two variables is statistically significant.

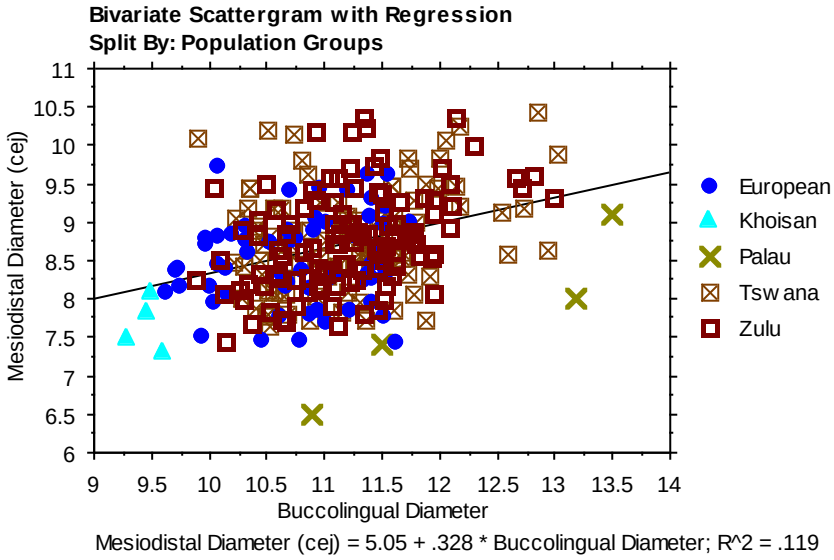

Figure 255: Bivariate plot of the BL and the MD (cej) diameters of the maxillary 2nd molars.

The BL diameter of the Palau population falls above and within the range of modern human variation. The Tswana and the Zulu populations are similar to each other, and they shift towards the upper end of the range. The Khoisan population is the smallest of the modern humans measured, thus making the difference between them and the Palau population the greatest.

The MD (cej) diameter of the Palau population falls within the range of modern human variation. One is smaller than the entire modern human sample. The Tswana, Zulu and the European populations are similar to one another, though the sample maximums of the former two are larger than that of the former. The Khoisan population is among the smallest of the modern humans measured. There is a low positive correlation between the BL and the MD (cej) diameter (r= 0. 35, n= 272, p< 0.0001, 95% CI 0.236-0.446). The correlation between these two variables is statistically significant.

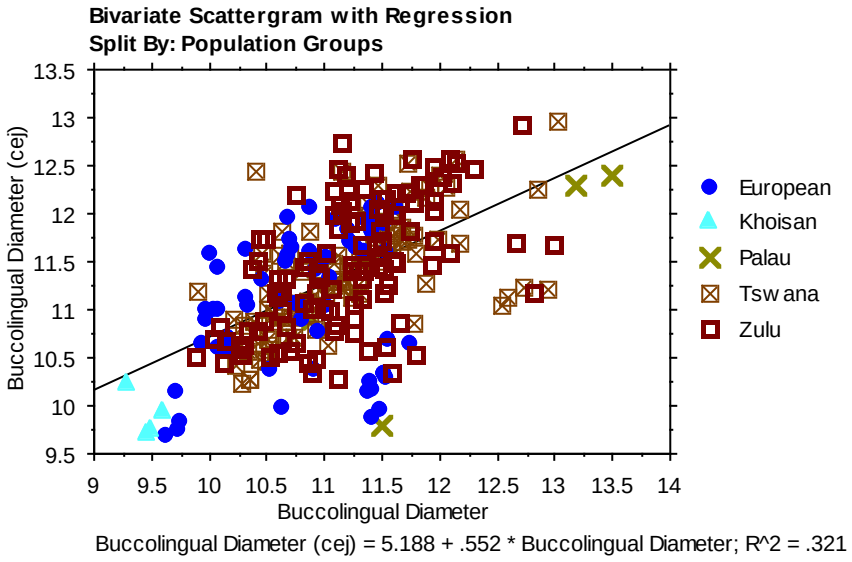

Figure 256: Bivariate plot of the BL and the BL (cej) diameters of the maxillary 2nd molars.

The BL diameter of the Palau population falls within and above the range of modern human variation. The Tswana, Zulu and the European populations are similar to each other, but the sample maximums of the former two are greater than that of the latter. The Khoisan population is the smallest of the modern humans, thus making the difference between them and the Palau population the greatest.

The BL (cej) diameter of the Palau population population falls within the range of modern human variation. One is at the lower end of the range, while two are at the upper end. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The Khoisan population is among the smallest of the modern humans measured. There is a moderate positive correlation between the BL and the BL (cej) diameter (r= 0.57, n= 273, p< 0.0001, 95% CI 0.480-0.642). The correlation between these two variables is statistically significant.

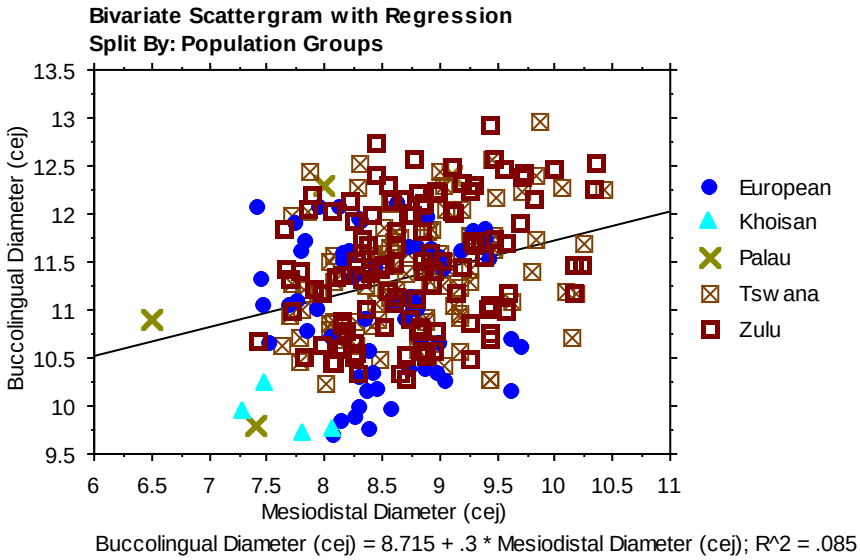

Figure 257: Bivariate plot of the MD (cej) and the BL (cej) diameters of the maxillary 2nd molars.

The MD (cej) diameter of the Palau population falls below and within the range of modern human variation. The sample minimums of the Tswana, Zulu and the European populations are similar, though the sample maximums of the former two are greater than that of the latter. The Khoisan population is among the smallest of the modern humans measured.

The BL (cej) diameter of the Palau population falls within the range of modern human variation. One is among the smallest of the modern humans, while the other is at the upper end. The Tswana and the Zulu populations are similar to each other, and are greater than the Europeans and the Khoisan. The Tswana, Zulu and the European populations are evenly distributed along the regression line, with equal quantities on either sides of the line. The Khoisan population is clustered in the lower end of the range of modern human variation. There is a low correlation between the MD (cej) and the BL (cej) diameter ($r= 0.29$, $n= 272$, $p< 0.0001$, 95% CI 0.179-0.397). The correlation between these two variables is statistically significant.

RESULTS -Anomalies

Frequency of anomalies

A survey of anomalies was conducted on the entire human sample of the Raymond Dart collection, and the Holocene human skeletons housed in the Iziko Museum. Not all the specimens could be used for the study due to the loss of the specific teeth needed to record the anomaly. Table 84 shows the number of specimens studied exhibiting the anomalies.

Table 84. Frequency of the anomalies observed in the three human samples.

Anomaly	**Palauans**		**Modern humans**		**Holocene Humans**	
	Sample size	Anomaly	Sample size	Anomaly	Sample Size	Anomaly
Congenital absence of third molar	7	57%	1943	6.99%	56	3.57%
Incisiform canines	4	50%	2054	1.21%	36	0
Caniniform premolar	12	16%	2032	2.31%	35	2.86%
Rotated premolar	12	16%	2065	2.62%	38	2.63 %

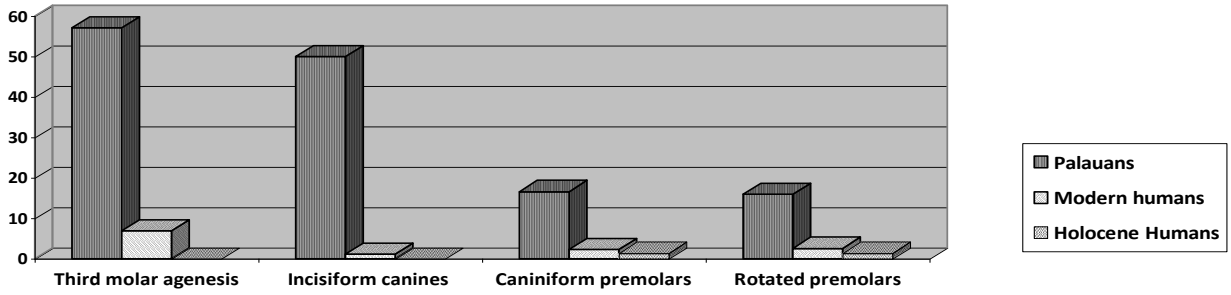

Figure 258: Histogram illustrating the frequency of anomalies in the three samples.

The above histogram indicates that the Palauans have a very high frequency of dental anomalies compared to the modern and Holocene human populations studied.

IMAGES OF ANOMALIES

The following are photographs of specimens from different samples indicating the anomalies studied.

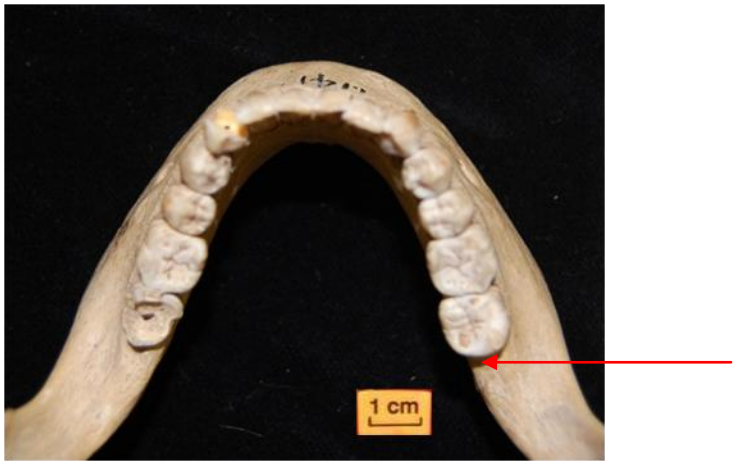

Figure 259: Photo of a Barolong female indicating congenital absence of a third molar.



Figure 260: Photo of a Xhosa female illustrating incisiform canine

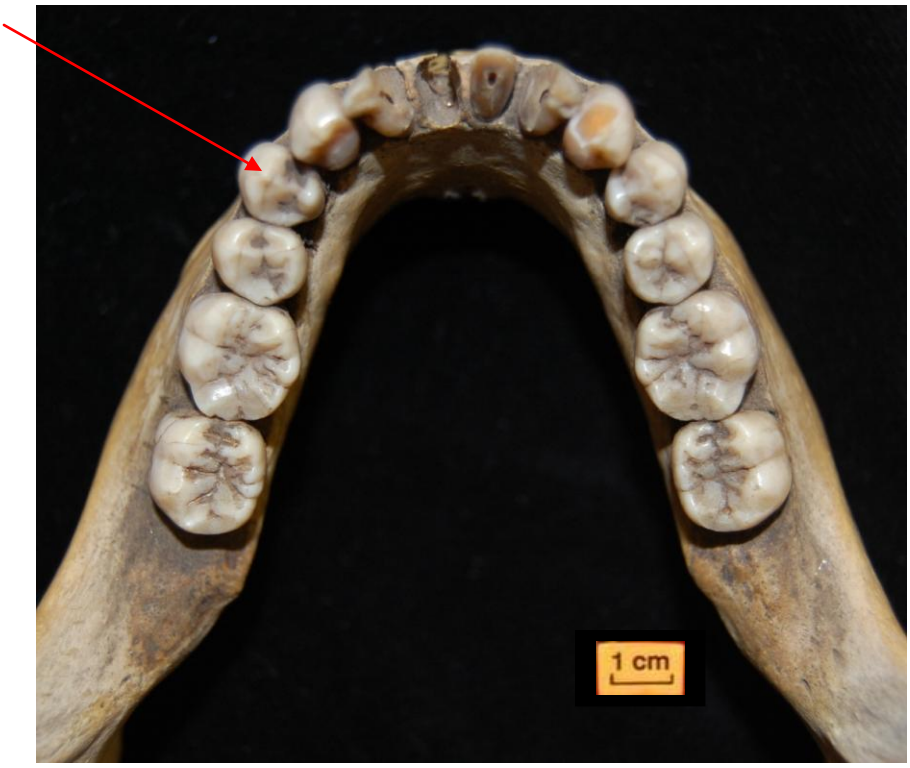

Figure 261: Photo of a Venda male illustrating the caniniform 3rd premolar.

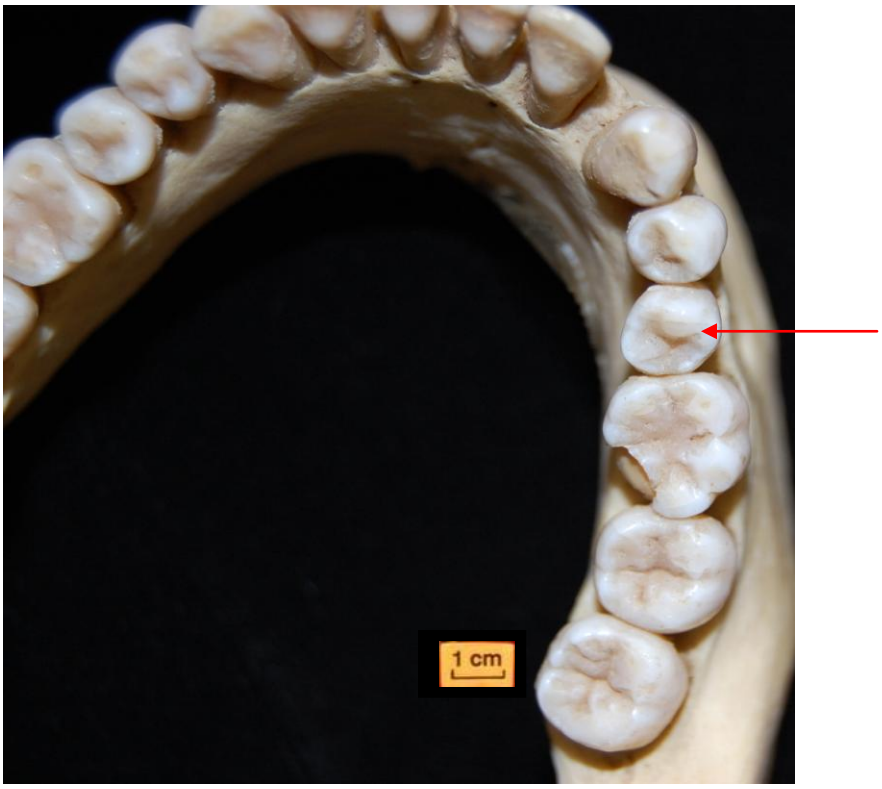

Figure 262: Photo of a Barolong female indicating the rotation of the 4th premolar.

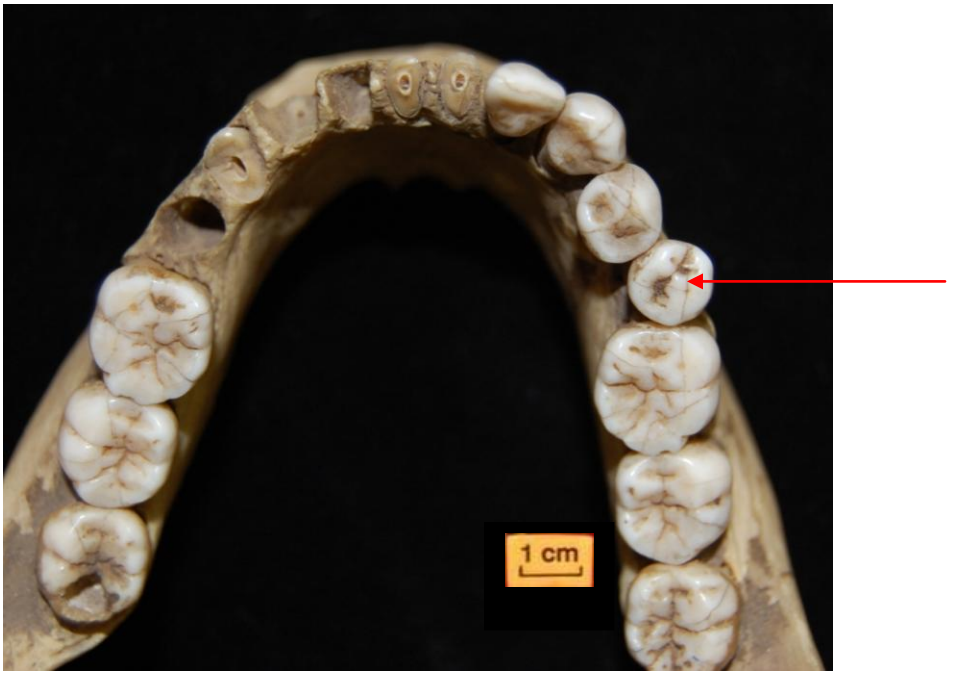

Figure 263: Photo of a Malawian male illustrating the rotation of the 4th premolar.

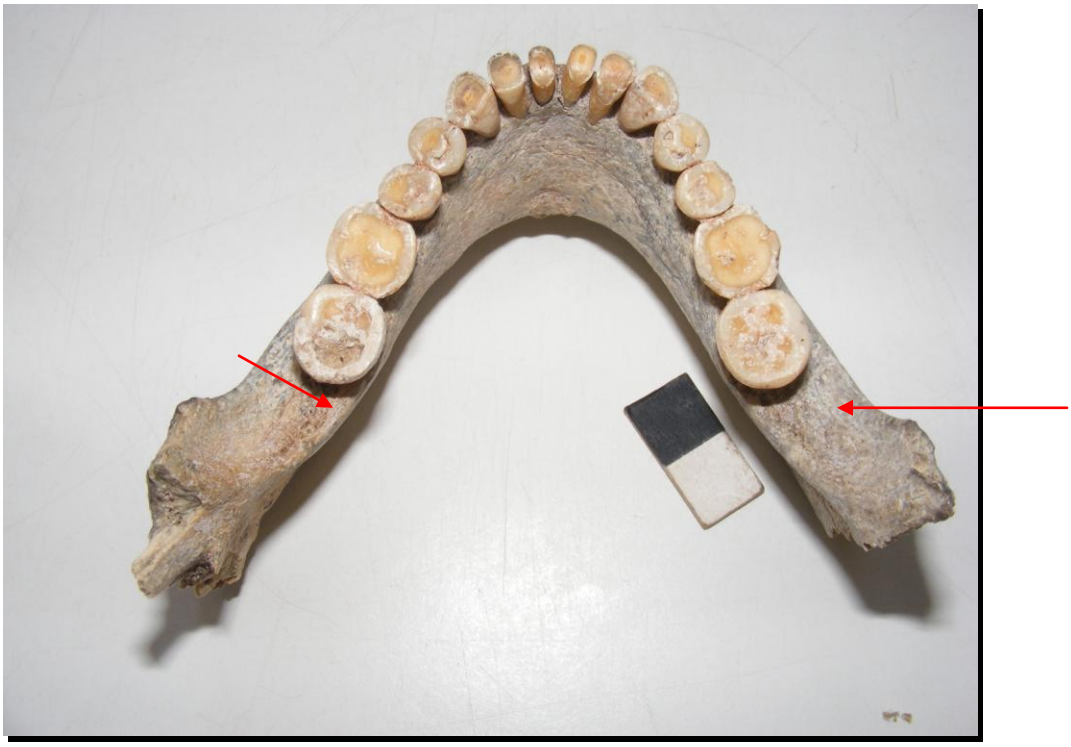

Figure 264: Photo of a Holocene human skeleton (Sam 5068) illustrating congenital absence of third molar.

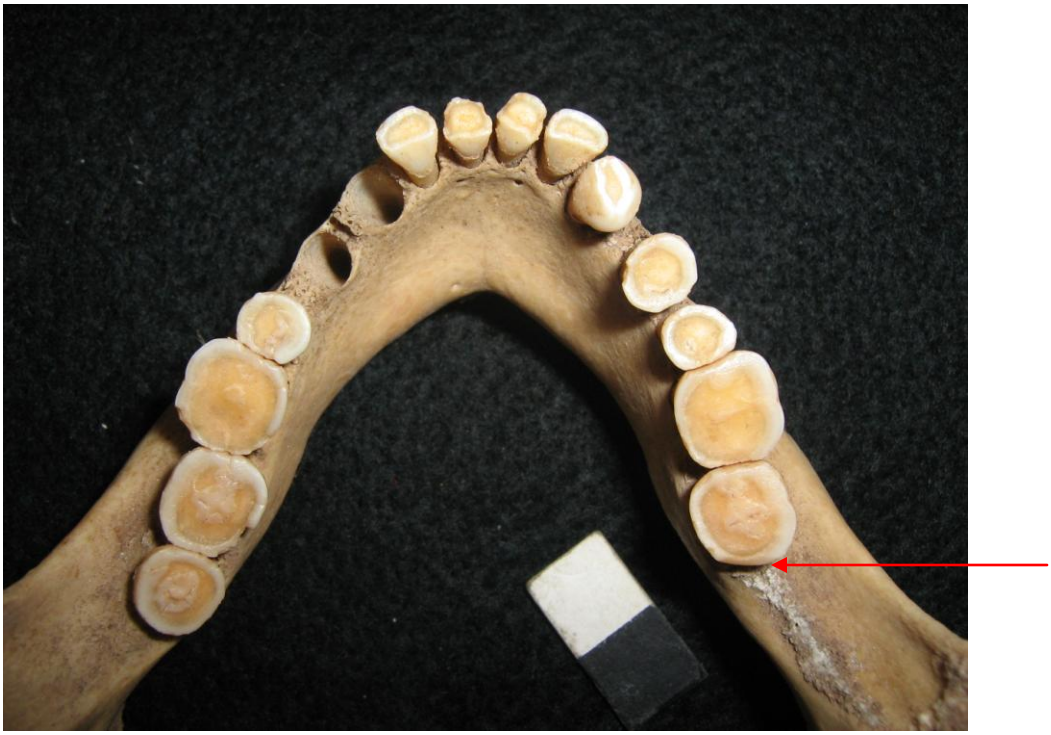

Figure 265: Photo of a Holocene human skeleton (Sam 5075) illustrating congenital absence of third molar on the right side of the mandible.

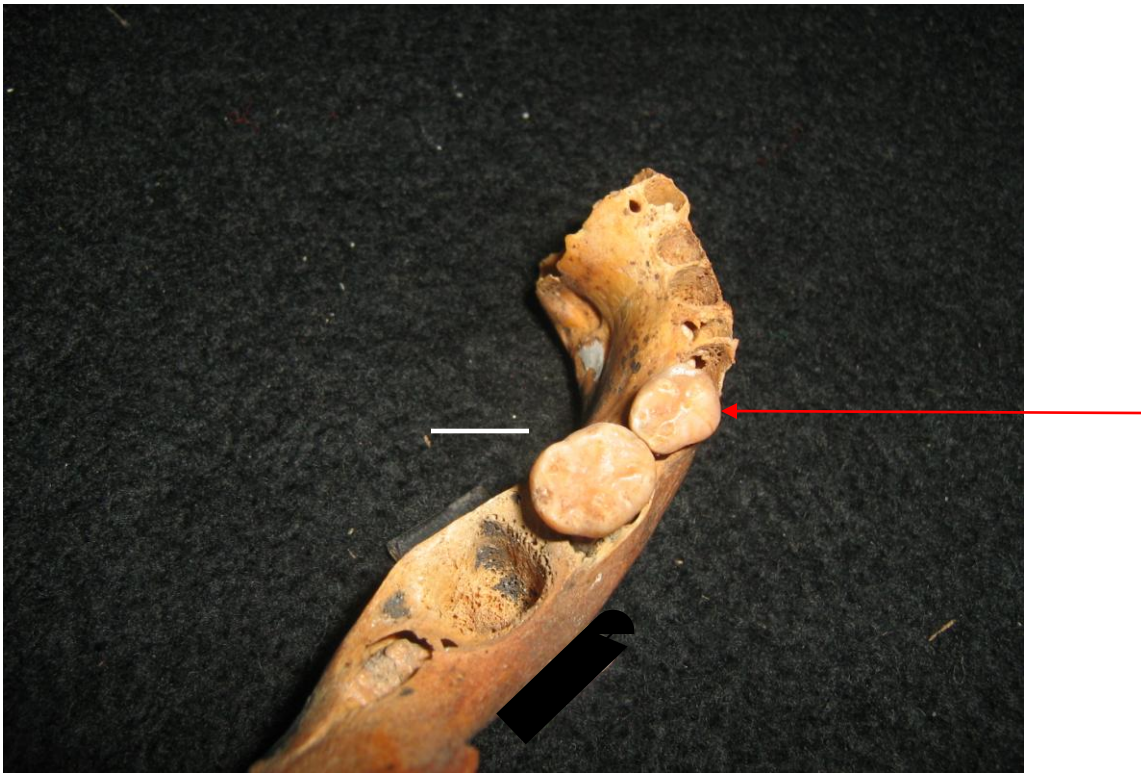

Figure 266: Photo of a Holocene human skeleton (Sam 3458) illustrating premolar rotation.

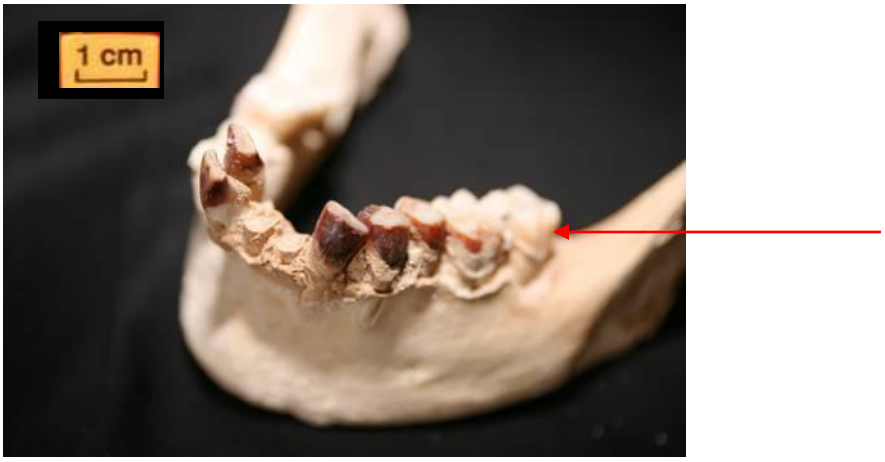

Figure 267: Photo of a Palauan mandible illustrating a number of anomalies observed in the Palauan sample. These are the congenital absence of third molar, incisiform canines and caniniform premolar.

Tooth anomalies

Congenital Absence of Third Molars

There is a high frequency of congenital absence of third molars in the Palauan sample. Out of seven mandibles sampled, four exhibited third molar agenesis (Figure 298). Modern human samples studied here have 'normal' sized teeth and a very low frequency of congenital absence of third molar. (Figure 290-294). Of the modern human sample, the European population group has the highest frequency of congenital absence of third molar compared to other population groups. Out of 6.9% they contributed about 1.73% and 28 population groups contributed the remaining 5.17%. In all the groups studied, males have the highest frequency of congenital absence of third molars than females. The Holocene human skeletons have a very low frequency of congenital absence of third molar. Out of 69 skeletons studied, two have the anomaly, Figure, 296 and 297.

Incisiform Canines

50% of the Palauans recorded the anomaly, whereas 1.21% of modern humans studied have incisiform canines. Males have the highest frequency of incisiform canines, with Shangaan and Xhosa males exhibiting the most. Out of 25, only 7 were recorded from the females, 5 of which are from the Europeans. The anomaly was not recorded on the Holocene human skeletons studied here.

Caniniform Premolars

Caniniform premolars are shown in figures 124, 125 and 130 as statistical graphs of the mandibular 3rd premolars; and in figure 295 as a photograph of a Palauan mandible (specimen number B: OR-15:18-083). The mediodistal (MD) and buccolingual (BL) diameters of those mandibular 3rd premolars are smaller than most of the mandibular 3rd premolars of the modern human populations. Figure 165 and 166 of the mandibular 4th premolars show these premolars mimicking the anomaly displayed by the ones in front of them. No anomaly or mimicking of any sort was present on the maxillary 3rd and 4th premolars. A caniniform premolar was recorded more in males than females of the entire modern human populations. The Xhosas and Shangaans displayed more anomalies than the other groups. Out of the 47 recorded, 15 were only females. Only one of the Holocene human skeletons studied exhibited the anomaly.

Rotated Premolars

Premolar rotation was very common on the Palauan sample (Berger *et al.,* 2008). Out of the 54 rotated premolars recorded on the modern human sample, 20 of those were females. The presence of rotated premolars in most females coincided with the congenital absence of the third molar. Zulu females have the highest frequency of this anomaly of all the females recorded. Holocene human skeletons have the lowest frequencies of the three groups studied, with only one mandible exhibiting the anomaly.

In general, tooth wear was more extensive on the Palauans and Holocene human skeletons. It was very moderate on the modern humans. The group that had more wear on the modern humans is the Zulus.

Sexual dimorphism on the modern human populations.

The mandibular and maxillary canines exhibited extensive degree of sexual dimorphism than other teeth measured. This extensive sexual dimorphism was more observed on the Tswana and the Zulu population groups than the European and Khoisan population groups.

CHAPTER 4

DISCUSSION

Based on the femoral lengths of two individuals averaged at 402 ±14 mm, body height for early Palauans is estimated as small bodied. Body size (weight) is averaged at 30 kg for females and 47 kg for males, and they have a megadontia quotient ranging from 1.09 to 1.31 (Berger, *et al*., 2008, 2008b). In addition to megadontia, many specimens exhibit dental anomalies: 57% record third molar agenesis, 50% record incisiform premolars, 16% caniniform premolars and 16% rotated premolars.

MEGADONTIA

The crown heights and the total root lengths of the Palau sample are normal compared to the modern human populations studied here. The crown teeth at the cervical enamel junction are equal to or sometimes smaller than the modern human sample. However, the Palauan specimens exhibit exceptionally large crown teeth compared to the modern and Holocene human populations studied, which may be a compensating mechanism to fit the roots into the relatively small jaws. There are four possible explanations for the dental anomalies observed in the Palau population studied. These include diet, lag in tooth size reduction as determined by an Old World

origin, island dwarfism and genetic inheritance. These four potential factors are discussed in detail below.

1. Tooth size and diet

The size and shape of the teeth have long been recognized as important indicators of diet and dental function (Bergqvist, 2003). A hard or tough diet requires large teeth, or great crown height with large occlusal surfaces, to endure wearing. The rate of wear depends on diet and environmental factors, the overall morphology of the crown, the area of occlusal surface, and the thickness and microstructure of enamel. Therefore the higher the crown, and thus the thicker the potential of the occlusal surface, the slower the tooth will wear, which will prolong the life of the tooth and by implication the individual. In light of this, megadontia in the Palauan sample might be due to the type of diet they consumed.

One of the most important factors influencing hominid evolution has been change in diet. Modern humans are thought to have evolved from a savanna-adapted early hominid form with the enormous masticatory apparatus required for a predominantly tough vegetarian diet, to a scavenger and eventually a hunter with an omnivorous diet requiring less mastication for the same amount of energy intake (Wolpoff, 1971). Even though Smith (1977) did not find correlation between reduction in tooth size and reduction in functional demands made on dentition, reduction in tooth size is one of many features characteristic of hominid evolution, and is generally attributed to the relaxation of selective pressure favoring demands made on the dentition. The reduction in functional demands has been attributed to dietary change and improved tool technology (Brace, 1983 & 1987; Greenfield, 2005; Wolpoff, 1971). According to Larsen (1983), alteration in the growth and development of masticatory apparatus is brought on by a shift to softer prepared foods. Softer prepared foods reduced the strain that was imposed on

the jaw and the teeth during chewing. This led to the relaxation of the masticatory apparatus and the reduction in tooth size observed on *Homo sapiens.* There are exceptions, for example where crowding occured, and this led to the anomalies observed in modern human populations. Most of these anomalies are, however, believed to be hereditary (Rougier *et al.*, 2006).

The Palauan teeth are severely worn, and at times the dentine is evident. The highly worn teeth might be an indication of the toughness of the food, or the amount of sand present on the food they were consuming. They were apparently dependent upon marine resources (Fitzpatrick *et al*., 2005, Fitzpatrick *et al*., 2007), which may explain the excessive wear observed, considering that certain shellfish contain a high percentage of sand and are known to cause attrition of the teeth (Macchiarelli, 1989; Littleton *et al*., 1993). Microwear analysis of human teeth subjected to marine and inland diets, which is beyond the scope of this project, may help to resolve this issue.

2. Lag in tooth size reduction

Brace, *et al.* (1983, 1987, and 1991) found modern Australo-Melanesian populations to have large teeth compared to other racial groups such as European, Mainland Asian, Eskimo, African, and Jomon-Pacific (Japanese). They found that Europeans, Mainland Asians and the Ainu from Japan have smaller teeth, with the latter having the smallest. According to Brace and colleagues, tooth size changed dramatically during the Late-Pleistocene in the northern portions of the Old World. These changes are thought to have produced the north-south differences observed in living populations of *Homo sapiens*, brought about by the cooking of food. This resulted in the reduction of tooth size due to a probable mutation effect, namely the relaxation of selective forces for larger teeth. Within the northwestern regions of the Old World, dental reduction apparently proceeded further because pottery had been in use for a long time. The earliest evidence of pottery comes from Japan and is dated to about 10,500 BC (Scarre, 1988), which

probably explains the extensive reduction of tooth size seen in Jōmon-Pacific people. In the western regions, pottery first appeared in Africa around 8,000 BC in Sub-Saharan Africa, in Lake Turkana (Gifford-Gonzalez, 1998), and in Southern Europe a thousand years later (Scarre, 1988). Although earth ovens were used in Australia at the time of first contact with the Europeans, pottery was not, implying that dental reduction proceeded to a lesser extent among Australian aborigines, who were hunter-gatherers. Palau Island is not part of the Old or New World, but rather the Western Pacific Rim. Tooth reduction happened at a very slow pace in the Old World, so it is possible that the Palauans represent a diaspora that also experienced a lag in tooth size reduction. In addition, Palauans did not make use of pottery until relatively recently, 3,000 years ago (Clark, 2005). In this context, Palauans, like Australian Aboriginals, may have maintained an omnivorous hunting and gathering lifestyle that included the consumption of marine resources and a coarse component that favoured the retention of large teeth.

Results show that in general, Khoisan teeth are the smallest of all the human populations measured. This microdontia was also observed by Drennen (1929), who compared the dentition of the Bushmen (Khoisan) to that of modern Bantu tribes, prehistoric populations and great apes. Grine (1984) also found the Khoisan to be microdont when compared with other modern South African population groups and Plio-Pleistocene hominids. In some instances, the tooth size of European population groups may be equal to the Khoisan, but are mostly smaller than the Tswana and Zulus. Europe and Africa are both part of the Old World, which complicates matters because Australian aboriginals like Bushmen, are traditionally hunter gatherers, not pottery users, so both should have big teeth. This suggests that populations, whether from the New or Old World, are locally adapted and that tooth size is not driven simply by diet or geographical locality. Tooth size is mostly genetically determined, which would explain why the Tswana and

the Zulu population groups have tooth sizes that are usually equal to each other, given their common Bantu origin.

3. Island dwarfism

Another factor that could explain the anomalously large tooth size in the Palau sample might be island dwarfism. Island dwarfism is a process and condition of the reduction in body size of large animals, caused by the reduced availability of resources. To compensate for this, animals reduce their body size to use the energy available sparingly. Bone and enamel start with the same calcium-phosphate crystal lattice building block, but end up rather different in structure and physical properties. The difference is attributed to a key protein called amelogenin that moulds enamel crystals into strands thousands of times longer and much stronger than those in bone. The dimension of an enamel strand is 100.000 by 50 by 25 nanometers, whereas bone is 35 by 25 by 4 nanometers (Shaw *et al.*, 2004). This probably explains why the teeth of island dwarfed organisms do not reduce as fast as the remainder of the skeleton, and might account for the megadont dentition observed in small-bodied Palauans.

DENTAL ANOMALIES

Congenital absence of third molars

The excessive megadontia observed in the Palauan population caused them to experience a high frequency of congenital absence of third molars. Out of seven mandibles sampled, four exhibited third molar agenesis (Figure 295). Third molar agenesis was also present on the maxilla, but not as high as on the mandibles. The high frequency of third molar agenesis on the Palauan sample corresponds with the findings of De Castro (1989) on a prehistoric Indian population from the Canary Islands, an archipelago of seven islands located in the Atlantic Ocean off the northwest

coast of Africa (Juan *et al*., 2000; Guatelli-Steinberg *et al*., 2001). The three island populations studied by De Castro (1989) were Gran Canaria, Tenerife and La Gomera. The frequencies were always higher on the mandibles than on the maxilla in all the three samples examined. On a small sample of Melanesians, Le Bot *et al.* (1977) observed the same trend of more agenesis on the mandibles than on the maxilla, whereas Turner *et al*. (1978) found agenesis to be higher on the maxilla, showing that third molar agenesis is not specific to the mandible in island populations. Because third molars are the last teeth to erupt, an absence of third molar frees additional space for the remaining teeth to develop. In the case of the Palauan sample, there was insufficient space for third molars to erupt. Even so, the large teeth led to dental crowding, malpositioned and impacted teeth. There is a high degree of other anomalies, including incisiform canines, caniniform premolars, and rotated premolars.

Modern humans studied here have 'normal' sized teeth and a very low frequency of anomalies (Figures 290-294). Because the teeth are not extremely large, there is adequate space for their regular development. Modern humans have congenitally missing third molars in 6.9% of cases. The reduction in tooth number is related to the reduction in the size of the jaws in human evolution and is believed to be a continuing evolutionary trend. Lavelle *et al.* (1970) studied great apes and *Homo sapiens* and noted that *Homo sapiens* have developed a tendency toward a shortened maxillomandibular skeleton compared to their ancestors. In addition, Sánchez *et al.* (2009) found that maxillary third molar agenesis is related to reduced mandibular plane angles. Since Palau Micronesians have an even shorter maxillomandibular skeleton than modern humans (Berger *et al.*, 2008), it makes sense that they have the highest frequency of congenital absence of third molars, to create space for other teeth, which are very large, to develop.

Of the modern human populations sampled, Europeans have the highest frequency of congenital absence of third molar. Out of 6.9% they contributed 1.73%, and 28 population groups contributed the remaining 5.17%. In all the groups studied here, females have the highest frequency of third molar agenesis. The same trend was found in populations from England (Garn *et al.*, 1962, Shinn, 1976), whereas Levesque *et al.* (1981), found less agenesis in French-Canadian females. No difference between the sexes was found in populations from South America (Thompson, *et al.*, 1974).

The Holocene human skeletons studied here have a very low frequency of anomalies. Out of 69 individuals studied, two have congenital absence of third molars. This low frequency of anomaly is in contrast with what is observed on the Palauan sample, even though they are of the same age. The difference might be due to the fact that the Palauans are from an island, and the Holocene human skeletons are from a mainland, and are therefore not affected by insular dwarfism. One similarity between the teeth of the Palauans and the Holocene human skeletons is the amount of wear observed on both. Tooth wear is linked to the hard particles in and on food such as sand, small bones or phytoliths (Escalassan *et al.*, 2009; D Incau *et al*, 2003; Teaford *et al.*, 1996). Marine foods may contain a large amount of sand particles, and this could have led to the extensive amount of wear noted on the two samples, considering that both populations are believed to have consumed marine resources.

Incisiform canines

Fifty percent of Palauans have incisiform canines. Modern humans have 1.21%, the majority of which are males. European females exhibit the highest frequency of incisiform canines of all the modern females studied. The Holocene human skeletons studied exhibited no anomalies. The

difference between the three samples could well be attributed to the size of the teeth, with the megadont Palauans experiencing crowding, and hence the high frequency of incisiform canines.

Caniniform premolars

Caniniform premolars are presented in Figures 124, 125 and 130 as statistical graphs of the mandibular 3rd premolars; and in Figure 295 as a photograph of a Palauan mandible (specimen number B:OR-15:18-083). The mediodistal (MD) and buccolingual (BL) diameters of these mandibular 3rd premolars are smaller than most of the mandibular 3rd premolars of the modern human populations. Figures 165 and 166 of the mandibular 4th premolars show them mimicking the anomaly displayed by the ones in front of them. No anomaly or mimicking was present on the maxillary 3rd and 4th premolars. The caniniform premolars resulted from the crowding of the teeth in the jaw. The length of the Palauan jaw decreased, but the size of the teeth did not. The Palauan teeth erupted so close to one another that they tended to look like the one in front of them, hence the high frequency of anomalies.

This type of dentition is also observed in *Homo florensiensis*, discovered on Flores Island, and dates back to about 18,000 years BP. *Homo florensiensis* lacks both the upper third molars, and shows rotation of the upper 4th premolars on both sides of the jaw (Brown *et al.*, 2004). The extremely small body size of *H. floresiensis*, its island habitat, and tooth anomolies lend support to the idea that island dwarfing contributed to the megadont condition and high frequency of anomolies observed in the Palau population.

Caniniform premolars were observed in 2.31% of the modern humans studied, and most of these were males. This anomaly was present in 2.86% of Holocene human skeletons. The dental arch (jaw length) of modern and Holocene humans is larger than that of the Palauans. This enabled

the mesodont dentition of modern and Holocene humans to erupt normally, thus leading to fewer dental anomalies.

Rotated Premolars

Rotated premolars are very common on the Palauan sample (Berger *et al*., 2008). Rotated premolars occur in 2.62% of modern humans, and mostly in males. Premolar rotation in females was found to coincide with congenital absence of third molars. Premolar rotation occurs in 2.63% of the Holocene human population. High frequencies of premolar rotation as well as the other anomalies in the Palauan sample are likely due to the megadontia observed in the population, coupled with the small jaws they possessed. Modern and Holocene humans display mesodontia and normal-sized jaws, which probably accounts for the low frequencies of anomalies in these populations.

SEXUAL DIMORPHISM

It was not possible to infer the gender of the Palau tooth sample because the majority of the teeth studied were independent of a skull. Even though sexing from the cranial bones is believed not to be as accurate as from other skeletal remains such as the pelvis (Brothwell, 1972), the skull generally offers good evidence of gender. Inferring the sex from isolated teeth is now possible using DNA analysis (Arnay-de –la-Rosa *et al*., 2007), but is beyond the scope of this project. Without knowing the gender of the Palau specimens studied I am unable to discuss sexual dimorphism in this population. The modern human sample displays some degree of sexual dimorphism. In all the tooth groups studied, dimorphism is prominent mostly on the canines, both mandibular and maxillary. This result is in accordance with the findings of other researchers (Garn *et al*., 1967; Brace *et al.*, 1980; Frayer, 1980; Anderson *et al*., 1973; Hillson, 2005; Kieser,

1990). According to Anderson, *et al.*, (1973) the lateral incisor does not display any form of sexual dimorphism, and if it is present; it is to a very small degree. Kieser (1990) argued that males have larger canines than females because they have larger bodies than females. This means that canine size dimorphism may be the result of body size dimorphism. Hillson, (2005) did not find any dimorphism in the premolars, and attributed this to their lack of a honing function, which is in contrast to the canines. The Tswana and the Zulu population groups are more highly dimorphic than the European and the Khoisan population groups, which are moderately dimorphic in most cases. The measurements responsible for these differences are particularly the crown dimensions, the MD and BL diameters. The pre- and post-canine teeth display some level of sexual dimorphism, with Zulu and Tswana population groups showing the larger difference, but the difference is not as extensive as in the canines.

In sum, it would appear that while the Palauans reduced their body size due to a limitation in resources, they retained large teeth. This may be due in part to their diet, genetic history, and the early timing of genetic tooth development in mammalian ontogeny, which could account for a lag in tooth size reduction relative to the rest of the body.

CHAPTER 5

CONCLUSION

In accordance with the hypothesis tested, results show that the population of fossil humans from the island of Palau have a high degree of anomalies and a high megadontia quotient relative to body size. It is furthermore clear that there is no optimum tooth size that would meet the requirements of all human populations. It is striking to note that the Palauan dentition falls at the opposite extreme in size to the other small bodied population examined in this study (the Khoisan) and this finding alone is important for assessing the variability of tooth size relative to body size and the caution with which such results should be viewed. This observation was more apparent on the incisors, canines, and molars, whereas premolars were sometimes equal to or smaller than those of modern humans. Also, the buccolingual diameters of the aforementioned teeth of the Palauans showed a marked difference than the mesiodistal diameters. This study confirms that tooth size must be viewed in relation to other factors, such as diet or genetics and is, at least in the population studied, largely independent of body size. Thus a simple result of this study is that estimating body size from tooth size is something that needs to be done with caution, as the linear relationship between the two can be lost, as has been demonstrated here in the Palauan population as well as inversely in the Khoisan population.

Diet of course must be considered as a cause of the megadontia found in the Palauan sample. Palau Micronesians, who appear to have depended heavily on abrasive diets, may have adaptively solved the problem of extreme and premature tooth wear by retaining relatively large teeth in proportion to their small bodies. This hypothesis should, however be viewed with caution as the sub-fossil Khoisan population examined in this study, which, with the exception of

not having access to a marine diet, almost certainly was subjected to an equally abrasive diet, yet does not show such an adaptive megadontia. It is however, likely that regardless of the cause of the megadontia in the Palauan sample, the combination of this, in the presence of a reduction in mandibular size led them to experience some congenital tooth defects, which were most likely due to a limited amount of space for tooth development.

This study has therefore demonstrated that there appears to be a close association with megadontia combined with small body size that results in a high proportion of defects and dental anomalies. It, however, must be viewed as a cautious association as the high level of anomalies and pathologies may very well be equally caused by untested effects of small populations subsisting on islands, low genetic variability, high incidences of inbreeding or other factors of island populations of humans poorly understood or studied. The present study has also emphasized the general caution that must be taken when examining populations of humans from island, as typical frequencies of such anomalies and pathologies may exceed substantially those results obtained from populations studied on larger continental landmasses. This finding has important ramifications for studies of extant and extinct populations from island, as more appropriate comparative samples would be other island populations rather than continental ones, at least when examining such features as megadontia or the frequency of anomalies.

With specific reference to megadontia in the Palauan sample, the causality of the megadontia deserves further study. Humans have long been suggested to be less prone to the stresses and stressors of their environment, generally thought to manifest cultural changes rather than adapting their morphology. It is of course, difficult to assess the cause of the extreme manifestation of both size and frequency of anomalies in the Palauan sample. The two most likely causes of at least the megadontia observed in the Palauan sample – retained large tooth

size inherited from an ancestral or founding population, or the adaptive evolution of large dentition to diet or other factors related to island living – deserve significant attention as they may give us insight into the how extinct populations of humans with low levels of genetic exchange may manifest such features and frequencies. The results of such studies might also have implications for studies of more ancient hominins, and in fact other species and animals.

REFERENCES

Anderson, D.L., Thompson, G.W. 1973. Interrelationships and sex differences of dental and skeletal measurements. *Journal of Dental Research.* **52**(3): 431-438

Arnay-de-la-Rosa, M., González-Reimers, E., Fregel, R., Velasco-Vásquez, J., Delgado-Darias, T., González, A.M., Larruga, J.M. 2007. Canary islands aborigin sex determination based on mandible parameters constrasted by amelogenin analysis. *Journal of Archaelogical Science.* **34**: 1515-1522

Athens, J.S., Ward, J.V. 2001. Palaeoenvironmental evidence for early settlement in Palau: The Ngerchau core. In: Stevenson, C.M., Lee, G., Morin, F.J. (eds). *Pacific 2000. Proceedings of the fifth International conference on Easter Island and the Pacific.* Easter Island Foundation, Bearsville Press, pp.164-177

Baba-Kawana, S., Toyoshima, Y., Regalado, L., Sa`do, B., and Nakasima, A. 2002. Relationship between congenitally missing lower third molar and late formation of tooth germs. *Angle Orthodontist*. **72**(2):112-117

Bartlett, D.W. 2005. The role of erosion in tooth wear: aetiology, prevention and management. *International Dental Journal.* **55**(4): 277-284

Bellwood, P. 1985. Prehistory of the Indo-Malaysian Archipelago. Australia. Academic Press.

Berger, L.R., De Klerk, B., Churchill, S.E., Quinn, R. 2008. Small-bodied humans from Palau, Micronesia. *PLoS ONE*. **3**(3): 1780-1791

Berger, L.R., Churchill, S.E., De Klerk, B., 2008b. The small-bodied early inhabitants of Palau. Available at: http://www.plosone.org/annotation/listThread.action?inReplyTo=info%3Adoi%2F10.1371%2Fannotation%2F28098f13-efb2-4d85-ba20-2973103d41bc&root=info%3Adoi2F10.1371%2Fannotation%2F28098f13-efb2-4d85-ba20-2973103d41bc. Date visited: 02 March 2012

Bergqvist, L.P. 2003. The role of teeth in mammal history. *Brazilian Journal of Oral Science*. **2**(6):249-257

Brace, L.C., Ryan, A.S. 1980. Sexual dimorphism and human tooth size differences. *Journal of Human Evolution.* **9**(5): 417-435

Brace, L.C., Harris, E.F., Hinton, R.J., Smith, R.J., 1983. On tooth size and oceanic prehistory. *Current Anthropology* .**24**(2): 243-246

Brace, C.L., Rosenberg, K.R., Hunt, K.D. 1987. Gradual change in human tooth size in the late Pleistocene and post Pleistocene. *Evolution*. **41**(4): 705-720

Brace, C.L., Smith, S.L., Hunt, K.D. 1991. What big teeth you had grandma: Human tooth size, past and present. In: Kelly, M.A., Larsen, C.S. (eds). *Advances in dental anthropology*. New York, Wiley-Liss, pp 33-57.

Bromham, L., Cardillo, M. 2007. Primates follow the "island rule": implications for interpreting *Homo floresiensis*. *Evolutionary Biology*. **3**: 398-400

Brothwell, D.R. 1972. *Digging up bones.* Trustees of the British Museum, London.

Brown, P., Sutikna, T., Morwood, M.J., Soejono, R.P., Jatmiko, E., Saptomo, E.W., Due, R.A. 2004. A new small-bodied hominin from the Late Pleistocene of Flores, Indonesia. *Nature*. **431**: 1055-1061

Calgagno, J.M., Gibson, K.R., 1988. Human dental reductions: Natural selection or the probable mutation effect. *American Journal of Physical Anthropology*. **77**(4):505-517

Callaghan, R., Fitzpatrick, S.M. 2007. On the relative isolation of a Micronesian Archipelago during the historic period: the Palau case study. *The International Journal of Nautical Archaeology*. **36**(2): 353-364

Callaghan, R., Fitzpatrick, S.M. 2008. Examining prehistoric migration patterns in the Palauan archipelago: A computer simulated analysis of drift voyaging. *Asian Perspectives.* **47**(1): 28-44

Clark, G. 2004. Radiocarbon dates from the Ulong site in Palau and implications for Western Micronesian prehistory. *Archaeological Oceania*. **39**: 26-33

Clark, G. 2005. A 3000–year culture sequence from Palau, Western Micronesia. *Asian Perspectives*. **44**(2): 349-380

Clark, G., Anderson, A., Wright, D. 2006. Human colonization of the Palau Islands, Western Micronesia. *Journal of Islands and Coastal Archaeology*. **1**(2): 215-232

Craib, J.L. 1983. Micronesian prehistory: An archaeological overview. *Science*. **219**(4587): 922-927

Crispim, J., Trigueiro, K.G., De Sa E Benevides Filho, F.R., Salzano, F.M. 1972. Third molar agenesis in a trihybrid Brazilian population. *American Journal of Physical Anthropology*. **37**(2): 289-292

De Castro, J.M.B. 1989. Third molar agenesis in the human prehistoric populations of the Canary Islands. *American Journal of Physical Anthropology*. **79**(2): 207-215

Devlin, B., Roeder, K., Otto, C., Tiobech, S., Byerley, W. 2001. Genome–wide distribution of linkage disequilibrium in the population of Palau and its implications for gene flow in remote Oceania. *Human Genetics*. **108**: 521-528

Diamond, J.M. 1988. Express train to Polynesia. *Nature.* **336**: 307-308

Dickinson, W.R., Athens, J.S. 2007. Holocene paleoshoreline and paleoenvironmental history of Palau: Implications for human settlement. *Journal of Island and Coastal Archaeology*. **2**(2): 175-196

D´Incau, E., Rouas, P. 2003. Dental and skeletal relationship to attritional occlusion. *Journal of Dental Research.* **82**(Special Issue B):164

Drennen, M.R. 1929. The dentition of the Bushman tribe. *Annals of the South African Museum*. **24**: 61-88

Esclassan, R., Grimoud, A.M., Ruas, M.P., Donat, R., Sevin, A., Astie, F., Lucas, S., Crubery, E. 2009. Dental caries, tooth wear and diet in an adult medieval (12th-14th century) population from Mediterranean France. *Archives of Oral Biology.* **54**(3): 287-297

Ferguson, W.W. 1987. Taxonomic status of the Hominine cranium KNM-ER 1813 (primates: Homininae) from the Plio/Pleistocene of Koobi Fora. *Primates.* **28**(4): 423-438

Fitzpatrick, S.M. 2002. AMS dating of human bone from Palau: New evidence for a pre-2000 BP settlement. *Radiocarbon*. **44**(1): 217-221

Fitzpatrick, S.M. 2003. Early human burials in the western Pacific: Evidence for a 3000 year old occupation on Palau. *Antiquity*. **77**(298): 719-731

FitzPatrick, S.M., Dickinson, W.R., Clark, G. 2003. Ceramic petrography and culture interaction in Palau, Micronesia. *Journal of Archaeological Science*. **30**: 1175-1184

Fitzpatrick, S.M., Kataoka, O. 2005. Prehistoric fishing in Palau, Micronesia. Evidence from the Northern Rock Island. *Archaeology in Oceania*. **40**(1): 1-13.

Fitzpatrick, S.M., Donaldson, T.J. 2007. Anthropogenic impacts to coral reefs in Palau, western Micronesia during the Late Holocene. *Coral Reefs*. **26**(4): 915-930

Fitzpatrick, S.M., Nelson, G.C., Clark, G. 2008. Small scattered fragments do not a dwarf make: Biological and Archaelogical data indicate that prehistoric inhabitants of Palau were normal sized. *PLoS ONE.* **3**(8): 3015-3027

Filipson, R., Goldson, L. 1963. Correlation between tooth width, width of the head, length of the head, and stature. *Acta Odontologica Scandinavica.* **21**(5): 359-365

Foster, J.B. 1964. Evolution of mammals on islands. *Nature*. **202**: 234-235

Frayer, D.W. 1980. Sexual dimorphism and cultural evolution in the late Pleistocene and Holocene of Europe. *Journal of Human Evolution.* **9**(5): 399-415

Gallagher, A. 2008. Size variation in small-bodied humans from Palau, Micronesia. *PLoS ONE*. **3**(12): 3939-3941

Garib, D.G., Zanella, N.L.M., Peck. S. 2005. Associated dental anomalies: Case study. *Journal of Applied Oral Science.* **13**(4):431-436

Garn, S.M., Lewis, A.B. 1958. Tooth-size, body-size and 'giant' fossil man. *American Anthropologist*. **60**(5): 874-880

Garn, S.M., Lewis, A.B. 1962. The relationship between third molar agenesis and reduction in tooth number. *Angle Orthodontist*. **32**(1): 14-18.

Garn, S.M., Lewis, A.B., Kerewsky, R.S. 1967. The relationship between sexual dimorphism in tooth size and body size as studied within families. *Archives of Oral Biology.* **12**(2): 299-301

Garn, S.M., Lewis, A.B., Kerewsky, R.S. 1968. The magnitude and implications of the relationship between tooth size and body size. *Archives of Oral Biology.* **13:** 129-131

Gifford-Gonzalez, D. 1998. Early pastoralists in early east Africa. Ecological and social dimensions. *Journal of Anthropological Archaeology*. **17**:166-200

Gray, R.D., Jordan, F.M. 2000. Language trees support the express-train sequence of Austronesian expansion. *Nature.* **405**: 1052-1055

Greenfield, L.O. 1992. A non-adaptive dental trait. *International Journal of Primatology*. **13**(6): 631-657

Greenfield, L.O. 1993. A tooth at the border of two morphogenetic fields. *Human Evolution*. **8**(3): 187-204

Greenfield, L.O. 1998. Canine tip wear in male and female anthropoids. *American journal of physical anthropology*. **107**(1):87-96.

Greenfield, L.O. 2005. Origin of the human canine: A new solution to an old enigma. *American journal of physical anthropology*. **35**(S15): 153-185

Greenfield, L.O., Washburn, A. 1991. Polymorphic aspects of male anthropoid canines. *American journal of physical Anthropology.* **84**(1):17-34

Grine, F.E. 1984. The deciduous dentition of the Kalahari San, the South African Negro and the South African Plio-pleistocene hominids. PhD Thesis. University of the Witwatersrand.

Guatelli-Steinberg, D., Irish, J.D., Lukacs, J.R. 2001. Canary islands-north African population affinities: Measure of divergence based on dental morphology. *Homo.* **52**(2):173-188

Henderson, A.M., Corruccini, R.S. 1976. Relationship between tooth size and body size in American Blacks. *Journal of Dental Research*. **55**:94-96

Hertzberg, M., Mickleson, K.N.P., Serjeantson, S.W., Prior, J.F., Trent, R.J. 1989. An Asian-specific 9-bp deletion of mitochondrial DNA is frequently found in Polynesians. *American journal of Human Genetics.* **44**:504-510

Hillson, S. 2005. *Teeth*. 2nd ED. London . Cambridge University Press.

Hillson, S., Fitzgerald, C., Flinn, H. 2005. Alternative dental measurements: Proposals and relationships with other measurements. *American journal of Physical Anthropology*. **126**: 418-426

Intoh, M. 1997. Human dispersals into Micronesia. *Anthropological Science*. **105**(1): 15-28

Juan, C. Emerson, B., Omori', P., Hewitt, G.M. 2000. Colonization and diversification: towards a phylogeographic synthesis of the Canary Islands. *Trends in Ecological Evolution.* 15:104-109

Jungers, W.L. 1978. On canine reduction in early hominids. *Current Anthropology*. **19**(1): 155-156

Keene, H.J. 1964. Third molar agenesis, spacing and crowding of teeth, and tooth size in caries-resistant naval recruits. *American journal of Orthodontics*. **50**(6):445-451

Kieser, J.A. 1990. *Human adult odontometrics. The study of variation in adult tooth size.* Cambridge University Press

Kieser, J.A., Groeveveld, H.T. 1988. Allometric relations of teeth and jaws in man. *American journal of Physical Anthropology*. **77**:57-67

Kim, Y.H., Shiere, F.R., Fogels, H.R. 1961. Pre-eruptive factors of tooth rotation and axial inclination. *Journal of Dental Research.* **40**(3): 548-557

Kram, E., McMullan, R.E.1990. Investigation of the premolar rotation in a group of 15-year-old Norwegian children. *The European journal of Orthodontics*. **12**(3): 311-315

Kurten, B. 1967. Some quantitative approaches to dental microevolution. *Journal of Dental Research.* **46**(Supp 5): 817-828

Larsen, C.S. 1981. Skeletal and dental adaptations to the shift to agriculture on the Georgia Coast. *Current Anthropology*. **22**(4): 422-423

Lavelle, C.L.B., Ashton, E.H., Flinn, R.M. 1970. Cusp pattern, tooth size and third molar agenesis in the human mandibular dentition. *Archives of Oral Biology*. **15**: 227-237

Lavelle, C.L.B. 1974. Relationship between tooth and skull size. *Journal of Dental Research.* **53**(5): 1301

Lavelle, C.L.B. 1977. Relationship between tooth and long bone size. *American Journal of Physical Anthropology*. **46**(3): 423-426

Le Bot, P, Salmon, D. 1977. Congenital defects of the upper lateral incisors (ULI): Condition and measurements of the other teeth, measurements of the superior arch, head and face. *American Journal of Physical Anthropology*. **46**(2): 231-243

Levesque, G.Y., Demirjian, A., Tanguay, R. 1981. Sexual dimorphism in the development, emergence, and agenesis of the mandibular third molar. *Journal of Dental Research.* **60**(10): 1735-1741

Liston, J. 2005. Assessment of radiocarbon dates from Palau, Western Micronesia. *Radiocarbon*. **47**(2): 295-354

Littleton, J., Frohlich, B. 1993. Fish-eaters and farmers: Dental pathology in the Arabian Gulf. *American journal of Physical Anthropology*. **92**:427-447

Lucas, P.W. 2006. Facial dwarfing and dental crowding in relation to diet. *International congress Series*. **1296**: 74-82

Lucas, P.W. 2007. The evolution of the hominin diet from a dental functional perspective, In: Ungar, P.S (ed). *Evolution of the Human Diet: The Known, the Unknown, and the Unknowable*. Oxford University Press

Lum, J.K., Cann, R.L., Martinson, J.J., Jorde, L.B. 1998. Mitochondrial and nuclear genetic relationships among Pacific Island and Asian Populations. *American Journal of Human Genetics*. **63**: 613-624

Lum, J.K., Cann, R.L. 2000. MtDNA linkage analyses: Origins and migrations of Micronesians and Polynesians. *American Journal of Physical Anthropology*. **113**: 151-168

Lum, J.K. Jorde, L.B., Schiefenhovel, W. 2002. Affinities among Melanesians, Micronesians and Polynesians: A neutral biparental genetic perspective. *Human Biology*. **74**(3): 413-430

Macchiarelli, R. 1989. Prehistoric “fish-eaters” along the Eastern Arabian Coasts: Dental variation, morphology, and oral health in the Ra’s al-Hamra community. (Qurum, Sultanate of Oman; 5th-4th Millenia BC. *American journal of Physical Anthropology.* **78**: 575-594

Martinson, J.J. 1996. Molecular perspectives on the colonization of the pacific. In: Boyce, A.J., Mascie-Taylor, C.G.N. (eds). *Molecular biology and human diversity*. Cambridge University Press, London, pp: 171-195

Masse, W.B., Liston, J., Carucci, J., Athens, J.S. 2006. Evaluating the effects of climate change on environment, resource depletion, and culture in the Palau Islands between AD 1200 and 1600. *Quaternary International*. **151**: 106-132

McHenry, H.M. 1984. Relative cheek-tooth size in *Australopithecus*. *American Journal of Physical Anthropology*. **64**(3):297-306

McMullan, R.E., Richardson, A. 1991. Spontaneous changes in the rotation of premolar teeth from eruption until the established dentition. *European Journal of Orthodontics*. **13**:392-396

Meiri, S., Cooper, N., Purvis, A. 2008. The island rule: made to be broken? *Proceedings of the Royal Society*. **275**: 141-148

Millien, V. 2006. Morphological evolution is accelerated among island mammals. *PLoS Biology*. **4**(10): 1863-1868

Morris, A.G. 1992. *A master catalogue: Holocene human skeletons from South Africa. Johannesburg*. Witwatersrand University Press.

Nanda, R.S. 1954. Agenesis of the third molar in man. *American Journal of Orthodontics.* **40**: 698-706

Nelson, G., Fitzpatrick, S.M. 2006. Preliminary investigations of the Chelechol ra orrak cemetery, Republic of Palau: I, Skeletal biology and palaeopathology. *Anthropological Science.* **114**:1-12

Osborn, J.W. 1978. Morphological gradients: field versus clones. In: Butler, P.M., Joysey, K.A. (eds) *Development, Evolution, and function of teeth*. Academic Press, London, pp 171-201

Perzigian, A.J. 1981. Allometric analysis of dental variation in a human population. *American Journal of Physical Anthropology*. **54**: 341-345

Plavcan, J.M., Kelly, J. 1996. Evaluating the "dual selection" hypothesis of canine reduction. *American journal of Physical Anthropology.* **99**: 379-387

Rainbird, P. 2004. *The archaeology of Micronesia.* Cambridge University Press, Cambridge, UK

Rougier, H., Crevecoeur, I., Wolpoff, M.H. 2006. Lower third premolar rotation in the Krapina dental sample. *Periodicum Biologorum.* **108**(3): 269-278

Sanchez, M.J., Vicente, A., Bravo, L.A. 2009. Third molar agenesis and craniofacial morphology. *Angle Orthodontist.* **79**(3): 473-478

Scarre, C. 1988. *Past worlds. The times atlas of archaeology*. Bay books, Sydney, London

Scheid, R.C. 2007. *Woefel's Dental Anatomy: Its relevance to Dentistry*. 7th ed. Lippincott Wiliams & Wilkins, pp. 416

Scott, J.H., Symons, N.B. 1977. *Introduction to Dental Anatomy*. 8th ed. New York. Churchill Livingstone.

Scott, G.R., Turner, C.G. 1997. *The Anthropology of Modern Human Teeth: Dental Morphology and its Variation in Recent Human Populations*. United Kingdom. Cambridge University Press.

Scott, G.R., Turner, C.G. 1988. Dental Anthropology. *Annual Review of Anthropology.* **17:** 99-126

Serjeantson, S.W. 1984. Migration and admixture in the Pacific: insights provided by human leukocyte antigens. *The journal of Pacific history.* **19**(3 Part 1):160-171

Shaw, W.J., Campbell, A.A., Paine, M.L., Snead, M.L. 2004. The COOH terminus of the amelogenin, LRAP, is oriented next to the hydroxyapatite surface. *The Journal of Biological Chemistry.* **279**(39): 40263-40266

Shaw, J.C.M. 1931. *The Teeth, the Bony Palate and the Mandible in Bantu Races of South Africa*. London. John Bale, Sons and Danielson, Ltd.

Shea, B.T., Gomez, A.M. 1988. Tooth scaling and evolutionary dwarfism: An investigation of allometry in human pygmies. *American journal of Physical Anthropology.* **77**:117-132

Shinn, D.L. 1976. Congenitally missing third molars in a British population. *Journal of Dentistry*. **4**(1):42-22

Shroff, F.R. 1966. *Basic Dental Anatomy and Histology*. London. Henry Kimpton.

Smith, P. 1977. Selective pressures and dental evolution in hominids. *American Journal of Physical Anthropology.* **47:**453-458

Smith, P. 1977. Regional variation in tooth size and pathology.*American journal of physical Anthropology*. **47:**459-466

Taylor, R.M.S. 1978. *Variation in the Morphology of Teeth. Anthropologic and Forensic Aspects.* University of Michigan. Charles C. Thomas

Teaford, M.F., Lytle, D.M.1996. Diet-induced changes in rates of human tooth microwear: A case study involving stone-ground maize. *American Journal of Physical Anthropology*. **100**: 143-147

Thompson, G.W., Popovich, F., and Anderson, D.L. 1974. Third molar agenesis in the Burlington Growth Centre in Toronto. *Community Dentistry and Oral Epidemiology*. **2**(4): 187–192

Turner, C.H.G., Swindler, D.R. 1978. The dentition of New Britain West Nakanai Melanesians VII. Peopling of the Pacific. *American Journal of Physical Anthropology*. **49**: 361-372

van den Bergh, G.D. 1999. The late Neogene elephantoid-bearing faunas of Indonesia and their palaeozoogeographic implications: A study of the terrestrial faunal succession of Sulawesi, Flores, and Java, including evidence for early hominid dispersal east of Wallace's Line. *Scripta Geologica*. **117**: 1-419

van den Bergh, G.D., De Vos, J., Aziz, F., Morwood, M.J. 2001. Elephantoidea in the Indonesian region: new *Stegodon* findings from Flores. *The World of Elephants: Proceedings of the 1st International Congress, Rome*. 623-627

van den Bergh, G.D. Awe, R.D., Morwood, M.J. 2008. The youngest *stegodon* remains in Southeast Asia from the Late Pleistocene archaeological site Liang Bua, Flores, Indonesia. *Quaternary International*. **182**: 16-48

Vastardis, H. 2000. The genetics of human tooth agenesis: New discoveries for understanding dental anomalies. *American Journal of Orthodontics and Dentofacial Orthopedics.* **117**(6): 650-656

Weindenreich, F. 1945. Giant early man from Java and south China. *Science*. **99**(2581): 479-482

Welch, D.J. 2002. Archaelogical and paleoenvironmental evidence of early settlement in Palau. *Indo-Pacific Prehistory Association Bulletin*. **22**(6): 161-173

White, T.D., Folkens, P.A. 2005. *The human bone manual*. Elsevier Academic Press

Wolpoff, M.H. 1971. A functional measure of tooth size. *Southwestern Journal of Anthropology*. **27**(3): 279-286

www.GraphicsMaps.com, March 2010.

www.uic.edu/classes, May 2007

APPENDIX

A. Abbreviations of the measurements taken.

1. MD – Mesiodistal diameter
2. BL – Buccolingual diameter
3. CH- Crown height
4. MD (cej) –Mesiodistal diameter at cervical enamel junction
5. BL (cej) – Buccoligual diameter at cervical enamel junction
6. TRL – Total root length

B. Abbreviations of the Raymond Dart Collection

1. Fing - Amafengu from South Africa
2. Griq - Griqua from South Africa
3. Hlub - Hlubi from South Africa
4. Hott - Khoi-Khoi (Hottentots)
5. Kala – Kalanga (Karanga) from Zimbabwe
6. Kund – Kunda from South Africa
7. Mala – Malawian
8. Mixe – Mixed percentages (coloured) from South Africa

9. Moza - Mozambican
10. Ndeb – Ndebele from South Africa
11. Nyam –Nyambaan from South Africa
12. Nyik – Manyika from Zimbabwe
13. Ovam – Ovambo from Namibia
14. Pedi – Pedi from South Africa
15. Pondo – Pondo from South Africa
16. Rolo – Barolong from Botswana
17. Rots – Barotse from Zambia
18. Saki – Sakia from South Africa
19. Shangaan- Shangaan from South Africa
20. Shin – Shinga from South Africa
21. Shon – Mashona from Zimbabwe
22. Sotho –Sotho from South Africa
23. Swazi – Swazi from South Africa and Swaziland
24. Temb –Tembu from South Africa
25. Tson –Tsona from South Africa
26. Baca- Amabaca from South Africa
27. Euro – European (refers to South Africa whites that have been here two or more generations)
28. Tswana –Tswana from South Africa
29. Zulu – Zulu from South Africa

C. Lists of specimens

Below are the tables of the list of specimens used for the recording of the anomalies.

Table 1: List of specimens of the Palau Population sampled in Palau Island and used in this study.

Field Allocation no	Museum Specimen no	Identification	MD	BL	CH	MD (cej)	BL (cej)	TRL
FS-06-142	B:OR-14:8-142	Man L 3rd premolar	7.84	8.20	8.17	4.60	7.50	15.56
FS-06-1027	B:OR-14:8-1007	Man R 1st Molar	5.83	6.29	9.50	3.90	5.90	12.35
FS-06-173	B:OR-14:8-173	Man R lateral incisor	5.84	6.39	9.43	4.00	6.20	13.28
FS-06-1026	B:OR-14:8-1006	Max L central incisor	7.99	6.86	10.42	5.40	6.20	15.03
FS-06-147	B:OR-14:8-147	Man L 3rd premolar	7.14	8.30		5.30	7.50	14.34
FS-06-1028	B:OR-14:8-1008	Max R 2nd molar	11.01	12.34				
FS-06-126	B:OR-14:8-126	Max L canine	8.51	8.12		6.20	7.60	18.98
FS-06-1025	B:OR-14:8-1005	Max L lateral incisor	7.76	6.91	9.93	5.70	6.40	15.08
FS-06-172	B:OR-14:8-172	Max R canine	7.86	8.07		6.00	8.80	17.43
FS-06-563	B:OR-14:8-543	Man L 4th premolar	7.49	8.51		5.40	7.00	14.92
FS-06-908	B:OR-14:8-888	Man R 3rd premolar	7.47	8.92		5.30	6.90	
FS-06-121	B:OR-14:8-121	Man R 2nd molar	10.85	10.23		9.60	9.00	11.95
FS-06-558	B:OR-14:8-538	Man R 3rd premolar	8.25	8.94		5.30	7.60	15.18
FS-06-136	B:OR-14:8-136	Man R 3rd premolar	7.22	9.43		4.60	7.80	13.47
FS-06-158	B:OR-14:8-158	Max L 3rd premolar	7.26	9.94		5.10	8.10	15.14
FS-06-163A	B:OR-14:8-163A	Man L 3rd premolar	7.19	8.61		5.30	7.60	14.09
FS-06-155	B:OR-14:8-155	Max R lateral incisor	7.05	7.67	9.43	5.10	7.30	15.93
FS-06-559	B:OR-14:8-539	Max R lateral incisor	7.61	6.86	11.88	5.60	6.80	14.45
FS-06-119	B:OR-14:8-119	Man R 4th premolar	8.48	9.82				
FS-06-1031	B:OR-14:8-1011	Man R central incisor	5.62	4.92		3.90	6.10	13.98
FS-06-146	B:OR-14:8-146	Man R central incisor	6.48	6.53		4.00	6.00	12.85
FS-06-228	B:OR-14:8-207	Man R lateral incisor	6.55	6.64	9.88	4.10	6.60	
FS-06-165	B:OR-14:8-165	Max R central incisor	9.39	7.27		7.00	6.10	14.49
FS-06-165	B:OR-14:8-165	Max L central incisor	9		11.10			
FS-06-909	B:OR-14:8-889	Man R central incisor	5.66	6.24		4.10	6.00	11.88
FS-06-139	B:OR-14:8-139	Max R central incisor	8.69	7.10		5.90	6.40	14.67
FS-06-170	B:OR-14:8-170	Max L lateral incisor	6.39	5.93		4.60	6.00	12.27
FS-06-156	B:OR-14:8-156	Man L central incisor	5.93	6.24		3.80	5.70	
FS-06-140	B:OR-14:8-140	Max L lateral incisor	7.61	6.53	9.55			
FS-06-153	B:OR-14:8-153	Max L canine	8.32	8.58		5.70	7.90	14.50
FS-06-316	B:OR-14:8-295	Max L canine	7.11	6.21	7.33	4.90	5.20	
FS-06-123	B:OR-14:8-123	Man L 1st molar	12.25	11.22		10.00	8.90	14.72
FS-06-154	B:OR-14:8-154	Man L 1st molar	11.22	10.78		9.50	9.80	
FS-06-1030	B:OR-14:8-1010	Man L 1st molar	13.55	12.26				
FS-06-164	B:OR-14:8-164	Man L 3rd molar	12.15	11.01				
FS-06-163B	B:OR-14:163	Max R 3rd molar	10.07		8.80	11.20		
FS-06-607	B:OR-14:8-587	Man L molar	13.18	11.52				
FS-06-557	B:OR-14:8-537	Max R 2nd molar	10.62	13.18		8.00	12.30	
FS-06-130	B:OR-14:8-130	Max L 2nd molar	12.69	11.08		10.70	9.10	
FS-06-175A	B:OR-14:8-176	Max R 3rd molar	7.41	9.87	8.61			

FS-06-175B	B:OR-14:8-177	Max R 4th premolar	7.34	10.12	8.54			
FS-06-175C	B:OR-14:8-178	Max R canine	7.47	7.17	11.83			
OM-100	B:OR-15: 18-059	Man R central incisor	6.77	6.83		4.20	6.70	10.56
OM-101	B:OR-15: 18-060	Man L lateral incisor	5.92	6.11		3.90	5.40	12.57
OM-102	B:OR-15: 18-061	Man L canine	8.17	8.24		5.90	8.10	14.82
OM-103	B:OR-15: 18-062	Man L 4th premolar	7.36	7.88		5.10	6.50	15.86
OM-104	B:OR-15: 18-063	Man L 2nd molar	11.99	11.05	15.41	9.30	9.30	
OM-105	B:OR-15: 18-064	Man R 1st molar	12.75	11.66		10.20	10.00	
OM-106	B:OR-15: 18-065	Max R 2nd molar	11.70	13.49		9.10	12.40	
OM-107	B:OR-15: 18-066	Man molar				8.20	11.30	
OM-108	B:OR-15: 18-067	Max L central incisor	8.90	7.30		6.90	7.00	
OM-109	B:OR-15: 18-068	Max L lateral incisor	7.70	6.40		5.90	6.20	
OM-110	B:OR-15: 18-O69	Max L canine	8.80	9.10		6.10	8.00	
OM-111	B:OR-15: 18-070	Max R canine	9.40	10.00	11.90	6.50	8.80	16.80
OM-112	B:OR-15: 18-071	Man R 3rd premolar	8.30	9.70		5.30	8.10	13.40
OM-113	B:OR-15: 18-072	Max R 4th premolar	7.20	9.20		4.90	8.90	17.10
OM-114	B:OR-15: 18-073	Max R 3rd premolar	7.60	10.30		3.90	7.50	11.40
OM-115	B:OR-15: 18-074	Max R 2nd molar	8.80	10.90		6.50	10.90	
OM-116	B:OR-15: 18-075	Max L 1st molar	10.50	12.20				
OM-117	B:OR-15: 18-076	Max R 1st molar	12.60	13.10		9.60	12.70	
OM-118	B:OR-15: 18-077	Max R 2nd molar	9.90	11.50		7.40	9.80	
OM-119	B:OR-15: 18-078	Max L 3rd molar	10.00	11.70		7.00	10.00	
OM-120	B:OR-15: 18-079	L molar		12.40				
OM-33A	B:OR-15:18-052a	Max R canine	18.80	19.20		16.10	8.10	16.20
OM-33B	B:OR-15:18-052B	Max R central incisor	7.40	7.90		4.90	6.70	
OM-17A	B:OR-15: 18-022	Man L 3rd premolar	8.00	8.30				12.40
OM-17B	B:OR-15: 18-O23	Man L 2nd molar	11.10	10.20		8.90	8.90	10.90
OM-001B	B:OR-15: 18-002	Man R canine	7.20	7.50		6.00	7.90	19.80
OM-001C	B:OR-15: 18-003	Man R 3rd premolar	7.20	8.40		5.30	7.90	
OM-23	B:OR-15: 18-030	Man R 3rd premolar	7.10	8.00		4.80	6.60	15.10
FS-06-161	B:OR-14:8-161	Man R 3rd premolar	8.20	8.60	10.40	5.40	6.90	
OM-14A	B:OR-15: 18-018	Man R 2nd molar	12.00	11.00		10.40	9.60	
OM-14B	B:OR-15: 18-019	Man L 3rd premolar	7.50	7.70		5.30	7.20	13.70
OM-034	B:OR-15: 18-053	Max L 1st molar	12.20	11.00		10.30	8.80	
OM-025	B:OR-15: 18-032	Max R 3rd premolar	7.60		10.00	4.90	9.10	17.70
OM-13	B:OR-15: 18-017	Max R lateral incisor	6.40	6.20		4.90	6.40	12.20
OM-19A	B:OR-15: 18-025	Man L canine	7.70	7.60		6.60	8.20	16.20
OM-19B	B:OR-15: 18-026	Man R 1st molar	12.80	11.80		11.20	10.50	
OM-32A	B:OR-15: 18-051	Max L lateral incisor	6.40	5.60			5.20	
OM-32B	B:OR-15: 18-051	Max L canine	8.40	7.50			7.30	
OM-32C	B:OR-15: 18-051	Max L 3rd premolar	7.70	9.20			8.10	
OM-32D	B:OR-15: 18-051	Max L 4th premolar	8.30				8.00	
OM-35A1	B:OR-15: 18-055a	Max R 3rd premolar	7.90	9.50		5.90	9.10	
OM-35A2	B:OR-15: 18-055a	Max R 4th premolar	8.00	10.10			9.20	
OM-35A3	B:OR-15: 18-055a	Max R 1st molar	12.00	13.30		9.60	12.20	
OM-35B1	B:OR-15: 18-055b	Max L canine	8.10					
OM-35B2	B:OR-15: 18-055b	Max L 3rd premolar	8.10					
OM-35B3	B:OR-15: 18-055b	Max L 4th premolar	7.20	9.90				
OM-35B4	B:OR-15: 18-055b	Max L 1st molar	12.00	13.40			12.30	
OM-27G1	B:OR-15: 18-036	Man R 1st molar	11.50	10.70		9.10	8.90	
OM-27G2	B:OR-15: 18-036	Man R 3rd premolar	4.70	6.10				
OM-27G3	B:OR-15: 18-036	Man R 4th premolar	4.80	7.10				
OM-27G4	B:OR-15: 18-036	Man R 2nd molar	8.50	8.40				

Table 2. List of the specimens of the Raymond Dart collection used to record the anomalies.

Collection Accession number	**Population Groups**	**Sex**
A 3394	Tswana	Female
A 3127	Tswana	Female
A 3183	Tswana	Female
A 3188	Tswana	Female
A 2851	Tswana	Female
A 2129	Tswana	Female
A 2764	Tswana	Female
A 2967	Tswana	Female
A 2965	Tswana	Female
A 182	Tswana	Female
A 1491	Tswana	Female
A 1483	Tswana	Female
A 1202	Tswana	Female
A 3376	Tswana	Female
A 3499	Tswana	Female
A 3557	Tswana	Female
A 3095	Tswana	Female
A 931	Tswana	Female
A 1519	Tswana	Female
A 871	Tswana	Female
A 1666	Tswana	Female
A 3195	Tswana	Female
A 2371	Tswana	Female
A 1811	Tswana	Female
A 1673	Tswana	Female
A 3787	Tswana	Female
A 3773	Tswana	Female
A 3624	Tswana	Female
A 3532	Tswana	Female
A 3524	Tswana	Female
A 3501	Tswana	Female
A 5609	Tswana	Female
A 3419	Tswana	Female
A 529	Tswana	Male
A 3182	Tswana	Male
A 3167	Tswana	Male
A 2154	Tswana	Male
A 2125	Tswana	Male
A 1885	Tswana	Male

A 719	Tswana	Male
A 244	Tswana	Male
A 2818	Tswana	Male
A 2363	Tswana	Male
A 2305	Tswana	Male
A 3377	Tswana	Male
A 3373	Tswana	Male
A 3315	Tswana	Male
A 3245	Tswana	Male
A 1953	Tswana	Male
A 1776	Tswana	Male
A 641	Tswana	Male
A 1589	Tswana	Male
A 1586	Tswana	Male
A 1548	Tswana	Male
A1461	Tswana	Male
A 1955	Tswana	Male
A 1264	Tswana	Male
A 824	Tswana	Male
A 3409	Tswana	Male
A 3403	Tswana	Male
A 3160	Tswana	Male
A 1652	Tswana	Male
A 1284	Tswana	Male
A 3462	Tswana	Male
A 3453	Tswana	Male
A 3411	Tswana	Male
A 3093	Tswana	Male
A 3073	Tswana	Male
A 3468	Tswana	Male
A 3483	Tswana	Male
A 3485	Tswana	Male
A 3486	Tswana	Male
A 3500	Tswana	Male
A 3574	Tswana	Male
A 3589	Tswana	Male
A 3590	Tswana	Male
A 3685	Tswana	Male
A 3687	Tswana	Male
A 3715	Tswana	Male
A 3742	Tswana	Male
A 3743	Tswana	Male
A 3750	Tswana	Male
A 3793	Tswana	Male
A 94	Hottentots	Female

A 178	Hottentots	Female
A 663	Hottentots	Female
A 82	Hottentots	Male
A 450	Hottentots	Male
A 906	Hottentots	Male
A 2097	Hottentots	Male
A 233	Hottentots	Male
A 143	Hottentots	Male
A 171	Hottentots	Male
A 188	Hottentots	Male
A 1472	Hottentots	Male
A 102	Zulu	Female
A 158	Zulu	Female
A 448	Zulu	Female
A 617	Zulu	Female
A 912	Zulu	Female
A 105	Zulu	Female
A 206	Zulu	Female
A 527	Zulu	Female
A 646	Zulu	Female
A 746	Zulu	Female
A 943	Zulu	Female
A 156	Zulu	Female
A 381	Zulu	Female
A 580	Zulu	Female
A 648	Zulu	Female
A 799	Zulu	Female
A 1256	Zulu	Female
A 1301	Zulu	Female
A 1408	Zulu	Female
A 1451	Zulu	Female
A 1499	Zulu	Female
A 1557	Zulu	Female
A 1697	Zulu	Female
A 1302	Zulu	Female
A 1417	Zulu	Female
A 1463	Zulu	Female
A 1501	Zulu	Female
A 1685	Zulu	Female
A 1791	Zulu	Female
A 1319	Zulu	Female
A 1429	Zulu	Female
A 1468	Zulu	Female
A 1576	Zulu	Female
A 1689	Zulu	Female

A 1875	Zulu	Female
A 3579	European	Female
A 3683	European	Female
A 4022	European	Female
A 3860	European	Female
A 3845	European	Female
A 3838	European	Female
A 3851	European	Female
A 3972	European	Female
A 3554	European	Female
A 3603	European	Female
A 2660	European	Female
A 2957	European	Female
A 3129	European	Female
A 2409	European	Female
A 2453	European	Female
A 2930	European	Female
A 2399	European	Female
A 2179	European	Female
A 2358	European	Female
A 2228	European	Female
A 2657	European	Female
A 2457	European	Female
A 1057	European	Male
A 1207	European	Male
A 1959	European	Male
A 1289	European	Male
A 2479	European	Male
A 1948	European	Male
A 2256	European	Female
A 2292	European	Female
A 2351	European	Female
A 2372	European	Female
A 2287	European	Female
A 2331	European	Female
A 2558	European	Female
A 2201	European	Female
A 2286	European	Female
A 2309	European	Female
A 2357	European	Female
A 2397	European	Female
A 2109	European	Female
A 1966	European	Female
A 2127	European	Female
A 2400	European	Female

A 2117	European	Female
A 1962	European	Female
A 1252	European	Female
A 2092	European	Female
A 701	European	Female
A 1562	European	Female
A 1976	European	Female
A 1934	European	Female
A 2115	European	Female
A 2184	European	Female
A 2193	European	Female
A 2189	European	Female
A 2185	European	Female
A 2188	European	Female
A 2412	European	Female
A 2485	European	Female
A 2407	European	Female
A 2697	European	Female
A 2472	European	Female
A 2425	European	Female
A 2453	European	Female
A 2696	European	Female
A 2602	European	Female
A 2457	European	Female
A 2674	European	Female
A 2473	European	Female
A 2437	European	Female
A 2604	European	Female
A 2445	European	Female
A 3066	European	Female
A 2462	European	Female
A 2681	European	Female
A 2493	European	Female
A 3029	European	Female
A 2511	European	Female
A 3129	European	Female
A 2688	European	Female
A 2409	European	Female
A 2644	European	Female
A 2459	European	Female
A 3655	European	Female
A 3513	European	Female
A 3788	European	Female
A 3449	European	Female
A 3682	European	Female

A 3909	European	Female
A 3451	European	Female
A 3505	European	Female
A 3954	European	Female
A 3861	European	Female
A 3958	European	Female
A 4050	European	Female
A 3971	European	Female
A 3970	European	Female
A 4055	European	Female
A 3865	European	Female
A 3815	European	Female
A 3867	European	Female
A 3910	European	Female
A 3530	European	Female
A 3681	European	Female
A 3393	European	Female
A 3785	European	Female
A 3975	European	Female
A 3522	European	Female
A 3686	European	Female
A 4005	European	Female
A 3923	European	Female
A 3875	European	Female
A 3914	European	Female
A 3454	European	Female
A 3769	European	Female
A 3758	European	Female
A 3876	European	Female
A 3916	European	Female
A 4084	European	Female
A 3976	European	Female
A 4085	European	Female
A 3866	European	Female
A 3850	European	Female
A 3754	European	Female
A 3925	European	Female
A 3890	European	Female
A 3951	European	Female
A 3656	European	Female
A 3539	European	Female
A 3895	European	Female
A 3889	European	Female
A 4040	European	Female
A 4042	European	Female

A 3990	European	Female
A 4041	European	Female
A 1302	Zulu	Female
A 1228	Zulu	Female
A 1961	Zulu	Female
A 1904	Zulu	Female
A 2404	Zulu	Female
A 2849	Zulu	Female
A 2252	Zulu	Female
A 2430	Zulu	Female
A 2420	Zulu	Female
A 2521	Zulu	Female
A 1991	Zulu	Female
A 2012	Zulu	Female
A 2087	Zulu	Female
A 2848	Zulu	Female
A 2443	Zulu	Female
A 2682	Zulu	Female
A 2333	Zulu	Female
A 3062	Zulu	Female
A 2258	Zulu	Female
A 3157	Zulu	Female
A 3146	Zulu	Female
A 3124	Zulu	Female
A 2221	Zulu	Female
A 2359	Zulu	Female
A 3059	Zulu	Female
A 3219	Sotho	Male
A 144	Sotho	Male
A 602	Sotho	Male
A 1525	Sotho	Male
A 489	Sotho	Male
A 3798	Sotho	Male
A 490	Sotho	Male
A 482	Sotho	Male
A 550	Sotho	Male
A 556	Sotho	Male
A 184	Sotho	Male
A 543	Sotho	Male
A 723	Sotho	Male
A 1281	Sotho	Male
A 715	Sotho	Male
A 1271	Sotho	Male
A 3806	Sotho	Male
A 496	Sotho	Male

A 1967	Sotho	Male
A 555	Sotho	Male
A 470	Sotho	Male
A 432	Sotho	Male
A 1773	Sotho	Male
A 1596	Sotho	Male
A 847	Sotho	Male
A 1348	Sotho	Male
A 836	Sotho	Male
A 727	Sotho	Male
A 752	Sotho	Male
A 691	Sotho	Male
A 8	Sotho	Male
A 3227	Sotho	Male
A 3218	Sotho	Male
A 3311	Sotho	Male
A 3337	Sotho	Male
A 3236	Sotho	Male
A 3396	Sotho	Male
A 17	Sotho	Male
A 2511	Sotho	Male
A 200	Sotho	Male
A 61	Sotho	Male
A 214	Sotho	Male
A 3279	Sotho	Male
A 3695	Sotho	Male
A 914	Bush	Male
A 1096	Bush	Male
A 1654	Bush	Male
A 1048	Bush	Female
A 658	Bush	Male
A 674	Bush	Male
A 332	Bush	Male
A 338	Bush	Male
A 411	Bush	Male
A 330	Bush	Male
A 333	Bush	Male
A 334	Bush	Male
A 1099	Bush	Male
A 209	Sotho	Female
A 458	Sotho	Female
A 831	Sotho	Female
A 745	Sotho	Female
A 730	Sotho	Female
A 887	Sotho	Female

A 969	Sotho	Female
A 828	Sotho	Female
A 682	Sotho	Female
A 577	Sotho	Female
A 784	Sotho	Female
A 886	Sotho	Female
A 866	Sotho	Female
A 777	Sotho	Female
A 892	Sotho	Female
A 81	Sotho	Female
A 644	Sotho	Female
A 772	Sotho	Female
A 903	Sotho	Female
A 700	Sotho	Female
A 218	Sotho	Female
A 834	Sotho	Female
A 969	Sotho	Female
A 3508	Xhosa	Female
A 3480	Xhosa	Female
A 2858	Xhosa	Female
A 2850	Xhosa	Female
A 3563	Xhosa	Female
A 3275	Xhosa	Female
A 2887	Xhosa	Female
A 3180	Xhosa	Female
A 3290	Xhosa	Female
A 2876	Xhosa	Female
A 3503	Xhosa	Female
A 2021	Baca	Male
A 1575	Baca	Male
A 2032	Baca	Male
A 2177	Baca	Male
A 827	Baca	Male
A 2466	Baca	Male
A 649	Baca	Male
A 499	Baca	Male
A 492	Baca	Male
A 1806	Baca	Male
A 1686	Baca	Male
A 1905	Baca	Male
A 159	Kala	Male
A 101	Kala	Male
A 770	Kala	Male
A 557	Kala	Male
A 742	Kala	Male

A 578	Kala	Male
A 554	Kala	Male
A 86	Kala	Male
A 192	Kala	Male
A 100	Kala	Male
A 738	Kala	Male
A 594	Kala	Male
A 796	Kala	Male
A 1858	Kala	Male
A 3241	Kala	Male
A 1466	Kala	Male
A 241	Fing	Female
A 210	Fing	Male
A 186	Fing	Male
A 1277	Fing	Male
A 991	Fing	Male
A 994	Fing	Male
A 467	Fing	Female
A 394	Fing	Male
A 442	Fing	Female
A 21	Fing	Female
A 85	Fing	Female
A 84	Fing	Female
A 1431	Fing	Female
A 1234	Fing	Male
A 666	Fing	Male
A 474	Fing	Male
A 647	Fing	Female
A 1223	Fing	Male
A 2162	Fing	Female
A 2215	Fing	Male
A 972	Fing	Female
A 974	Fing	Female
A 861	Fing	Male
A 860	Fing	Female
A 844	Fing	Male
A 802	Fing	Male
A 1678	Fing	Male
A 1449	Fing	Male
A 1255	Fing	Male
A 980	Mala	Male
A 951	Mala	Male
A 789	Mala	Male
A 1565	Mala	Male
A 1627	Mala	Male

A 3541	Mala	Male
A 1387	Mala	Male
A 1347	Mala	Male
A 1191	Mala	Male
A 1923	Mala	Male
A 1868	Mala	Male
A 1478	Mala	Male
A 1494	Mala	Male
A 1982	Mala	Male
A 2009	Mala	Male
A 1913	Mala	Male
A 1503	Mala	Male
A 1540	Mala	Male
A 1556	Mala	Male
A 1908	Mala	Male
A 1462	Mala	Male
A 721	Mala	Male
A 1454	Mala	Male
A 122	Mala	Male
A 1396	Mala	Male
A 1432	Mala	Male
A 1573	Mala	Male
A 2257	Mala	Male
A 3083	Mala	Male
A 2211	Mala	Male
A 2879	Mala	Male
A 3198	Mala	Male
A 2205	Mala	Male
A 3455	Mala	Male
A 2194	Mala	Male
A 2202	Mala	Male
A 2063	Mala	Male
A 2051	Mala	Male
A 2182	Mala	Male
A 1484	Pedi	Male
A 1205	Pedi	Male
A 2064	Pedi	Male
A 2662	Pedi	Male
A 1674	Pedi	Male
A 2045	Pedi	Male
A 2410	Pedi	Male
A 2899	Pedi	Male
A 2099	Pedi	Male
A 2349	Pedi	Female
A 3104	Pedi	Female

A 1410	Pedi	Female
A 3731	Pedi	Male
A 2713	Pedi	Male
A 2145	Pedi	Male
A 2949	Pedi	Male
A 2200	Pedi	Male
A 3764	Pedi	Male
A 3133	Pedi	Male
A 598	Pondo	Male
A 2073	Pondo	Male
A 978	Pondo	Male
A 2251	Pondo	Male
A 1467	Pondo	Male
A 153	Pondo	Female
A 545	Pondo	Male
A 2181	Pondo	Male
A 841	Pondo	Male
A 2024	Pondo	Male
A 2335	Pondo	Male
A 1664	Pondo	Male
A 2312	Pondo	Male
A 1787	Pondo	Male
A 1931	Pondo	Male
A 2680	Pondo	Male
A 1242	Pondo	Male
A 731	Pondo	Male
A 1569	Pondo	Male
A 1505	Pondo	Male
A 1486	Pondo	Male
A 855	Pondo	Male
A 3085	Pondo	Male
A 762	Ndebele	Male
A 1274	Ndebele	Male
A 196	Ndebele	Male
A 1515	Ndebele	Male
A 1278	Ndebele	Male
A 436	Ndebele	Male
A 3282	Ndebele	Female
A 1418	Ndebele	Male
A 1954	Ndebele	Female
A 589	Ndebele	Male
A 1549	Ndebele	Female
A 1561	Ndebele	Male
A 3256	Ndebele	Male
A 964	Ndebele	Male

A 1294	Ndebele	Male
A 1375	Ndebele	Male
A 454	Ndebele	Male
A 2075	Ndebele	Female
A 677	Ndebele	Male
A 763	Ndebele	Male
A 710	Ndebele	Male
A 702	Ndebele	Male
A 2381	Ndebele	Male
A 1535	Ndebele	Male
A 3141	Ndebele	Male
A 2214	Ndebele	Male
A 2450	Ndebele	Male
A 1545	Ndebele	Male
A 2735	Ndebele	Male
A 1544	Ndebele	Male
A 3091	Ndebele	Male
A 1801	Ndebele	Male
A 2483	Ndebele	Male
A 927	Ndebele	Male
A 3136	Ndebele	Male
A 1671	Ndebele	Male
A 3135	Ndebele	Male
A 751	Ndebele	Male
A 2365	Ndebele	Male
A 1532	Ndebele	Female
A 929	Nyik	Male
A 862	Nyik	Male
A 293	Nyik	Female
A 273	Nyam	Male
A 780	Nyam	Male
A 18	Nyam	Male
A 513	Moza	Male
A 289	Moza	Male
A 91	Moza	Male
A 1292	Moza	Male
A 1817	Moza	Female
A 1487	Rolo	Male
A 2414	Rolo	Male
A 1860	Rolo	Male
A 1878	Rolo	Male
A 1571	Rolo	Female
A 1567	Rolo	Female
A 1552	Rolo	Male
A 1584	Rolo	Female

A 1574	Rolo	Female
A 1828	Rolo	Male
A 176	Rolo	Male
A 769	Rolo	Female
A 935	Rolo	Female
A 455	Rolo	Female
A 869	Rolo	Female
A 2342	Rolo	Male
A 2253	Rolo	Male
A 1200	Rolo	Female
A 460	Tsona	Male
A 1314	Tsona	Male
A 3313	Tsona	Male
A 3426	Tsona	Male
A 267	Tsona	Male
A 2204	Tsona	Male
A 3063	Tsona	Male
A 3115	Tsona	Male
A 3713	Tsona	Male
A 3555	Tsona	Male
A 3591	Tsona	Male
A 3765	Tsona	Male
A 3718	Venda	Male
A 2356	Venda	Male
A 3745	Venda	Male
A 3134	Venda	Male
A 2401	Venda	Male
A 3106	Venda	Male
A 3013	Venda	Male
A 2867	Venda	Male
A 2255	Venda	Male
A 3525	Venda	Female
A 2001	Venda	Male
A 2147	Venda	Male
A 2385	Venda	Male
A 3609	Venda	Male
A 2132	Venda	Male
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A 920	Zulu	Male
A 884	Zulu	Male
A 864	Zulu	Male

Table 3. List of the Holocene human skeletons from the Iziko Museum.

Collection Accession Number	**Locality**	**Date (B.P)**
SAM 4935	Stompneusbaai	2540±50yrsBP
SAM 4867	Vredenburg	590±45yrsBP
SAM 1449	Clanwilliam	2230±100yrsBP
SAM 6063	Saldahna Bay	1170±30yrsBP
SAM 4793	Saldahna	4110±60yrsBP
SAM 4899	Saldahna	2440±60yrsBP
SAM 4900	Saldahna	140±50yrsBP
SAM 5095	Saldahna	2660±70yrsBP
SAM 6074	Saldahna	1360±40yrsBP
SAM 6075	Saldahna	1330±40yrsBP

SAM 1149	Blouberg	3970±50yrsBP
SAM 1157	Blouberg	2420±60yrsBP
SAM 1247a	Blouberg	1180±50yrsBP
SAM 4636	Blouberg	2130±45yrsBP
SAM 4905	Blouberg	1210±50yrsBP
SAM 4930	Green Point	1130±40yrsBP
SAM 6149	Melkbos	1440±70yrsBP
SAM 5035a	Melkbosch	620±35yrsBP
SAM 6017	Melkbosch	2490±50yrsBP
SAM 1441	Melkbosch	2170±60yrsBP
SAM 6041b	Milnerton	2010±45yrsBP
SAM 6083	Milnerton	2000±50yrsBP
SAM 1863	Cape Point	800±50yrsBP
SAM 5075	Cape Point	2530±60yrsBP
SAM 1153	False Bay	440±50yrsBP
SAM 3737	Hout Bay	1370±45yrsBP
SAM 5076	Hout Bay	1510±40yrsBP
SAM 5082	Hout Bay	2150±60yrsBP
SAM 5034	Hout Bay	1390±40yrsBP
SAM 4203	Kommetjie	2760±50yrsBP
SAM 4942	kommetjie	2220±45yrsBP
SAM 4943	Kommetjie	2610±50yrsBP
SAM 4303	Noordhoek	2590±50yrsBP
SAM 4304a	Noordhoek	2220±50yrsBP
SAM 4304b	Noordhoek	2070±50yrsBP
SAM 4305	Noordhoek	2100±45yrsBP
SAM 4308	Noordhoek	2170±60yrsBP
SAM 4630	Sandy Bay	1775±80yrsBP
SAM 1443	Gordons Bay	2050±50yrsBP
SAM 1444	Gordons Bay	1290±50yrsBP
SAM 4637	Gordons Bay	3880±50yrsBP
SAM 3053	Strand	1990±50yrsBP
SAM 6051	Byneskranskop	3190±50yrsBP
SAM 6052	Byneskranskop	1780±50yrsBP
SAM 4178	Gourits River	2420±60yrsBP
SAM 1457	Klein Brak River	910±35yrsBP
SAM 4312	Mossel Bay	2260±170yrsBP
SAM 6032	Cape St Francis	5180±65yrsBP
SAM 1145	Robberg	3210±70yrsBP
SAM 1871	Robberg	3310±60yrsBP
SAM 1878	Robberg	2620±35yrsBP
SAM 1879	Robberg	3440±60yrsBP
SAM 5044	Wagennars Cave	2660±150yrsBP
SAM 1269	Henkries	200±50yrsBP
SAM 1268	Orange River	20±40yrsBP

SAM 4931	Buffels River	3750±60yrsBP
SAM 26	Clanwilliam	270±100yrsBP
SAM 27	Clanwilliam	250±90yrsBP
SAM 5029	Travalia	330±50yrsBP
SAM 4188	Kruidfontein	310±50yrsBP
SAM 3458	Blouberg	220±45yrsBP
SAM 4308	Noordhoek	2170±60yrsBP
SAM 5040	Bokbaai	3570±60yrsBP
SAM 5041	Melkbosch	2010±50yrsBP
SAM 4720	Kommetjie	2195±80yrsBP
SAM 5068	Ysterfontein	5680±70yrsBP
SAM 5083	Ysterfontein	1490±55yrsBP
SAM 5091	Ysterfontein	2830±50yrsBP
SAM 6020	Saldahna	620±30yrsBP
SAM 6041b	Milnerton	2010±45yrsBP
SAM 37	Blouberg	6120±70yrsBP
SAM 6149	Melkbos	1440±70yrsBP