The Diet and Management of Ancient Sheep and Goats: The Potential of Dental Microwear

by

Lucy Lawrence

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The University of Sheffield,

Faculty of Arts and Humanities

Department of Archaeology

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Volume 2

Supervisor: Paul Halstead

Second supervisor: Glynis Jones

Advisor: Ingrid Mainland

Student registration number: 130215671

CHAPTER 2 FIGURES AND TABLES

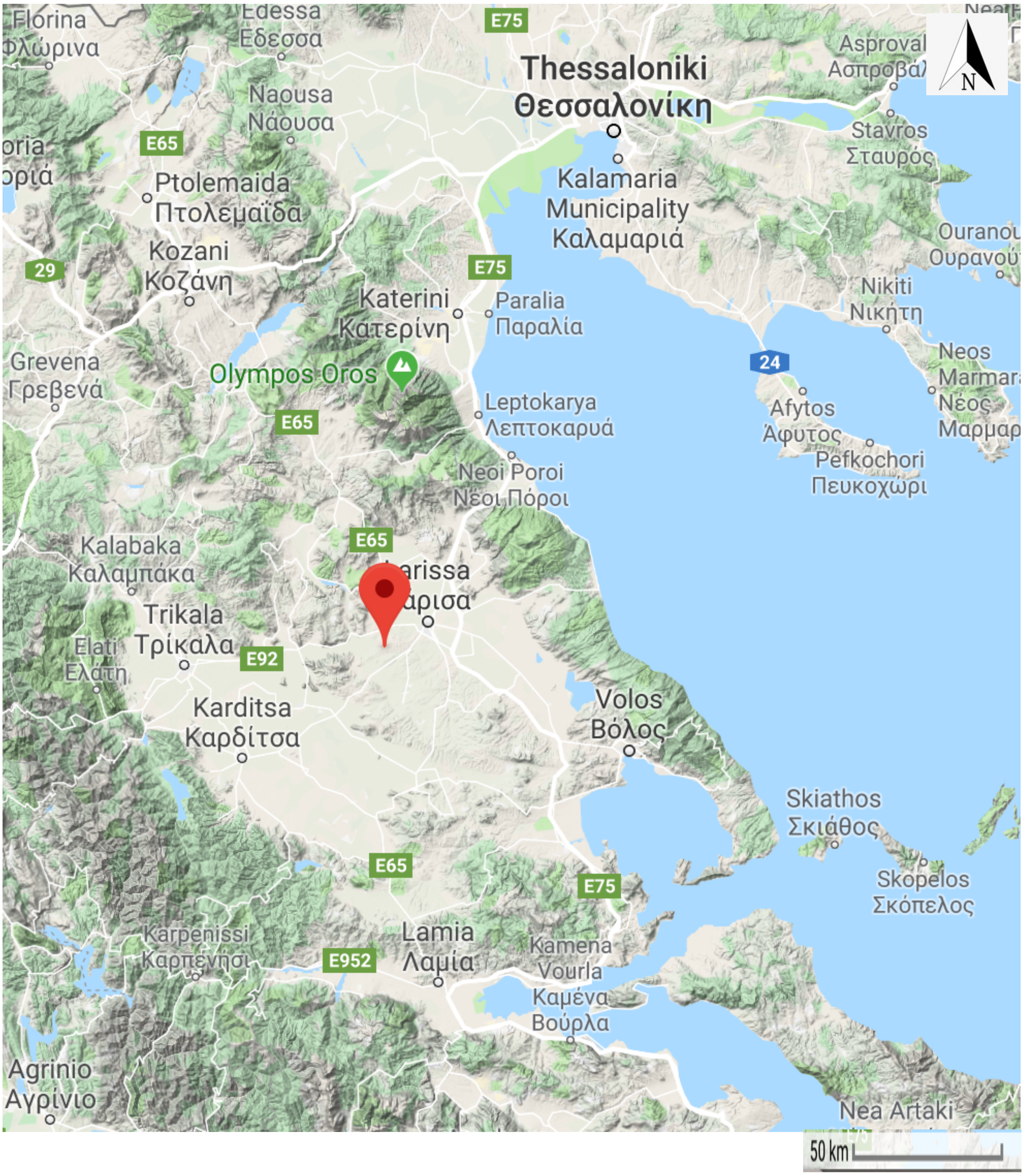


Figure 2.1: Map showing the location of Toumba Kremastis-Koiladas (Google map data 2019).

Figure 2.2: Plan of 1998-1999 excavation of TKK (after Hondrogianni-Metoki 2009). Key: – = excavation boundary, round circles = pits, black dots = cremations, linear feature made up of hachures = ditches.

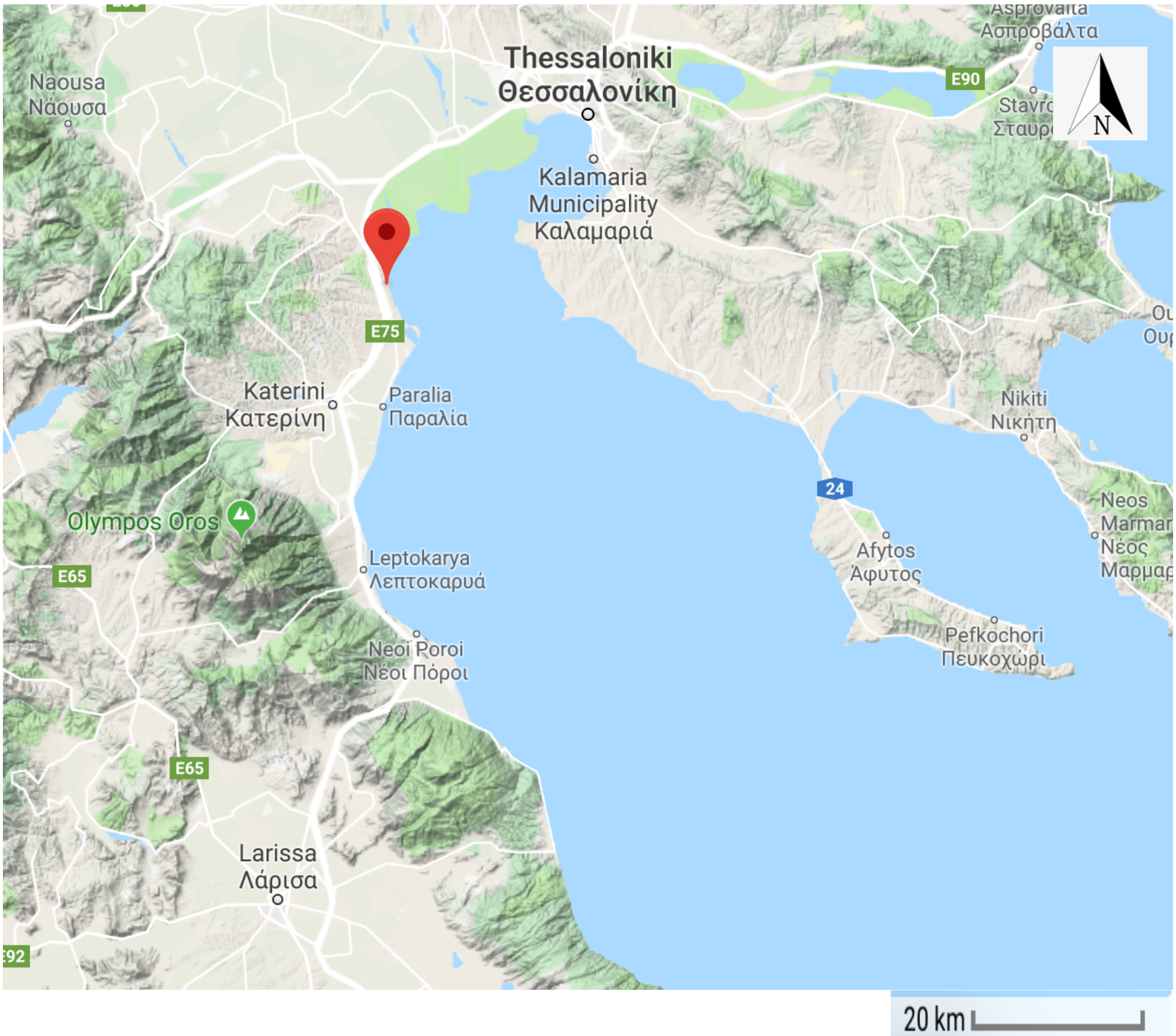


Figure 2.3: Map showing the location of the site, Makriyalos (Google map data 2019).

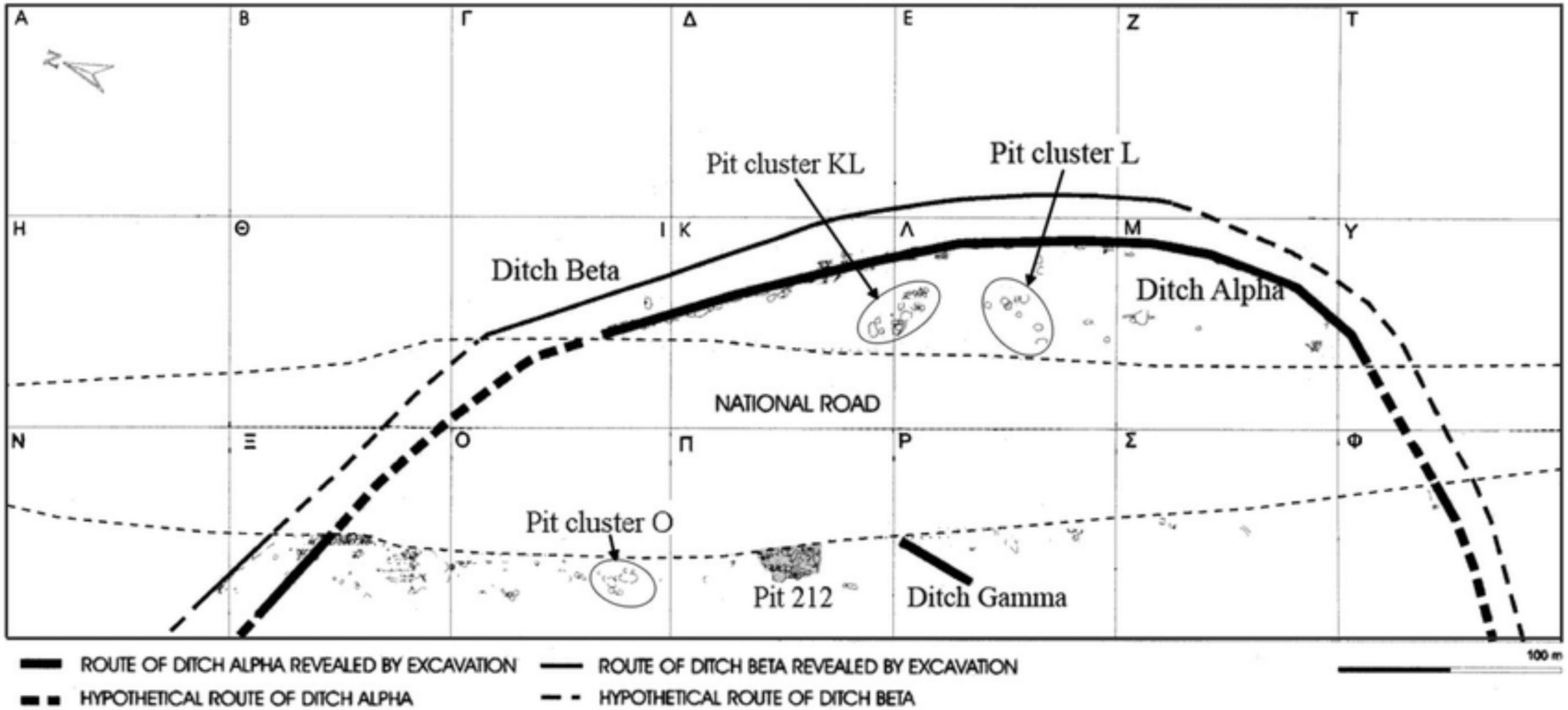


Figure 2.4: Plan of MKI (Phase I) (after Pappa et al. 2004 Figure 2.1) (scale: each square = 100mx100m).

Figure 2.5: Map showing the location of the site, Knossos (Google Map data 2019).

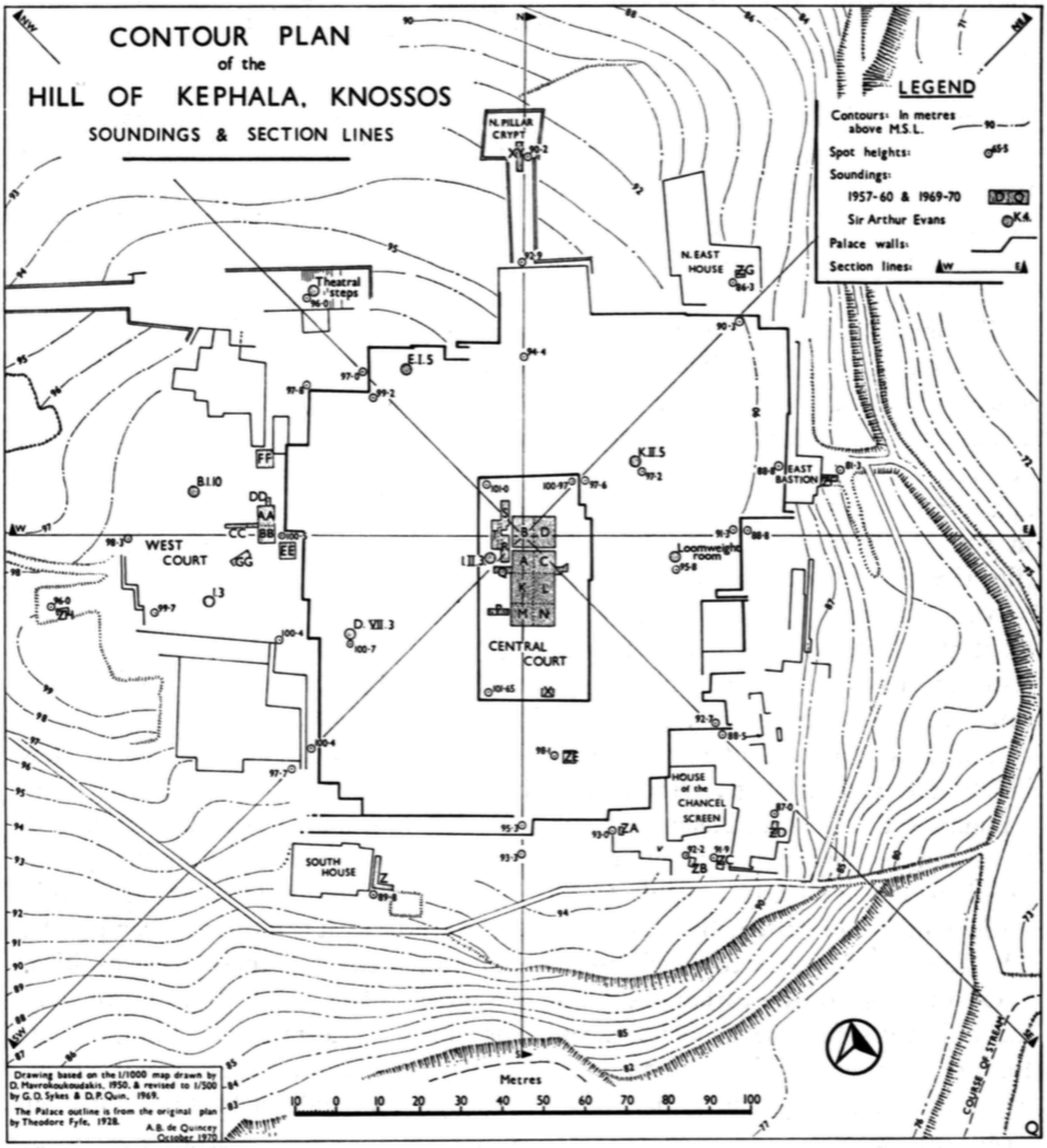


Figure 2.6: Contour plan of Knossos showing location of soundings (after Evans 1971 Figure 1).

	Sheep	Goats	Total number of samples
Pits	26	10	36
Ditches	9	3	12

Table 2.1: Table of the sample group selected for analysis from TKK (total sample size = 48).

	Sheep	Goat	Total number of samples
Pit	25	4	29
Ditch	8	2	10
Habitation	15	2	17

Table 2.2: Table of the sample group selected for analysis from MK (total sample size = 56).

Time period	Total sample number
LNI	1
LNII	14
LNII/FNIA	6
FNIA	15
FNIB	22
FNII	14
FNII/III	1
FNIII	3

Table 2.3: Table of the sample group selected for analysis from Knossos, before being grouped (total sample size = 76).

Time period	Total sample number
LNI-LNII	15
FNIA	15
FNIB	22
FNII-III	18

Table 2.4: Table of the sample group selected for analysis from Knossos, after being grouped, note LNII/FNIA samples (Table 2.3) have been removed for diachronic comparisons (total sample size = 70).

CHAPTER 3 FIGURES AND TABLES

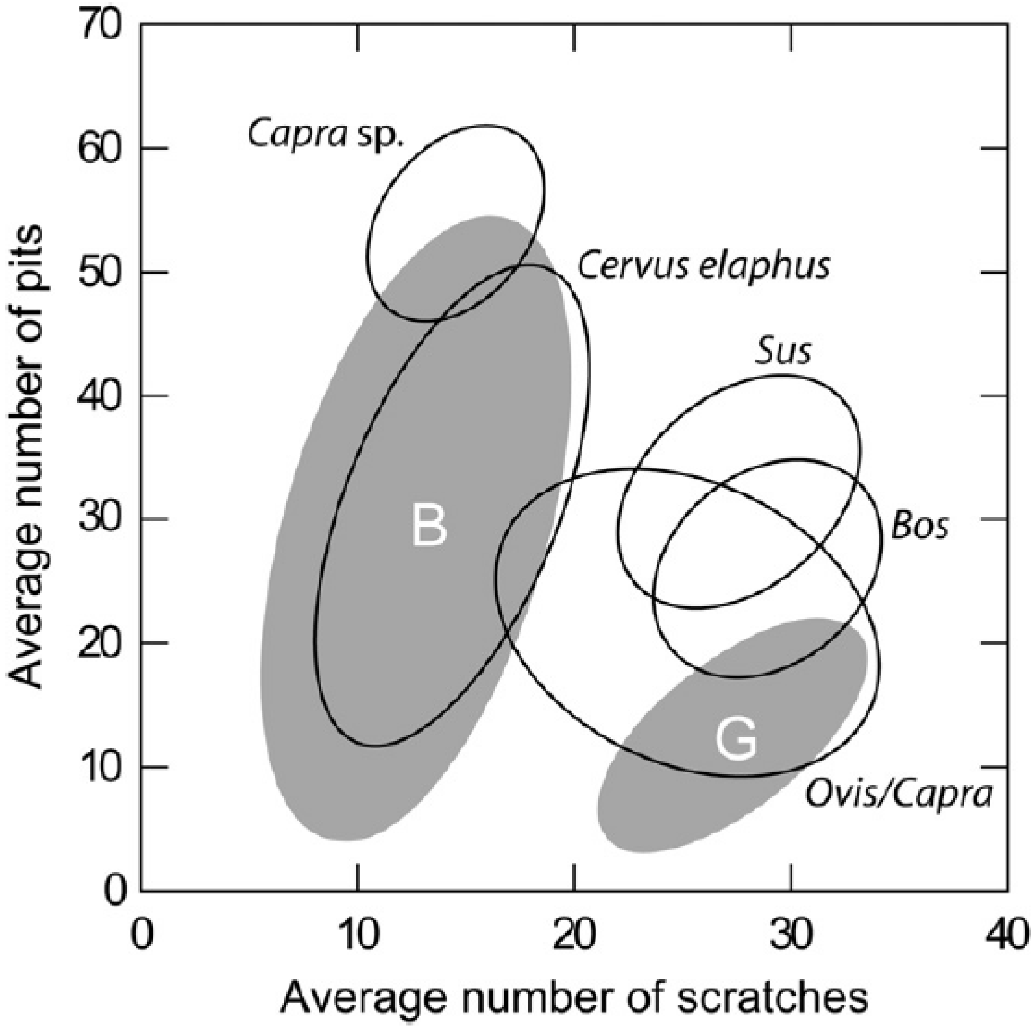


Figure 3.1: Bivariate graph from Rivals et al (2011 Figure 3, 534), displaying the average number of pits and scratches from Kouphovouno archaeological samples (white ellipses), compared to results from Solounias and Semprebon's (2002) database of extant ungulates grazers and browsers (grey ellipses, B = browsers, G = grazers).

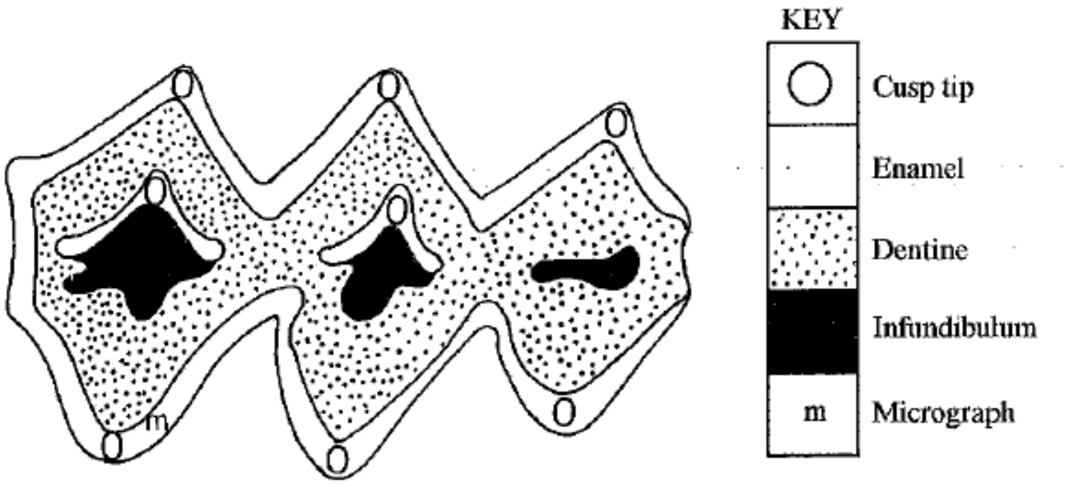


Figure 3.2: Diagram of the occlusal surface of a sheep/goat dP4. The 'm' on the anterior-facing enamel band of the bucco-posterior cusp indicates the area where microphotographs were and will be taken. (after Mainland's 1994 Figure 9.1).

Figure 3.3: Photograph demonstrating the method for creating negative impressions of teeth using silicone material (Lawrence 2013).

A B C D

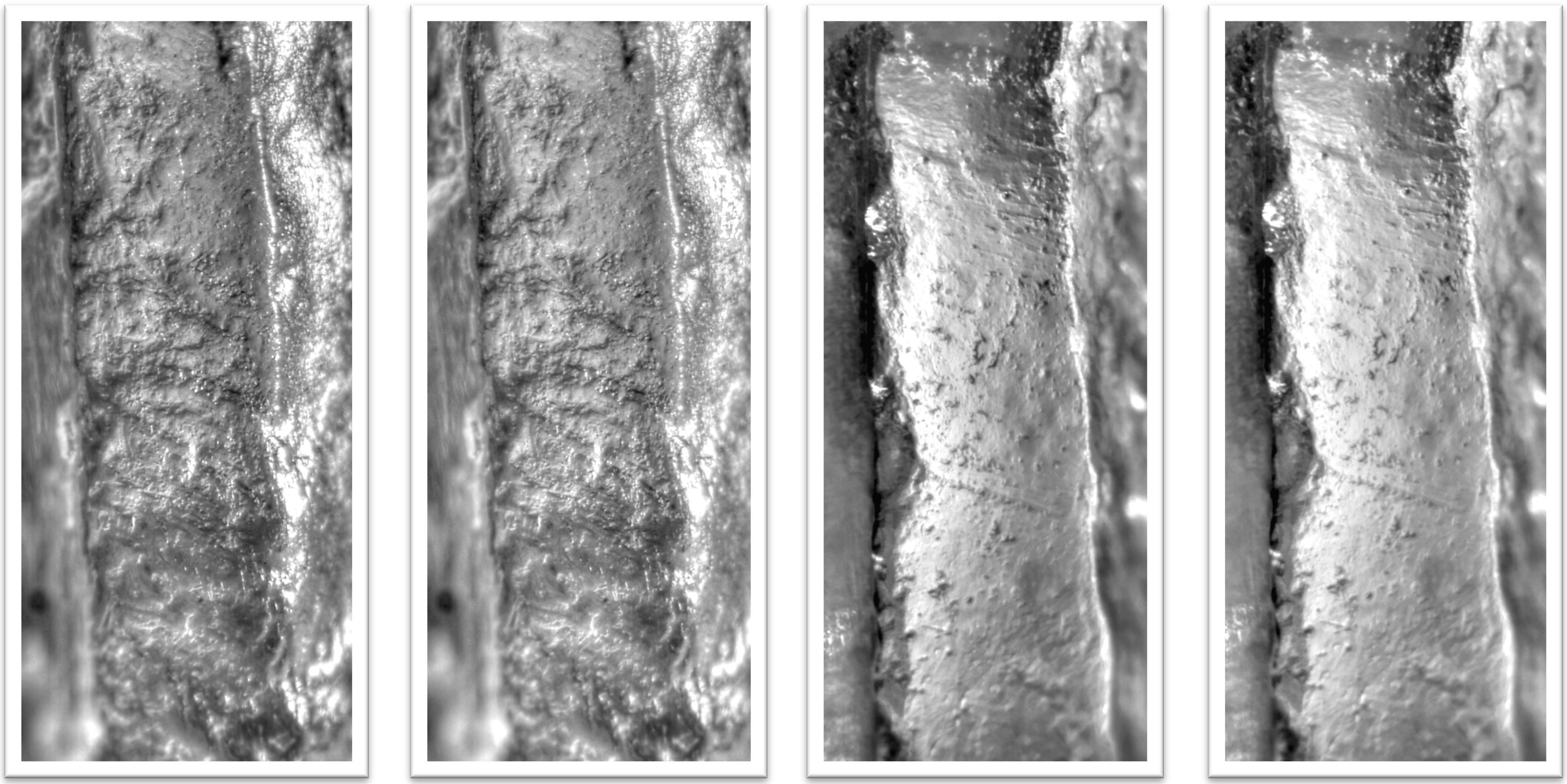


Figure 3.4: Detail enhancement information for HDR Tonemapped images A – D (Left to right). A) Enamel band from grazer displaying high abrasion: 9 Frames; Monochrome enhance setting; Tone Compression 6.2; Detail Contrast 10; Gamma 0.7; Microsmoothing 0; Medium lighting adjustments; medium sharpening. B) Same enamel band from high abrasive grazer with the same detail enhancements but created from 5 frames.

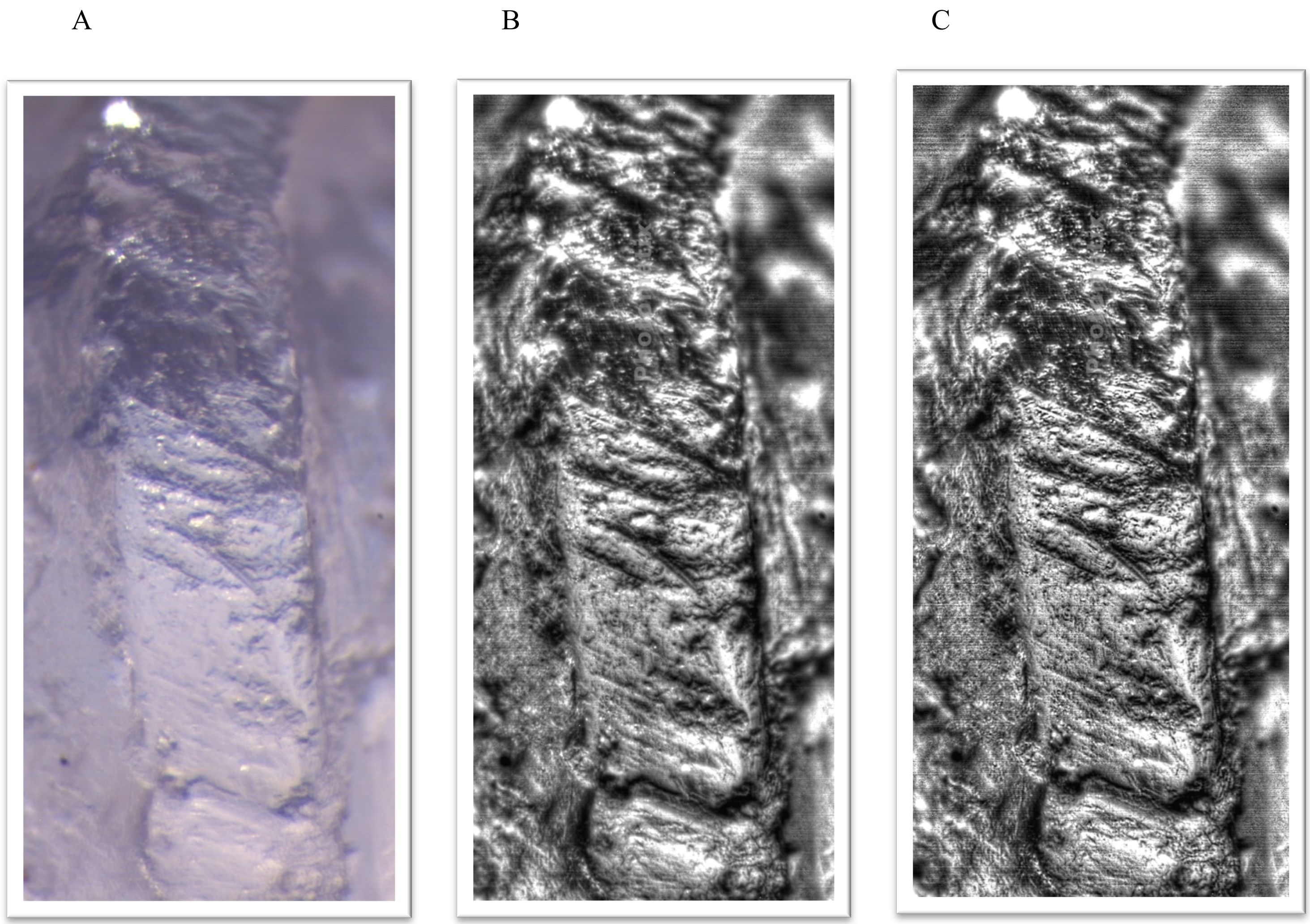
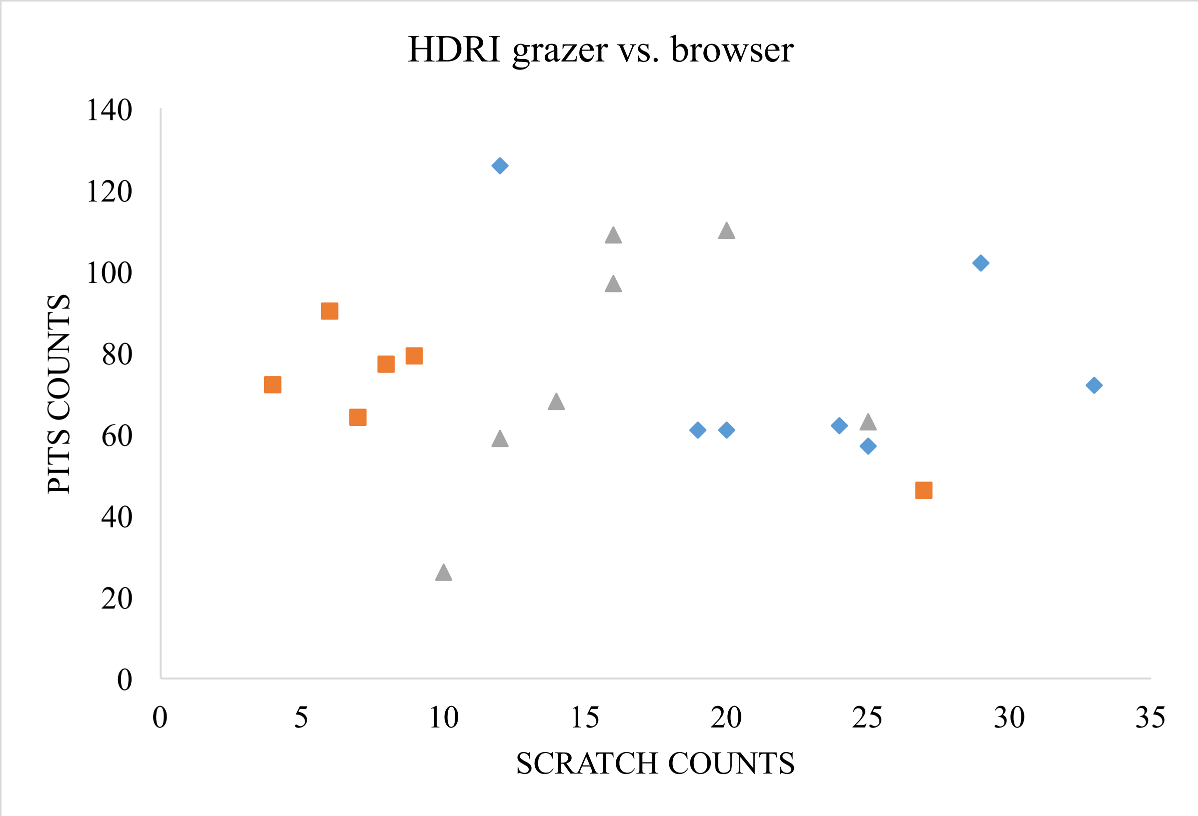


Figure 3.5: A: JPEG image of high abrasive grazer, no HDRI processing. B: HDRI of same enamel band, tonemapped using Photomatix Pro 64-bit with no additional sharpening. C: HDRI tonemapped with additional ‘strong’ sharpening enhancement causing a ‘grainy’ appearance.



low quality graze samples from Lejre Denmark

browsers from Lejre, Denmark

summer and winter grazed sheep from Greenland previously exhibiting low abrasion (See Table 3.3 for further details).

Figure 3.6: Bivariate graph showing the total pit and scratch counts for three dietary groups Results have been obtained using HDR imaging and detail enhancements.

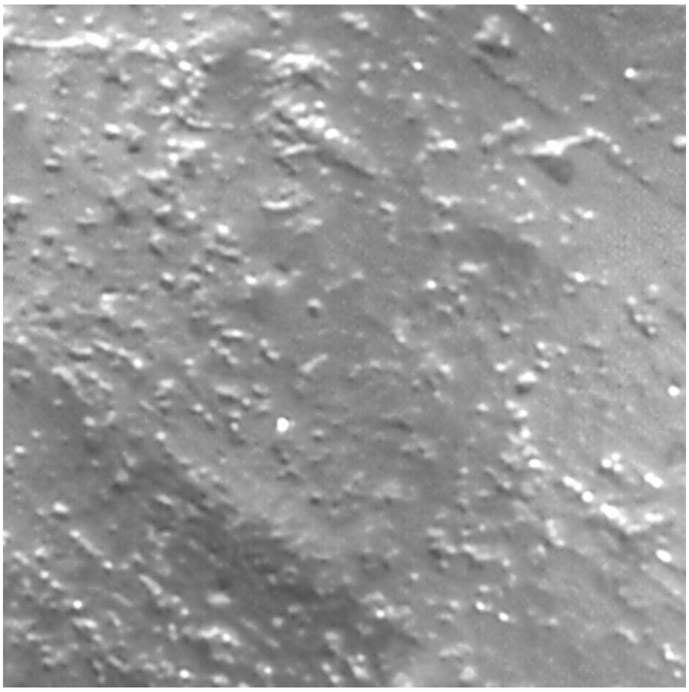


Figure 3.7: DLM image of pitted enamel surface from a sheep fed fresh browse (40x magnification) (taken by author).

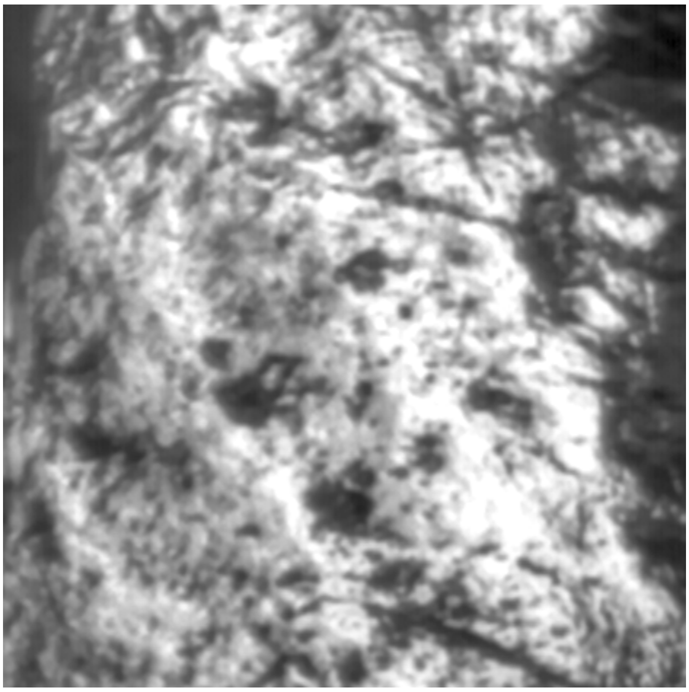
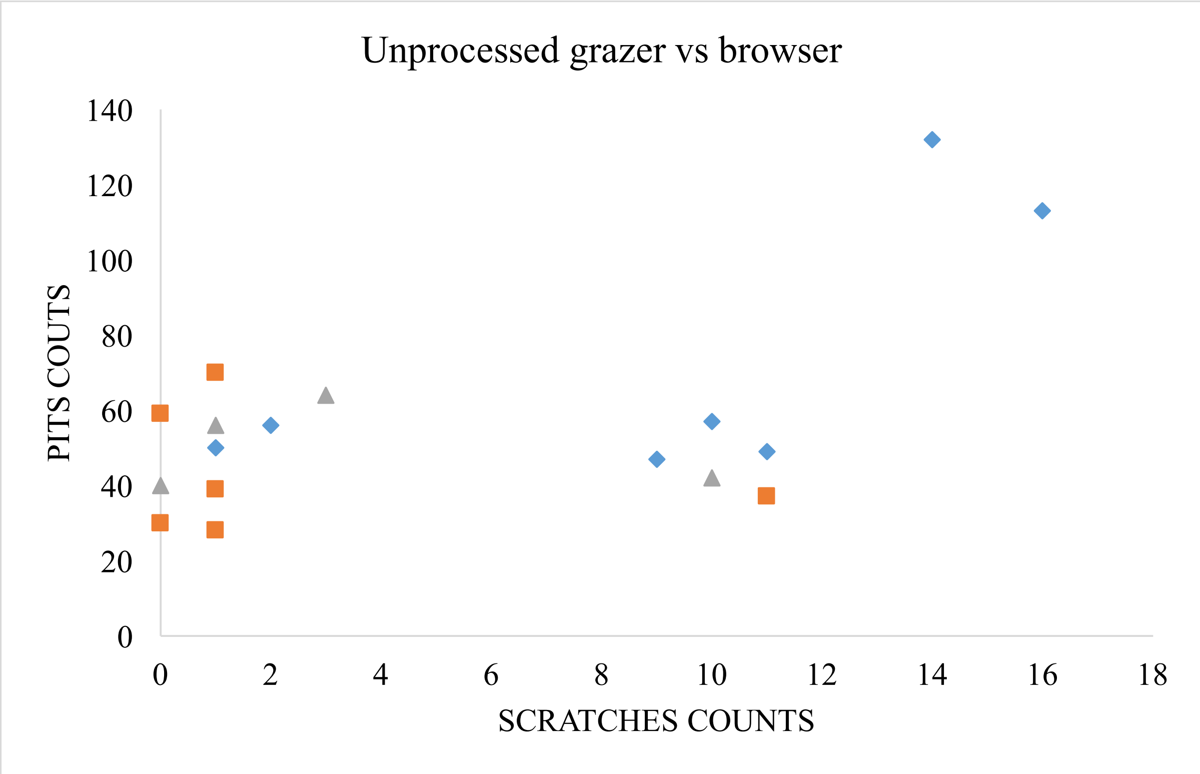


Figure 3.8: DLM image of heavily scratched and pitted enamel surface from a sheep fed fresh graze (40x magnification) (taken by author).



low quality graze samples from Lejre Denmark

browsers from Lejre, Denmark

summer and winter grazed sheep from Greenland previously exhibiting low abrasion (See Table 3.3 for further details).

Figure 3.7: Bivariate graph to show the pit and scratch counts from three diets using unprocessed images. These results have been taken from a pilot study in 2013 (Lawrence 2013).

Sample no.	Species	Age (mths)	Suckling	Fodder					Outdoors
				Leafy Hay	Grassy Hay	Sown Hay	Bran	Grain	
1	Sheep	4		✓	✓	✓	✓	✓	✗
2	Sheep	4		✓	✓	✓	✓	✓	✗
3	Sheep	3		✗		✓	✓	✓ G	✗
4	Goat	4		✓	✓	✓	✓	✓ W	✗
5	Sheep	3		✓	✓	✓	✓	✓ W	✗
6	Sheep	7		✓	✓		✓	✓	✓
7	Sheep	7		✓	✓		✓	✓ W+G	
8	Goat	7	✓	✓	✓		✓	✓	✗
9	Goat	2	✓	✓	✓		✓	✓	✗
10	Goat	4	✓	✓	✓	✓	✓	✓	✗
11	Goat	7	✓	✓	✓	✓	✓	✓	✗
12	Sheep	6	✗	✓	✓	✓	✓	✓ W	✗
13	Sheep	7		✓	✓	✓	✓	✓ W	✗
14	Goat	6	✗	✓		✓	✓	✗	✗
15	Sheep	12	✗	✓		✓	✓	✓ G	✓ (Nov. 1991)
16	Goat	1.5		✗		✓	✓	✓ G	✗
17	Sheep	16	✗	✓	✓			✓ W	✓ (Autumn 1991, April 1992)
18	Goat	4		✓	✓	✓	✓	✓	✗

Table 3.1: The diet and age at death (months) of the Plikati sheep and goats (after Mainland 1994 Figure 5.5).

Key: ✓ = yes, ✗ = no, blank = no information provided, W = whole grain, G = milled grain).

Diet	Sample origin	Sample number
High Abrasive Grazers	Gotland sheep Lejre, Denmark	N = 9
Low Abrasive Grazers	Greenland (winter and summer)	Total N = 55, (summer n = 29, winter n = 26)
	MLURI, Scotland	Total N = 8, rough indigenous pasture n = 3 (2 from winter + 1 from summer pasture), cultivated grasses n = 5 (3 from winter + 2 from summer)
Cereal	Assiros, N. Greece - transhumant	N = 20
	Assiros, N Greece - sedentary	N = 9
Leafy Hay	Plikati, NW Greece	N = 16
Browsers	Lejre, Denmark	N = 10
	Gonies, Crete	N = 3
Grassy Hay	Greenland	N = 29

Table 3.2: Table to show modern sample details and sample numbers.

Sample	Diet	Total feature tally	Pit Count	Scratch Count	Notes
LJ44	Poor quality grazer -Lejre	57	61	20	Increased
LJ56	Poor quality grazer -Lejre	86	62	24	
LJG6	Poor quality grazer -Lejre	80	61	19	
LJG4	Poor quality grazer -Lejre	115	126	12	Increased
LJ42	Poor quality grazer -Lejre	82	57	25	
LJ46	Poor quality grazer -Lejre	131	102	29	
LJG2	Poor quality grazer -Lejre	66	72	33	Increased
LJ47	Browser - Lejre	76	72	4	
LJ52	Browser - Lejre	88	79	9	
LJ54	Browser - Lejre	73	46	27	
LJW2	Browser - Lejre	64	77	8	Increased
LJW3	Browser - Lejre	71	64	7	
LJW5	Browser - Lejre	69	90	6	Increased
UP16	Summer Grazer-Greenland	88	63	25	Increased
UP18	Summer Grazer-Greenland	82	68	14	Increased
UP27	Summer Grazer-Greenland	125	109	16	
UP21	Summer Grazer-Greenland	71	59	12	
UP9	Summer Grazer-Greenland	113	97	16	

UP3	Summer Grazer-Greenland	130	110	20	Increased
UP46	Winter Grazer-Greenland	36	26	10	Blurred imaged

Table 3.3: Sample details for bivariate graph of HDRI analysis (Figure 3.6) and the counts for pits, scratches and total feature tally. 'Increased' indicates the samples whose pit and scratch counts were increased due to out of focus areas and enamel bands with a width smaller than 0.4mm.

Sample	Diet	Total feature tally	Pit Count	Scratch Count
LJ44	High abrasive grazer -Lejre	146	132	14
LJ56	High abrasive grazer -Lejre	60	49	11
LJG6	High abrasive grazer -Lejre	56	47	9
LJG4	High abrasive grazer -Lejre	67	57	10
LJ42	High abrasive grazer -Lejre	129	113	16
LJ46	High abrasive grazer -Lejre	58	56	2
LJG2	High abrasive grazer -Lejre	51	50	1
LJ47	Browser - Lejre	71	70	1
LJ52	Browser - Lejre	29	28	1
LJ54	Browser - Lejre	48	37	11
LJW2	Browser - Lejre	30	30	0
LJW3	Browser - Lejre	59	59	0
LJW5	Browser - Lejre	40	39	1
UP16	Summer Grazer-Greenland	52	42	10
UP18	Summer Grazer-Greenland	67	64	3
UP27	Summer Grazer-Greenland	n/a	n/a	n/a

UP21	Summer Grazer-Greenland	40	40	0
UP9	Summer Grazer-Greenland	n/a	n/a	n/a
UP3	Summer Grazer-Greenland	n/a	n/a	n/a
UP46	Winter Grazer-Greenland	57	56	1

Table 3.4: Sample details for bivariate graph of microwear analysis of unprocessed images (Figure 3.7) and the counts for pits, scratches and total feature tally.

Feature Type	Average Feature Size/Shape	Proportion of Feature Types	Feature Orientation
Total count of all features	Average width of all features	Percentage of pits out of total features	Average orientation of all features
Total count of pits	Average width of pits	Percentage of scratches out of total features	Average orientation of scratches
Total count of scratches	Average width of scratches		
	Average length of all features		
	Average length of pits		
	Average length of scratches		
	Average ratio of length to width		

	(thickness/thinness of features)		

Table 3.5: Table to show quantitative variables recorded.

		Recording System
Feature Types	Pits	Presence (1) Absence (0)
	Pit lines	Presence (1) Absence (0)
	Parallel striations	Presence (1) Absence (0)
	Non-parallel striations	Presence (1) Absence (0)
Description of Features	Features with sharp or rounded edges	Round (1) Sharp (0)
	Deep or shallow features	Deep (1) Shallow (0)
	Features with anterior-posterior orientation	Presence (1) Absence (0)
	Features with bucco-lingual orientation	Presence (1) Absence (0)
	Features with a definite shape	Yes (1) No (0)
	Features with edges joining up	Yes (1) No (0)
Description of Features	Porosity	Presence (1) Absence (0)
	Smooth surface	Presence (1) Absence (0)
	Abraded surface	Presence (1) Absence (0)
	Polished surface	Presence (1) Absence (0)
	Uneven surface	Presence (1) Absence (0)
	Areas of enamel with no features	Presence (1) Absence (0)
	Underlying enamel structure visible	Fully visible (1) Partially visible (0.5) Absent (0)

Table 3.6: Table showing qualitative variables recorded.

CHAPTER 4 FIGURES AND TABLES

Distinguishing between grazers, browsers, leafy hay, grassy hay and cereal foddering

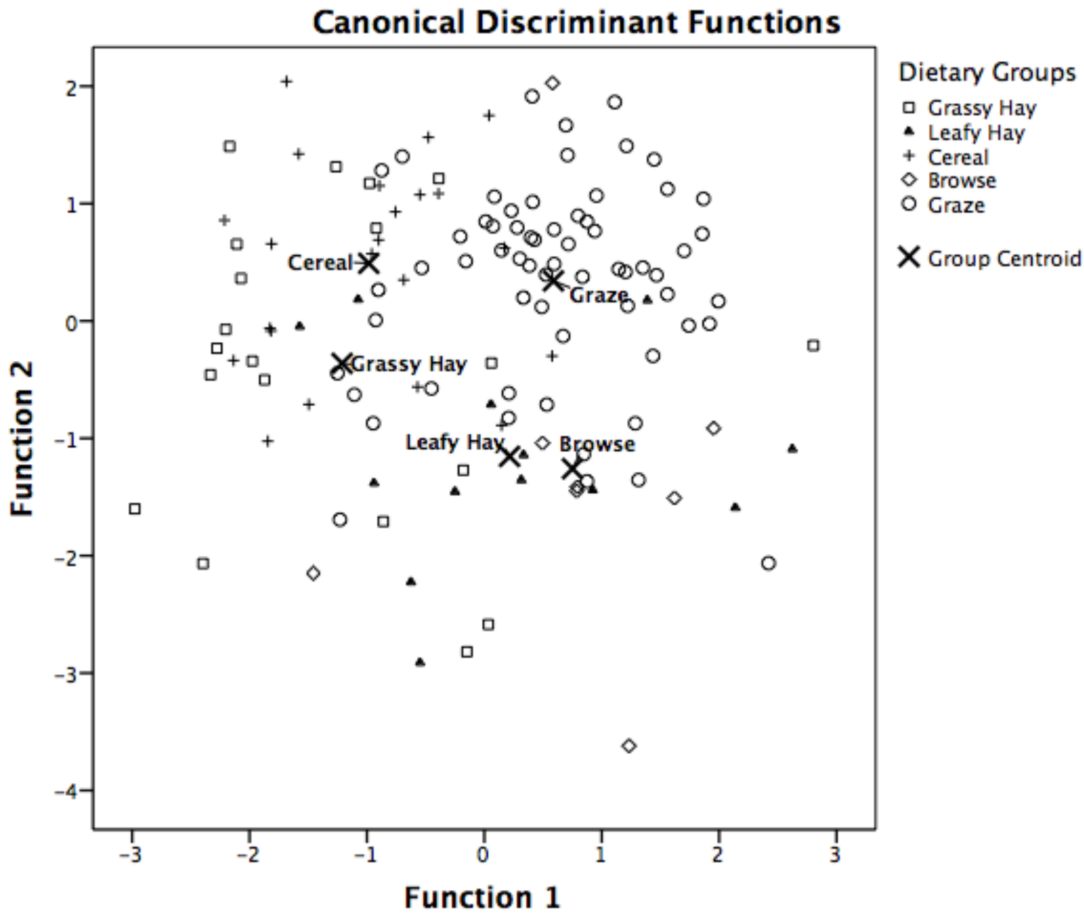


Figure 4.1: A plot of the first two discriminant functions for the discriminant analysis of five dietary groups: grazers (n=63), browsers (n=8), leafy hay (n=13), cereal (n=22) and grassy hay (n=20). Variables used in the analysis: number of pits, presence of surface porosity, presence of surface polish, presence of deep features, presence of uneven surfaces, presence of areas of empty enamel, and the square roots of scratch counts.

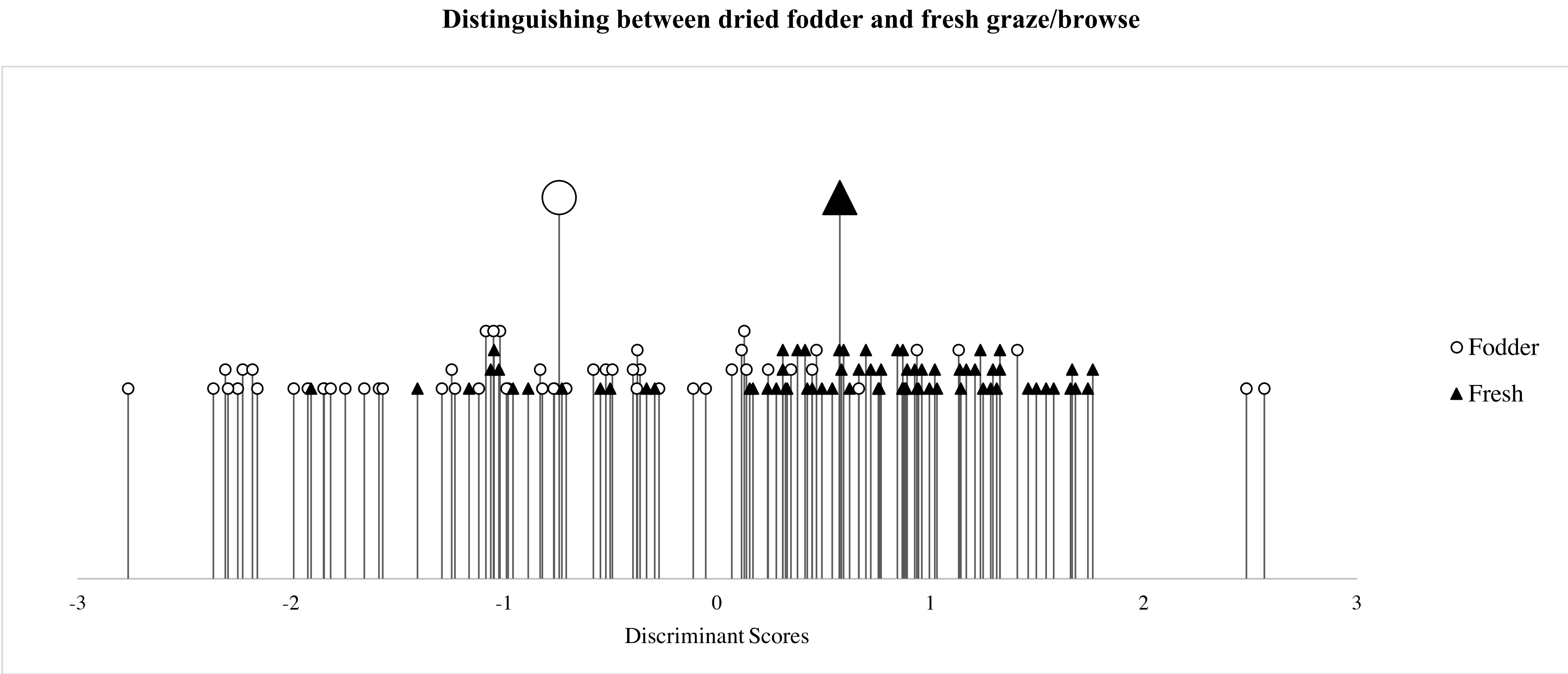


Figure 4.2: A plot of the discriminant function for the discriminant analysis of two dietary groups: fresh (graze and browse) (n=71) and foddered (cereal fodder, grassy hay and leafy hay) (n=55). Variables used in the analysis: feature count, presence of surface porosity, presence of smooth surfaces, and presence of deep features.

Distinguishing between dried leafy hay and fresh browse

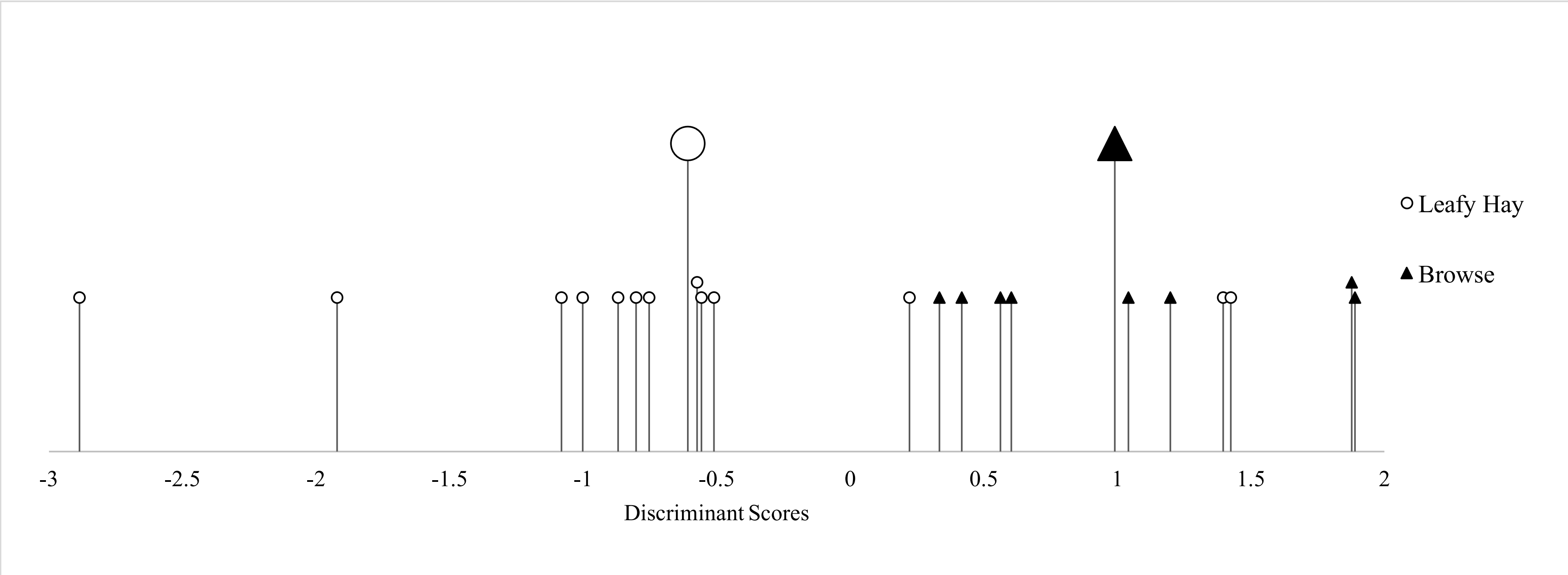


Figure 4.3: A plot of the discriminant function for the discriminant analysis of two dietary groups: leafy hay (n=13) and fresh browse (n=8). Variables used in the analysis: Log10 of feature orientation, square roots of scratch count, mean scratch length inversed.

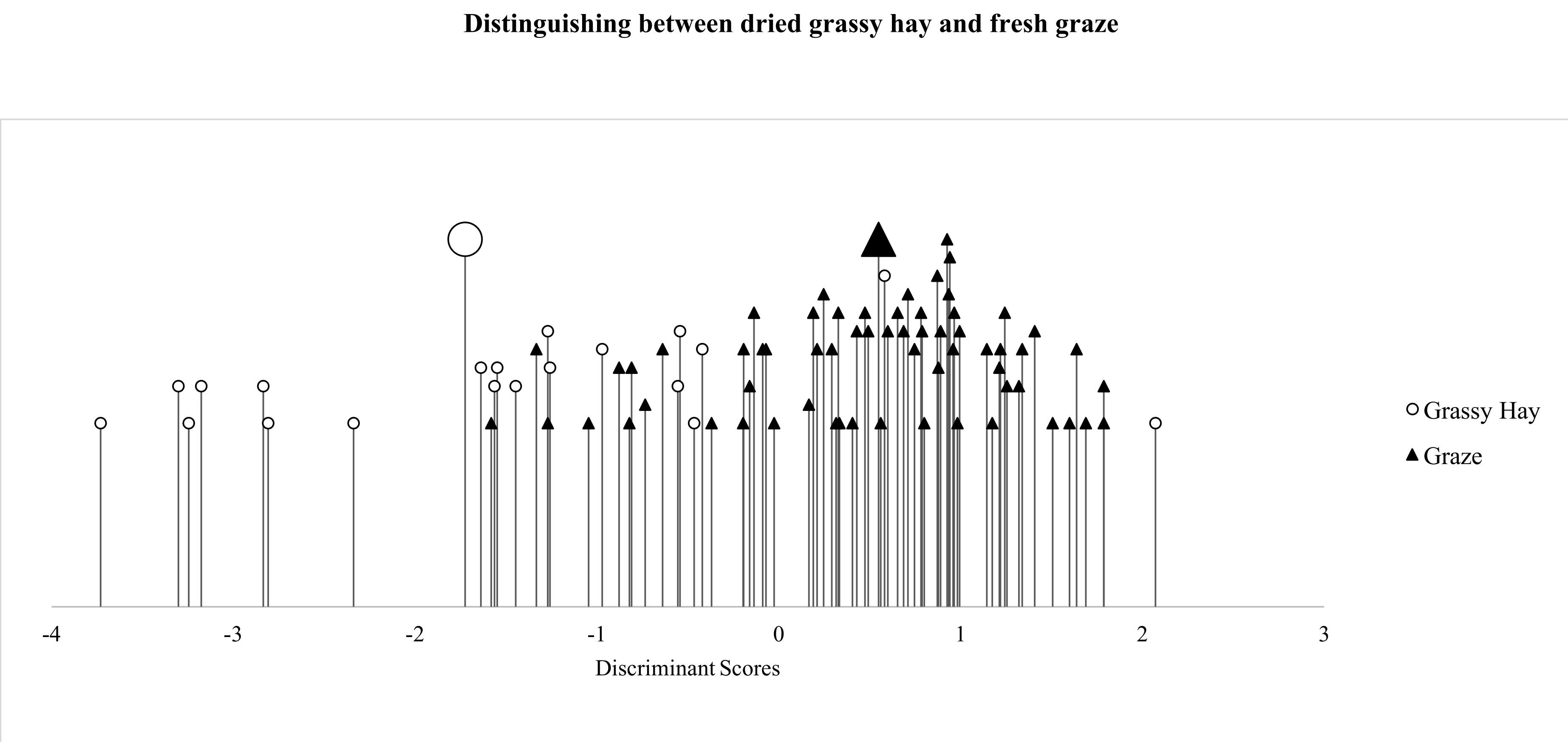


Figure 4.4: A plot of the discriminant function for the discriminant analysis of two dietary groups: grassy hay (n=20) and fresh graze (n=63). Variables used in the analysis: feature count, presence of surface porosity, presence of deep features, presence of features with rounded edges, Presence of areas of enamel with no features, and presence of parallel striations.

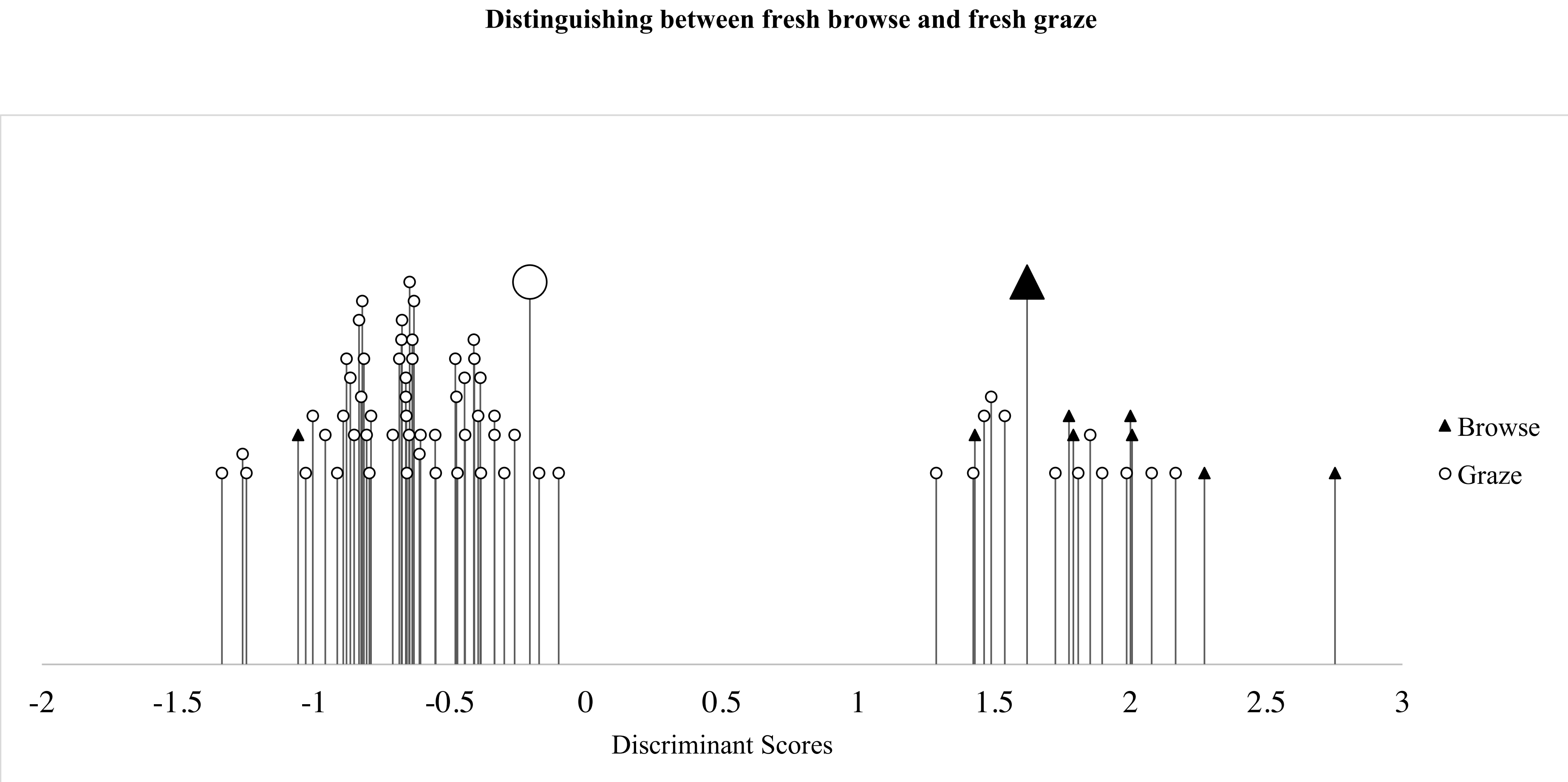


Figure 4.5: A plot of the discriminant function for the discriminant analysis of two dietary groups: grassy hay (n=20) and fresh graze (n=63). Variables used in the analysis: presence of surface polish, and mean feature length inversed.

Distinguishing between summer and winter graze (both fresh groups)

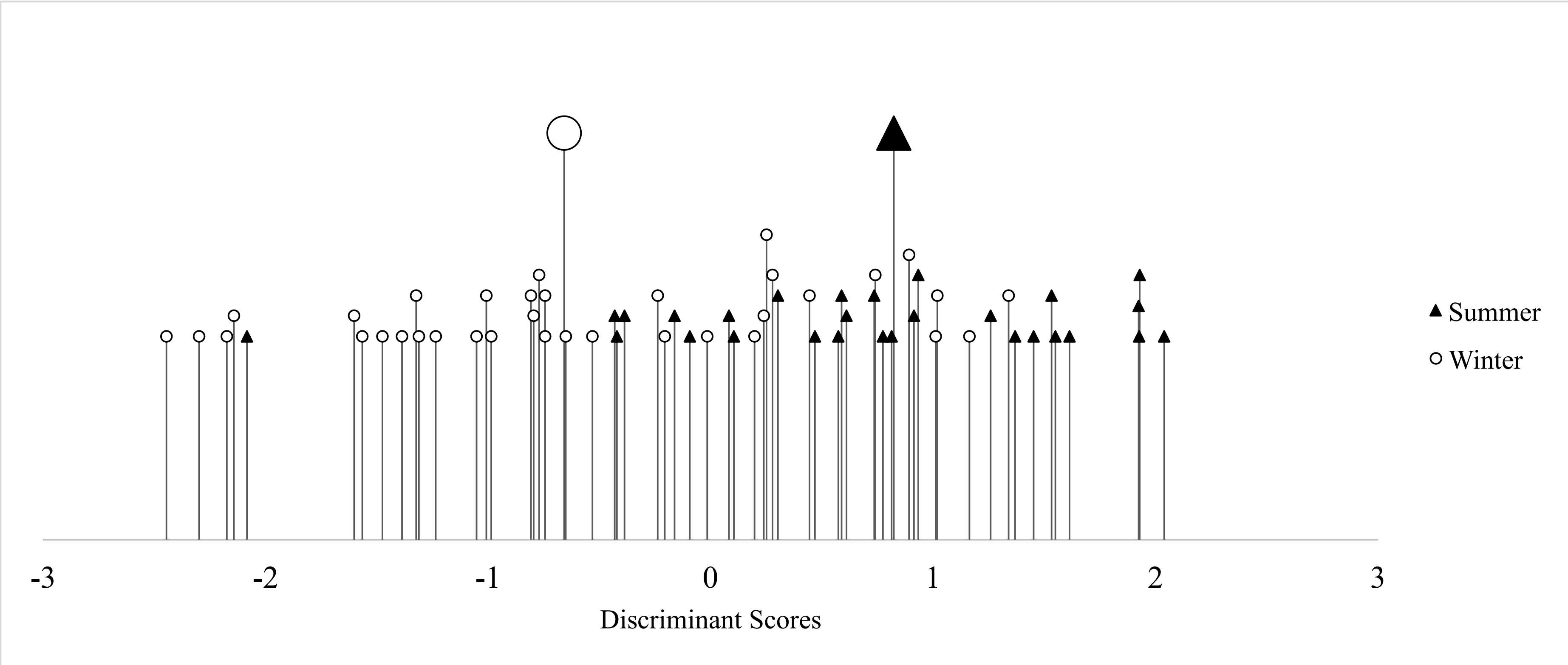


Figure 4.6: A plot of the discriminant function for the discriminant analysis of two dietary groups: summer graze (n=28) and winter graze (n=35). Variables used in the analysis: feature length:width ratio inversed, log10 of scratch percentage, presence of uneven surfaces, presence of features with anterior-posterior orientation.

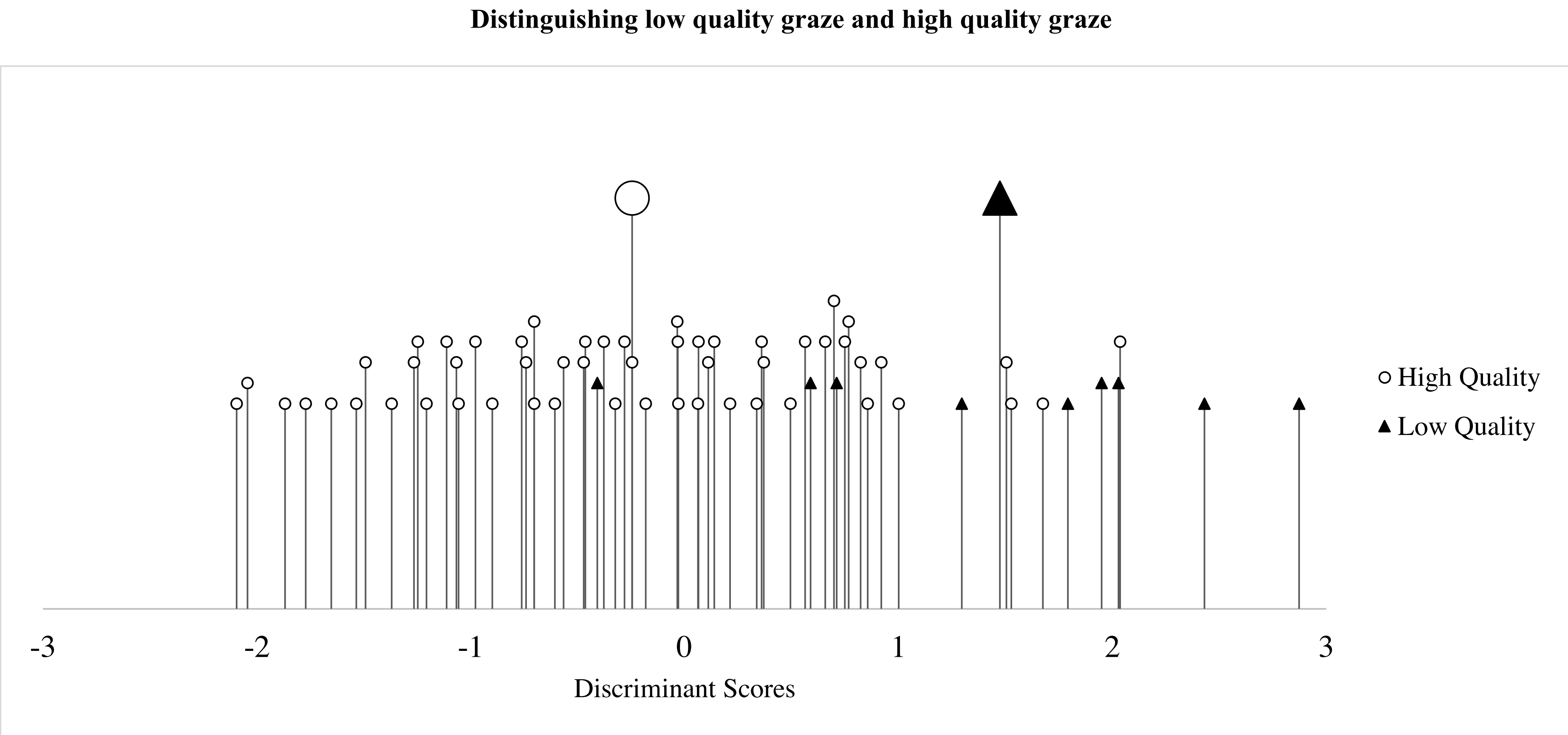


Figure 4.7: A plot of the discriminant function for the discriminant analysis of two dietary groups: high quality graze (n=54) and low quality graze (n=9). Variables used in the analysis: square roots of scratch counts, presence of uneven surfaces, mean feature length inversed, presence of smooth surfaces, and length:width ratio inversed.

Distinguishing between grassy hay, leafy hay and cereal fodder

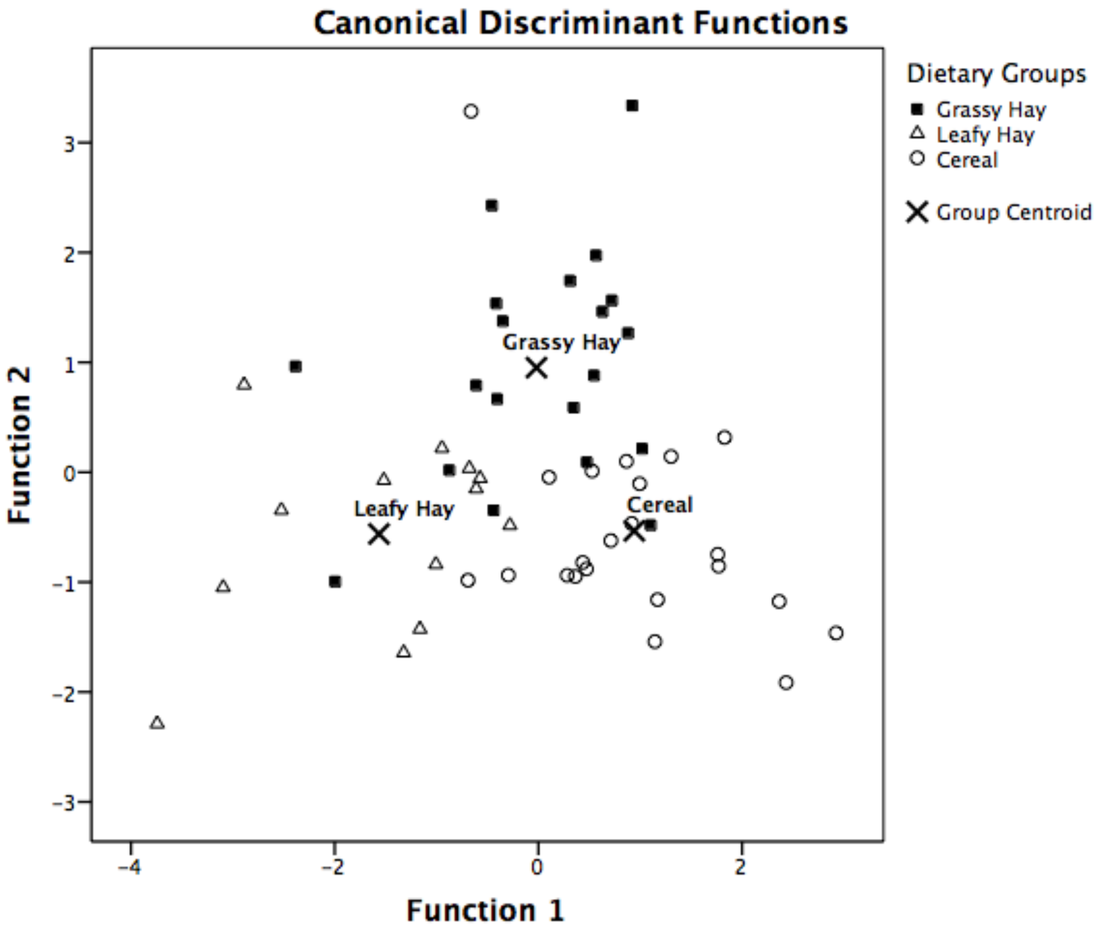


Figure 4.8: A plot of the two discriminant functions for the discriminant analysis of three dietary groups: grassy hay (n=20), leafy hay (n=13) and cereal (n=22). Variables used in the analysis: pit count, log10 of scratch percentage, mean length:width ratio inversed, presence of surface porosity, mean feature length inversed, mean width of scratches inversed, areas of enamel with no features, presence of deep features, presence of non-parallel scratches, and presence of uneven surfaces.

Distinguishing between grassy hay and leafy hay

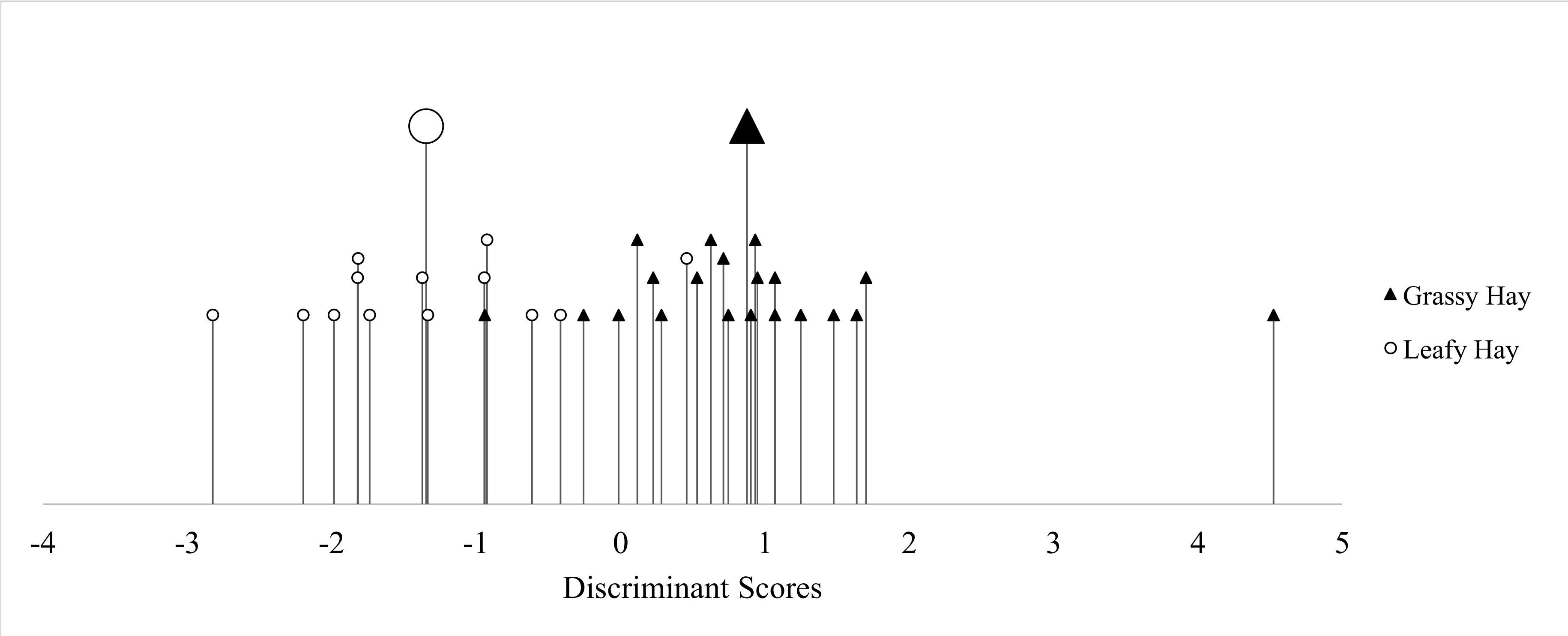


Figure 4.9: A plot of the discriminant function for the discriminant analysis of two dietary groups: grassy hay (n=20) and leafy hay (n=13). Variables used in the analysis: presences of areas of enamel with no features, presence of parallel scratches, presence of non-parallel scratches, and mean length:width ratio inversed.

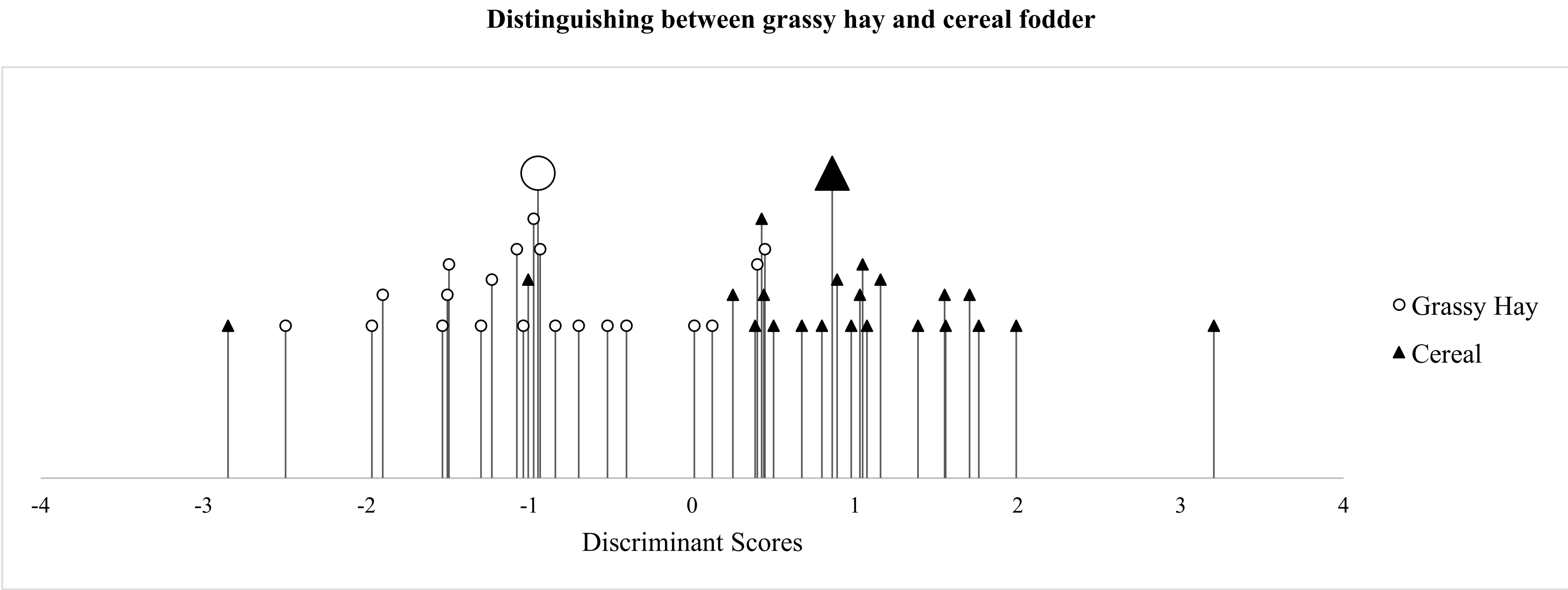


Figure 4.10: A plot of the discriminant function for the discriminant analysis of two dietary groups: grassy hay (n=20) and cereal (n=). Variables used in the analysis: presence of deep features, presence of areas of enamel with no features, square roots of scratch count, mean pit width inversed, mean scratch width inversed, mean length:width ratio inversed and presence of smooth surfaces.

	Function			
	1	2	3	4
Pit count	.85	-.237	.073	-.374
Porosity	.706	-.011	.180	.101
Presence of polish	-.052	-.646	-.292	.529
Presence of deep features	.303	.486	-.408	.080
Presence of uneven surface	.025	.289	-.186	-.097
Presence of areas of enamel with no features	-.291	-.026	.775	.363
Scratch count	.264	.337	-.289	.605

Table 4.1: Table showing the correlations between discriminating variables and the four discriminant functions extracted in the discriminant analysis using five dietary groups.

		Actual Dietary Groups	Predicted Group Membership					Total
			Grassy Hay	Leafy Hay	Cereal	Browse	Graze	
Pre-validation	Count	Grassy Hay	9	1	5	4	1	20
		Leafy Hay	0	6	2	4	1	13
		Cereal	2	0	16	2	2	22
		Browse	0	1	0	6	1	8
		Graze	5	6	6	5	41	63
Cross-validated	Count	Grassy Hay	8	1	6	4	1	20
		Leafy Hay	0	3	3	5	2	13
		Cereal	3	0	14	2	3	22
		Browse	1	1	0	5	1	8
		Graze	6	6	6	5	40	63
Overall, 61.9% of samples correctly reclassified into their original dietary groups; 55.6% of samples correctly reclassified into their original dietary groups after cross-validation.								

Table 4.2: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using five dietary groups.

	Function
Total feature count	.815
Presence of surface porosity	.758
Presence of smooth surface	-.500
Presence of deep features	.414

Table 4.3: Table showing the correlations between discriminating variables and the discriminant function extracted in the discriminant analysis using two dietary groups: dried fodder and fresh graze/browse.

		Actual Dietary Groups	Predicted Group Membership		Total
			Foddered	Fresh	
Pre-validation	Count	Foddered	40	15	55
		Fresh	13	58	71
	%	Foddered	72.7	27.3	
		Fresh	18.3	81.7	
Cross-validated	Count	Foddered	39	16	55
		Fresh	13	58	71
	%	Foddered	70.9	29.1	
		Fresh	18.3	81.7	
Overall, 77.8% of samples correctly reclassified into their original dietary groups; 77% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.4: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: dried fodder and fresh graze/browse.

	Function
Feature orientation	-.666
Scratch count	.586
Scratch length	.292

Table 4.5: Table showing the correlations between discriminating variables and the discriminant function extracted in the discriminant analysis using two dietary groups: fresh browse and dried leafy hay.

		Actual Dietary Groups	Predicted Group Membership		Total
			Browse	Leafy Hay	
Pre-validation	Count	Browse	8	0	8
		Leafy Hay	3	10	13
Cross-validated	Count	Browse	7	1	8
		Leafy Hay	3	10	13
Overall, 85.7% of samples correctly reclassified into their original dietary groups; 81% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.6: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: fresh browse and dried leafy hay.

	Function
Total feature count	.749
Presence of surface porosity	.612
Presence of deep features	.562
Presence of features with rounded edges	-.401
Presence of areas of enamel with no features	-.401
Presence of parallel striations	.274

Table 4.7: Table showing the correlations between discriminating variables and the discriminant function extracted in the discriminant analysis using two dietary groups: dried grassy hay and fresh graze.

		Actual Dietary Groups	Predicted Group Membership		Total
			Grassy Hay	Graze	
Pre-validation	Count	Grassy Hay	16	4	20
		Graze	9	54	63
	%	Grassy Hay	80.0	20.0	
		Graze	14.3	85.7	
Cross-validated	Count	Grassy Hay	14	6	20
		Graze	10	53	63
	%	Grassy Hay	70.0	30.0	
		Graze	15.9	84.1	
Overall, 84.3% of samples correctly reclassified into their original dietary groups; 80.7% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.8: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: dried grassy hay and fresh graze.

	Function
Presence of polished surface	.957
Feature length	.234

Table 4.9: Table showing the correlations between discriminating variables and the discriminant function extracted in the discriminant analysis using two dietary groups: fresh graze and fresh browse.

		Actual Dietary Groups	Predicted Group Membership		Total
			Grazer	Browser	
Pre-validation	Count	Grazer	51	12	63
		Browser	1	7	8
Cross-validated	Count	Grazer	51	12	63
		Browser	1	7	8
Overall, 81.7% of samples correctly reclassified into their original dietary groups; 81.7% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.10: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: fresh graze and fresh browse.

	Function
Feature length:width ratio	.780
Percentage of scratches	-.615
Presence of uneven surfaces	-.503
Presence of features with anterior-posterior orientation	-.483

Table 4.11: Table showing the correlations between discriminating variables and the discriminant function extracted in the discriminant analysis using two dietary groups: summer graze and winter graze.

		Actual Dietary Group	Predicted Group Membership		Total
			Summer graze	Winter graze	
Pre-validation	Count	Summer graze	22	6	28
		Winter graze	11	24	35
	%	Summer graze	78.6	21.4	
		Winter graze	31.4	68.6	
Cross-validated	Count	Summer graze	20	8	28
		Winter graze	11	24	35
	%	Summer graze	71.4	28.6	
		Winter graze	31.4	68.6	
Overall, 73% of samples correctly reclassified into their original dietary groups; 69.8% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.12: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: summer graze and winter graze.

	Function
Scratch count	.614
Presence of uneven surface	.562
Feature length	-.405
Presence of smooth surface	-.361
Feature length:width ratio	-.325

Table 4.13: Table showing the correlations between discriminating variables and the discriminant function extracted in the discriminant analysis using two dietary groups: high quality graze and low quality graze.

		Actual Dietary Group	Predicted Group Membership		Total
			High Quality	Low Quality	
Pre-validation	Count	High Quality	42	12	54
		Low Quality	2	7	9
	%	High Quality	77.8	22.2	
		Low Quality	22.2	77.8	
Cross-validated	Count	High Quality	40	14	54
		Low Quality	3	6	9
	%	High Quality	74.1	25.9	
		Low Quality	33.3	66.7	
Overall, 77.8% of samples correctly reclassified into their original dietary groups; 73% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.14: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: high quality graze and low quality graze.

	Function	
	1	2
Pit count	-.577	-.348
Scratch percentage	.508	.069
Feature length:width ratio	-.367	-.030
Presence of porous surfaces	-.308	-.155
Feature length	-.296	.085
Scratch width	.199	-.072
Presence of areas of enamel with no features	.048	.661
Presence of deep features	.223	-.396
Presence of non-parallel scratches	.003	.283
Presence of uneven surfaces	.200	-.210

Table 4.15: Table showing the correlations between discriminating variables and the two discriminant functions extracted in the discriminant analysis using three dietary groups: dried grassy hay, dried leafy hay and cereal fodder.

		Dietary Groups	Predicted Group Membership			Total
			Grassy Hay	Leafy Hay	Cereal	
Pre-validation	Count	Grassy Hay	13	4	3	20
		Leafy Hay	0	12	1	13
		Cereal	1	1	20	22
	%	Grassy Hay	65.0	20.0	15.0	
		Leafy Hay	.0	92.3	7.7	
		Cereal	4.5	4.5	90.9	
Cross-validated	Count	Grassy Hay	13	4	3	20
		Leafy Hay	4	8	1	13
		Cereal	2	2	18	22
	%	Grassy Hay	65.0	20.0	15.0	
		Leafy Hay	30.8	61.5	7.7	
		Cereal	9.1	9.1	81.8	
Overall, 81.8% of samples correctly reclassified into their original dietary groups; 70.9% of samples correctly reclassified into their original dietary groups after cross-validation.						

Table 4.16: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using three dietary groups: dried grassy hay, dried leafy hay and cereal fodder.

	Function
Presence of areas of enamel with no features	.410
Feature length:width ratio	-.302
Presence of non-parallel scratches	.200
Presence of parallel scratches	-.169

Table 4.17: Table showing the correlations between discriminating variables and the two discriminant functions extracted in the discriminant analysis using two dietary groups: dried grassy hay and dried leafy hay.

		Actual Dietary Groups	Predicted Group Membership		Total
			Grassy Hay	Leafy Hay	
Pre-validation	Count	Grassy Hay	18	2	20
		Leafy Hay	1	12	13
	%	Grassy Hay	90.0	10.0	
		Leafy Hay	7.7	92.3	
Cross-validated	Count	Grassy Hay	18	2	20
		Leafy Hay	1	12	13
	%	Grassy Hay	90.0	10.0	
		Leafy Hay	7.7	92.3	
Overall, 90.9% of samples correctly reclassified into their original dietary groups; 90.9% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.18: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: dried grassy hay and dried leafy hay.

	Function
Presence of deep features	.462
Presence of areas of enamel with no features	-.454
Scratch count	.336
Pit width	-.216
Scratch width	.164
Feature length:width ratio	-.160
Presence of smooth surfaces	.091

Table 4.19: Table showing the correlations between discriminating variables and the two discriminant functions extracted in the discriminant analysis using two dietary groups: dried grassy hay and cereal fodder.

		Actual Dietary Groups	Predicted Group Membership		Total
			Grassy Hay	Cereal	
Pre-validation	Count	Grassy Hay	16	4	20
		Cereal	2	20	22
	%	Grassy Hay	80.0	20.0	
		Cereal	9.1	90.9	
Cross-validated	Count	Grassy Hay	16	4	20
		Cereal	3	19	22
	%	Grassy Hay	80.0	20.0	
		Cereal	13.6	86.4	
Overall, 85.7% of samples correctly reclassified into their original dietary groups; 83.3% of samples correctly reclassified into their original dietary groups after cross-validation.					

Table 4.20: Reclassification of samples into their original dietary groups, before and after cross-validation, for the discriminant analysis using two dietary groups: dried grassy hay and cereal fodder.

CHAPTER 5 FIGURES AND TABLES

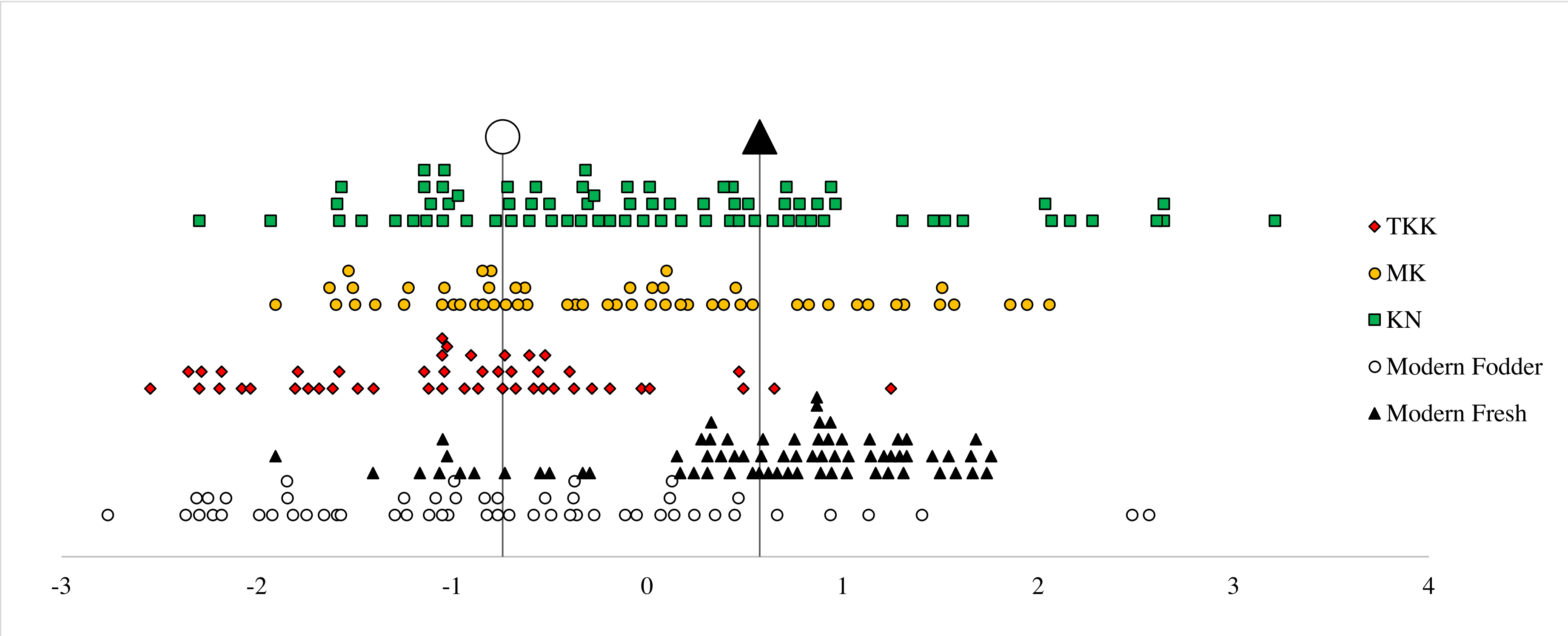


Figure 5.1: A plot of samples from TKK (red diamonds), MK (yellow circles), and KN (green squares) when compared to the discriminant analysis of two ethnographic dietary groups; dried fodder (clear circles including: cereal, grassy hay and leafy hay groups) and fresh diets (black triangles including: fresh browse and fresh graze groups) (large circle and triangle = central point of ethnographic groups (means of discriminant scores). *Outliers from the ethnographic fodder group (samples beyond the ethnographic fresh centroid) are from the ethnographic leafy hay group along with 1 grassy hay and 1 cereal sample.

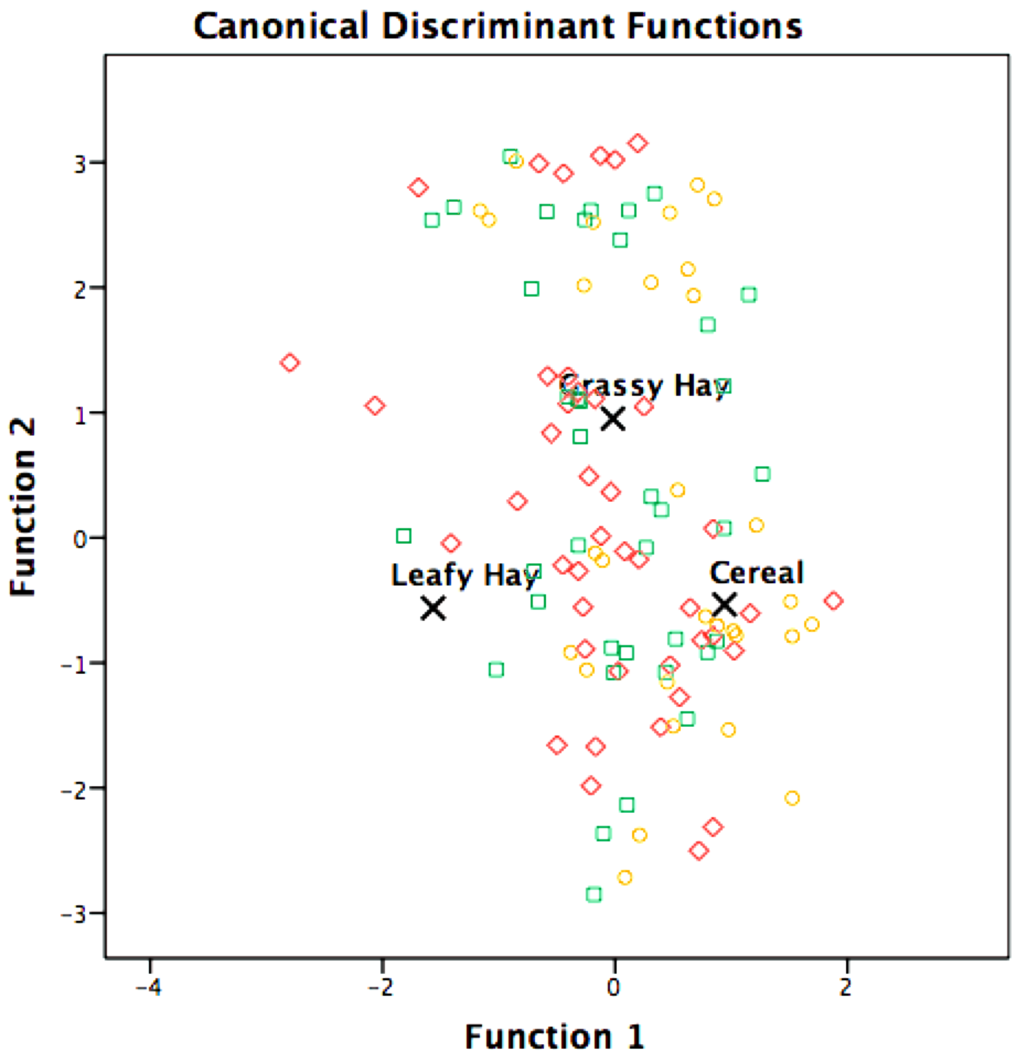


Figure 5.2: A plot of samples from TKK (red diamonds), MK (yellow circles), and KN (green squares), previously classified as fodder (Table 5.2), when compared to the discriminant analysis of three ethnographic dietary groups: grassy hay, leafy hay, and cereal (X = central point of ethnographic groups (means of discriminant scores)). (To see plots from ethnographic samples refer to Figure 4.8).

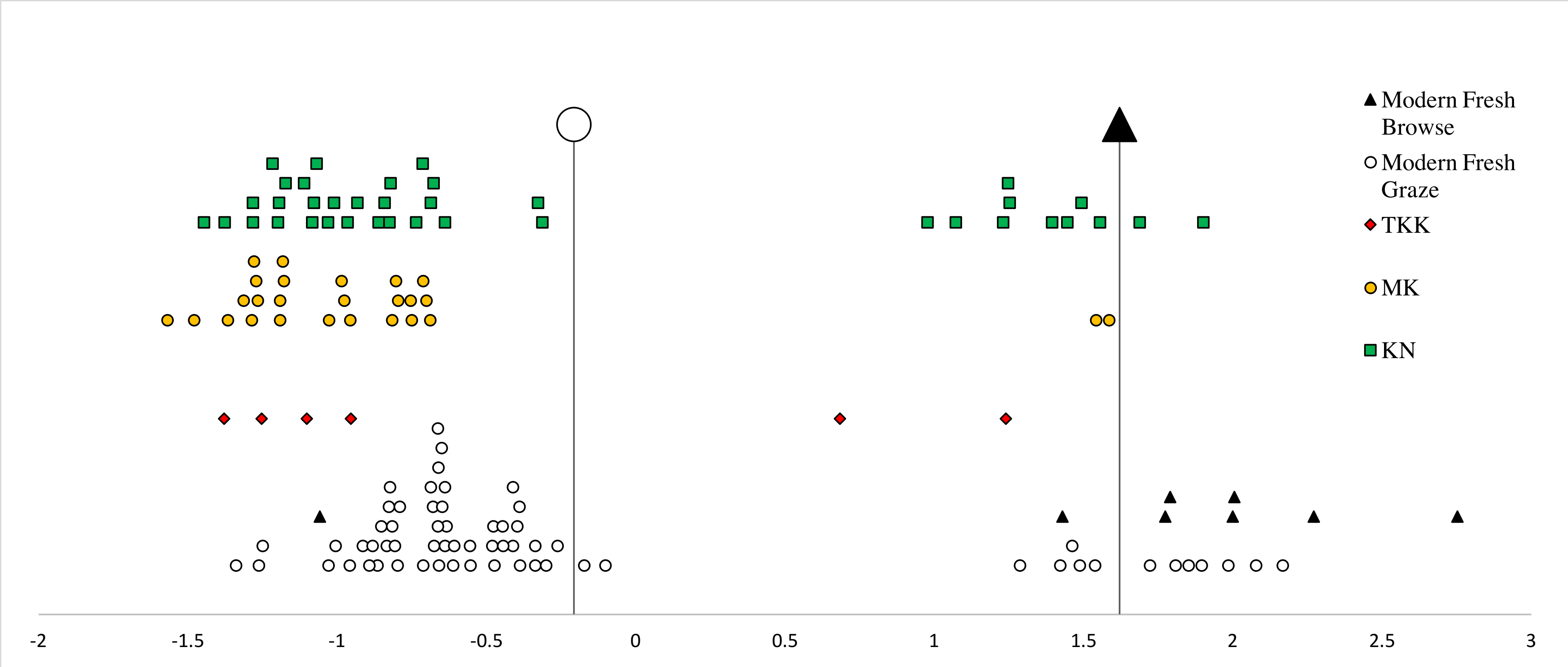


Figure 5.3: A plot of samples from TKK (red diamonds), MK (yellow circles), and KN (green squares) when compared to the discriminant analysis of two ethnographic dietary groups: fresh graze (clear circles) and fresh browse (black triangles) (large circle and triangle = central point of ethnographic groups (means of discriminant scores).

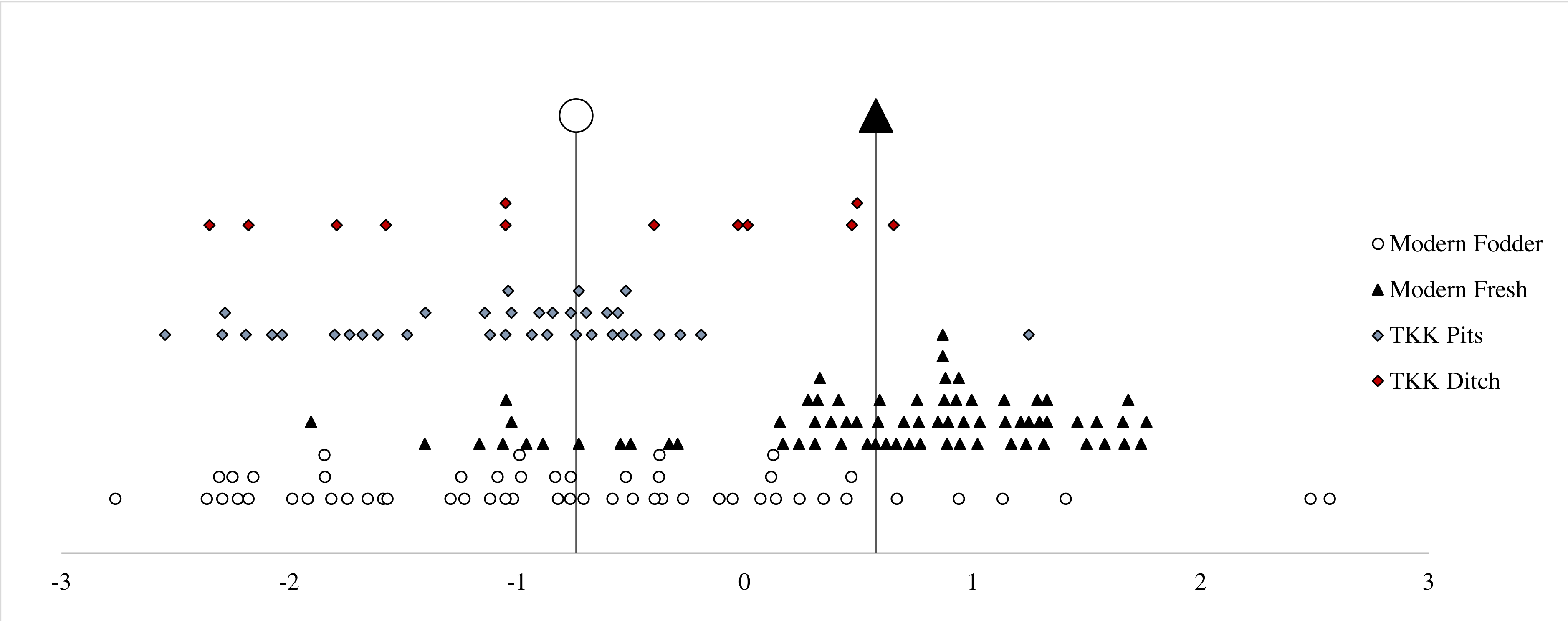


Figure 5.4: A plot of all TKK samples from pit and ditch contexts when compared to the discriminant analysis of two ethnographic dietary groups: dried fodder (clear circles including: cereal, grassy hay and leafy hay groups) and fresh diets (black triangles including: fresh browse and fresh graze groups) (large circle and triangle = central point of ethnographic groups (means of discriminant scores).

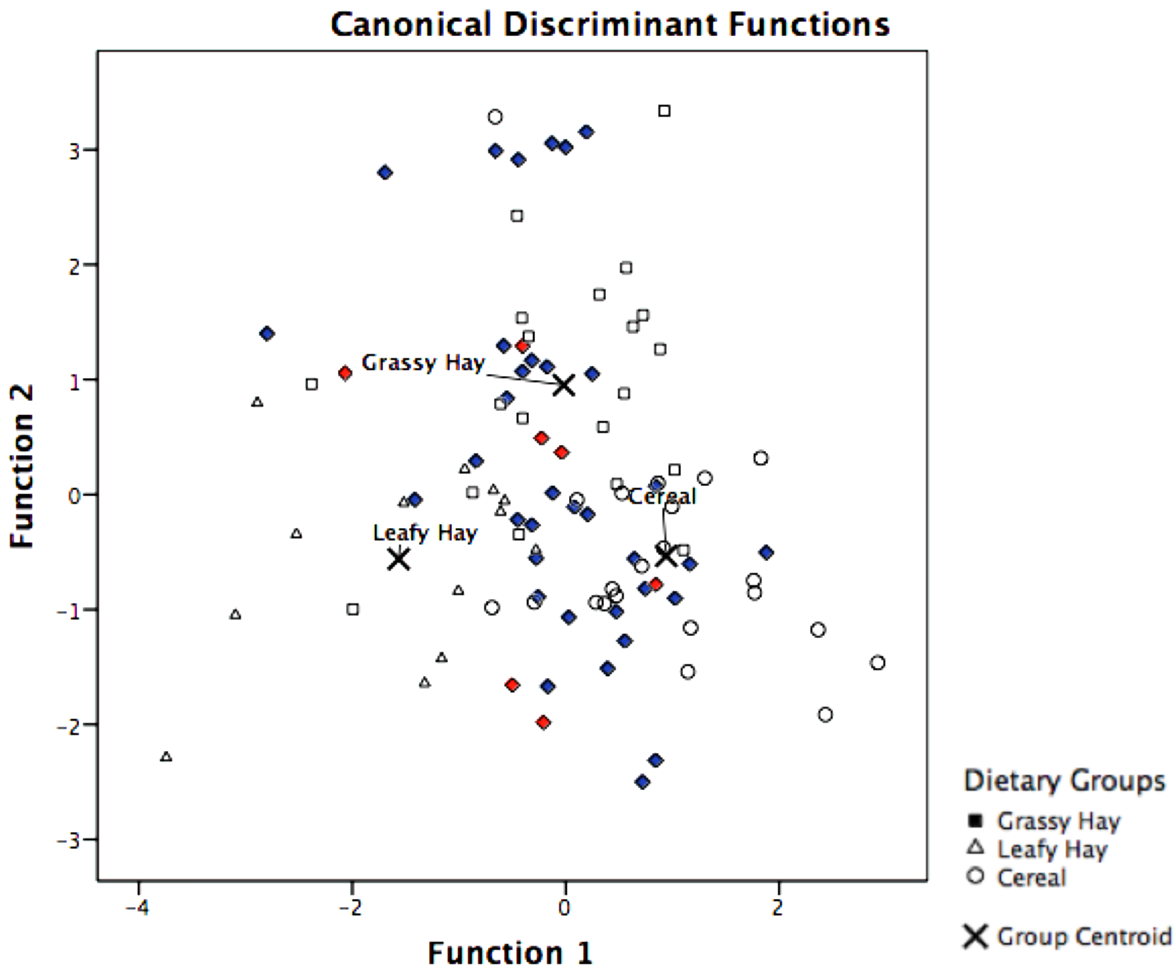


Figure 5.5: A plot of TKK samples from two contexts: pits (blue diamonds) and ditch (red diamonds) that were classified as fodder (Table 5.2), compared to the discriminant analysis of three ethnographic dietary groups: grassy hay, leafy hay and cereal fodder (**X** = central points of ethnographic groups).

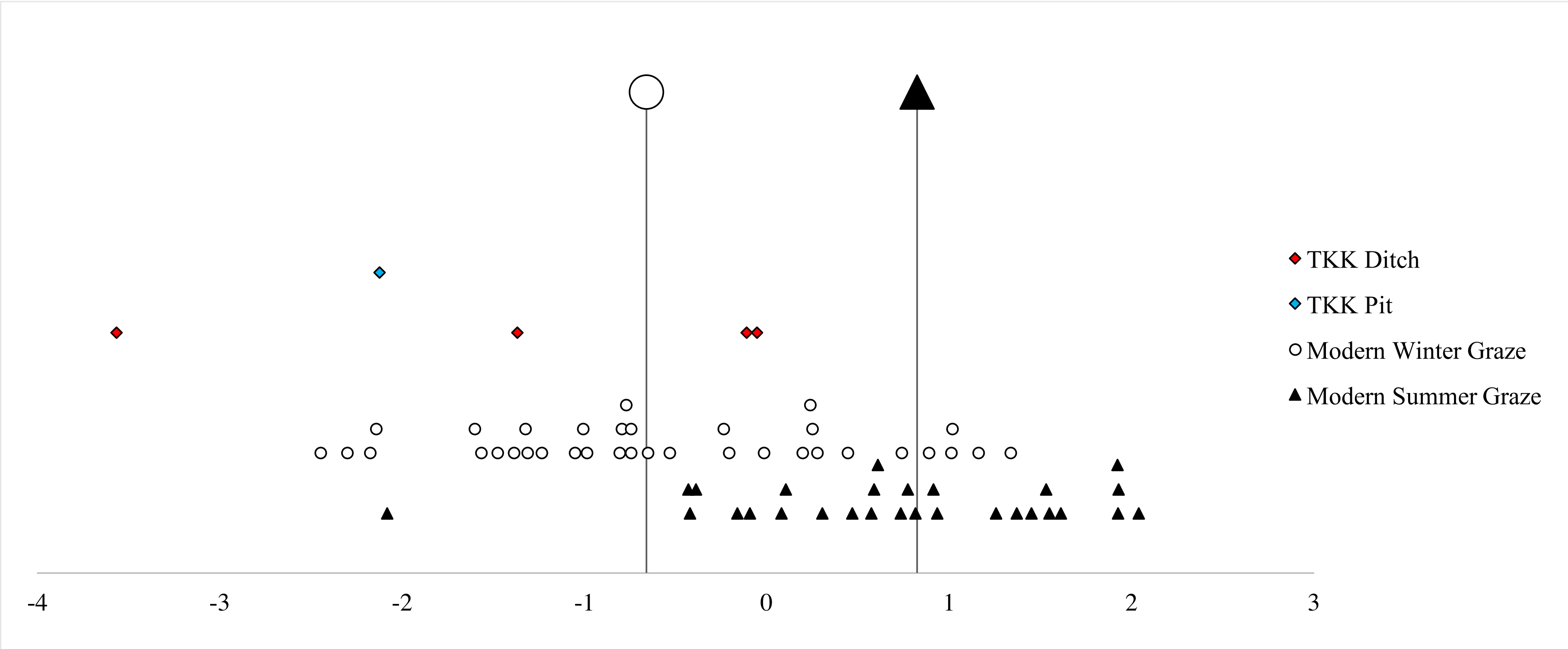


Figure 5.6: A plot of TKK samples from pit and ditch contexts that were classified as ‘graze’ (Table 5.4) compared to the discriminant analysis of two ethnographic dietary groups: winter graze and summer graze (large circle and triangle = central point of ethnographic groups).

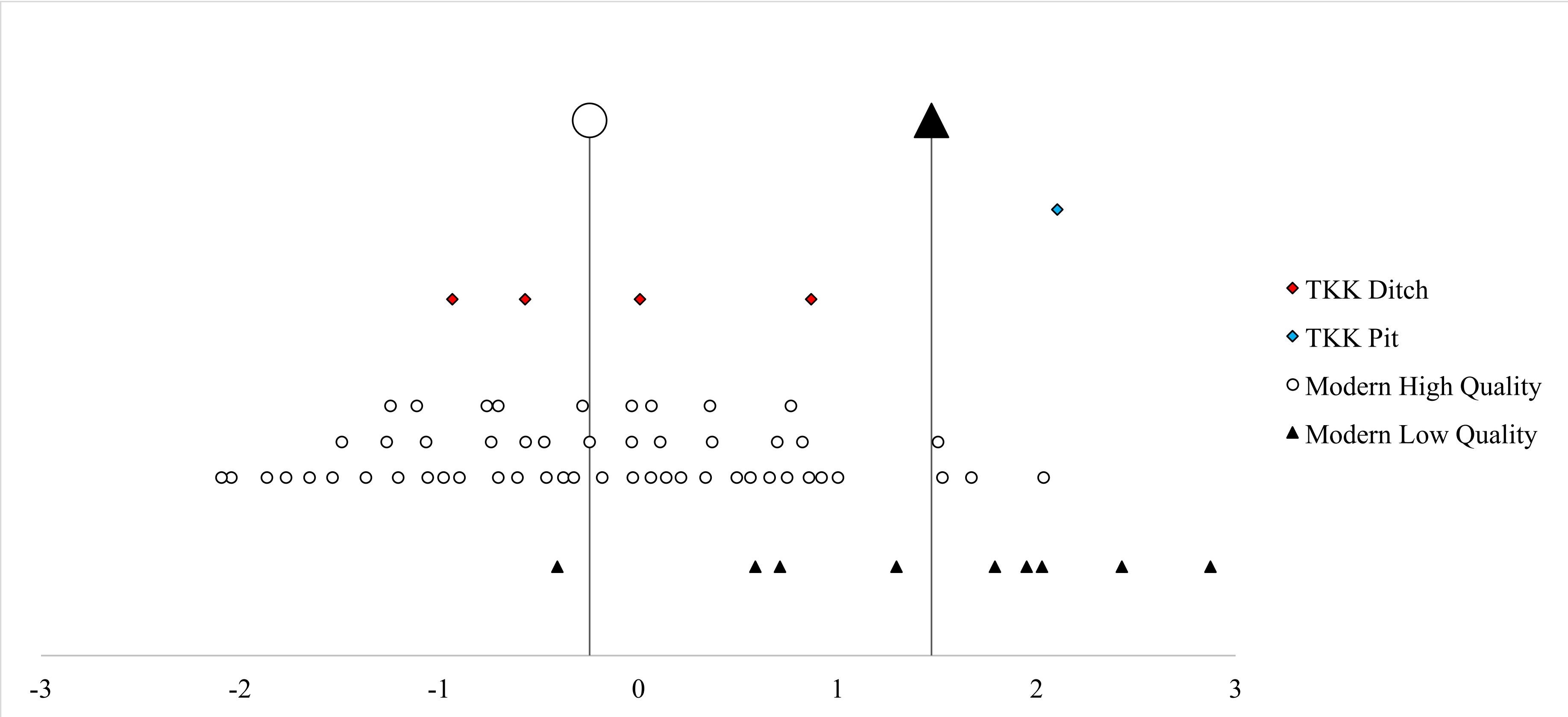


Figure 5.7: A plot of TKK samples from pit and ditch contexts that were classified as ‘graze’ (Table 5.4) compared to the discriminant analysis of two ethnographic dietary groups: high quality graze and low quality graze (large circle and triangle = central point of ethnographic groups).

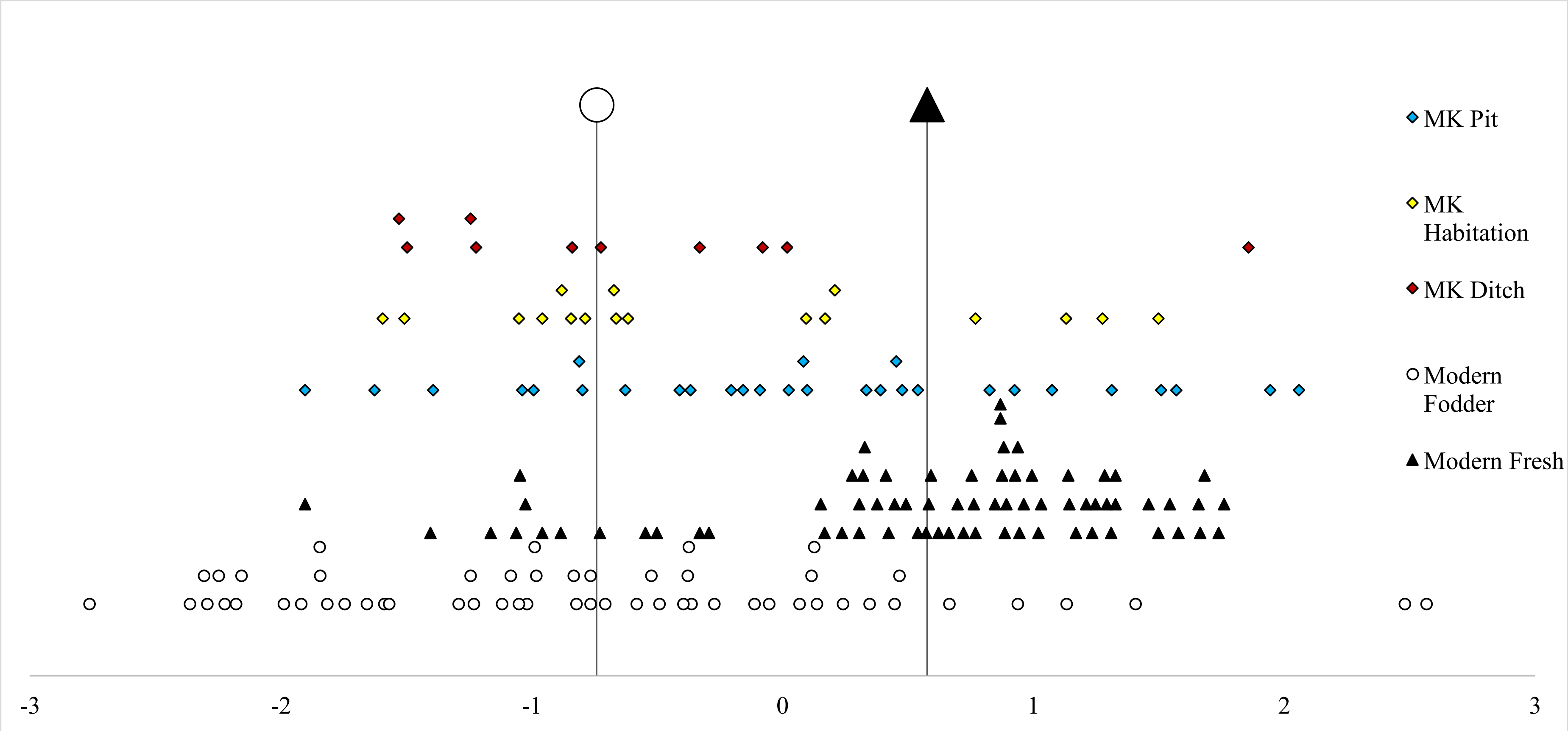


Figure 5.8: A plot of all MK samples from pit, habitation and ditch contexts when compared to the discriminant analysis of two ethnographic dietary groups: fodder (including: leafy hay, grassy hay and cereal) and fresh (including: browse and graze) (large circle and triangle = central point of ethnographic groups).

MK: exploring samples classified as “fodder”

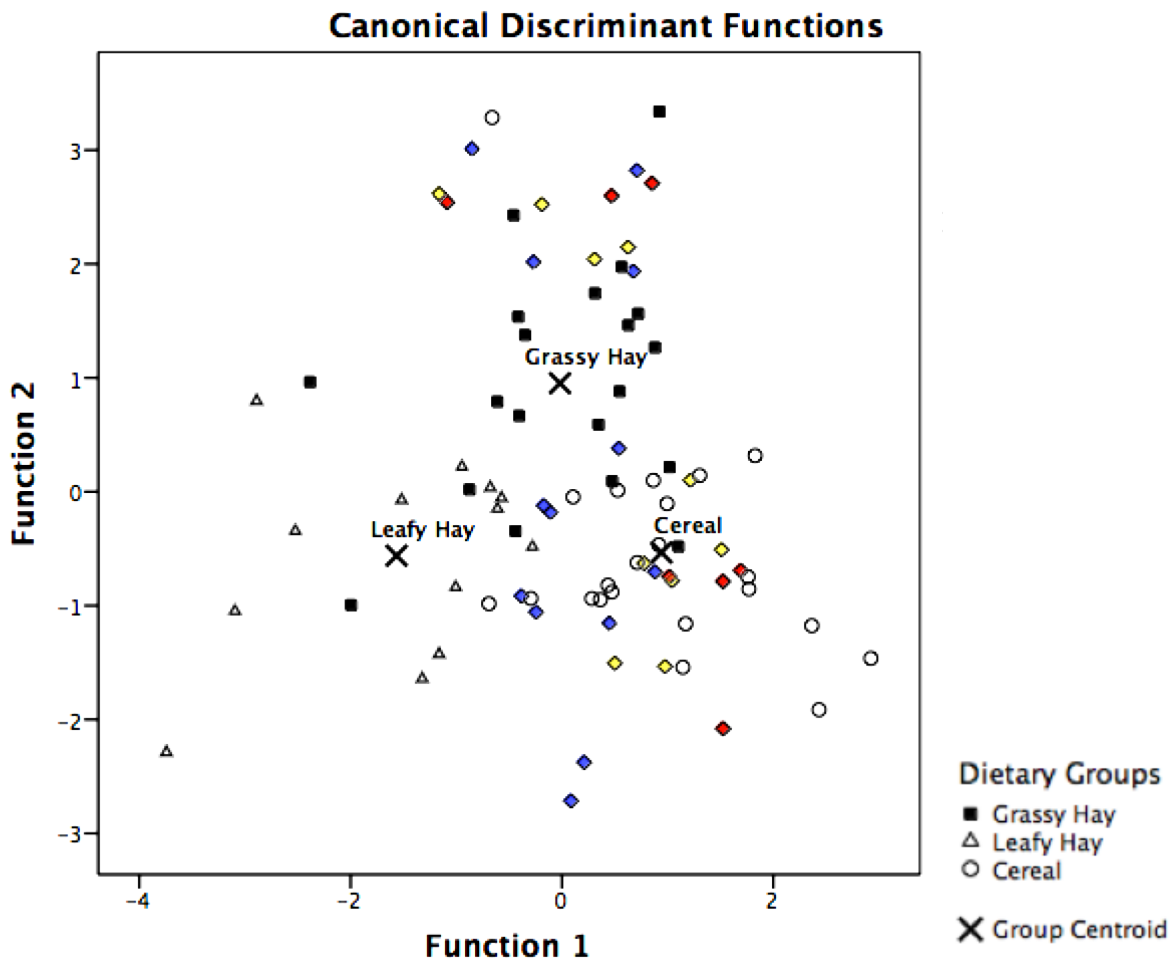


Figure 5.9: A plot of MK samples from three contexts; pits (blue diamonds), ditch (red diamonds), and habitation (yellow diamonds) that were classified as fodder (Table 5.2), compared to the discriminant analysis of three ethnographic dietary groups: grassy hay, leafy hay and cereal fodder (**X** = central points of ethnographic groups).

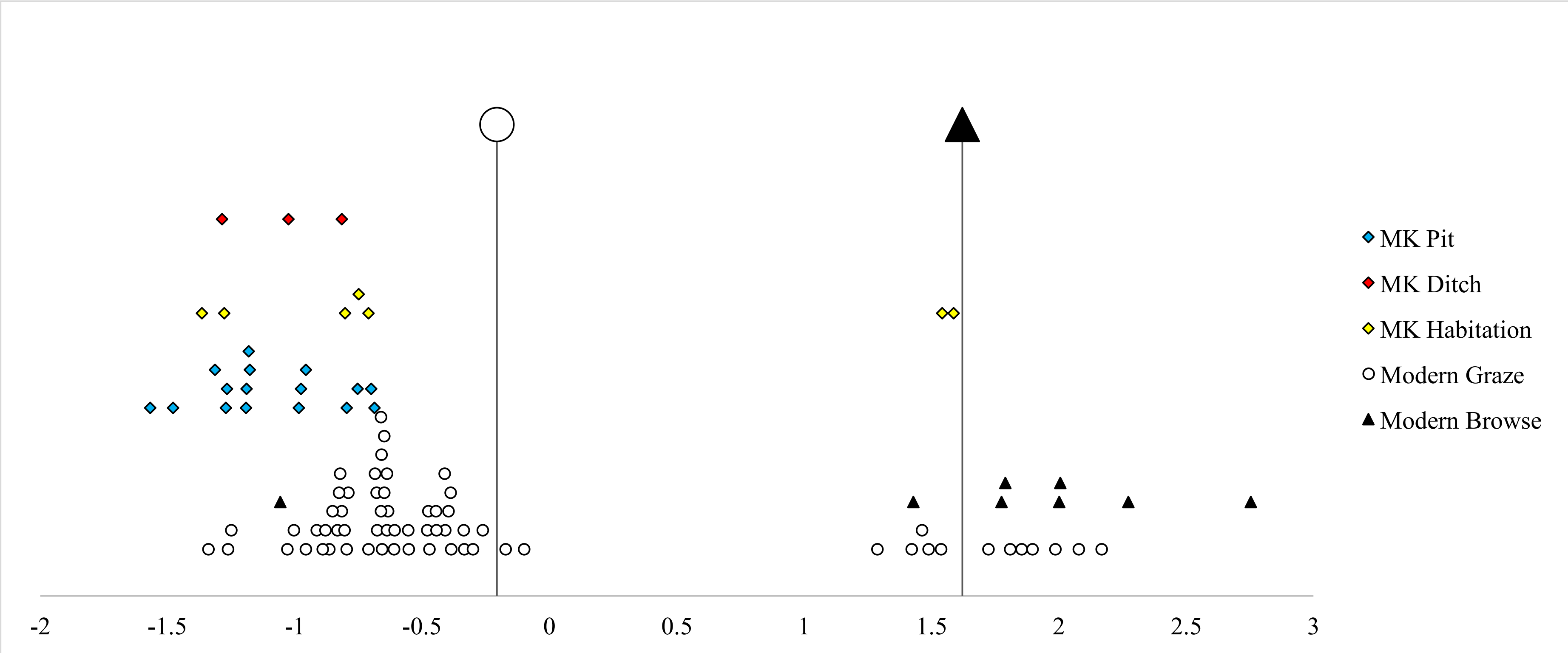


Figure 5.10: A plot of TKK samples from pit, ditch and habitation contexts that were classified as ‘fresh’ (Table 5.2) compared to the discriminant analysis of two ethnographic dietary groups: browse and graze (large circle and triangle = central point of ethnographic groups).

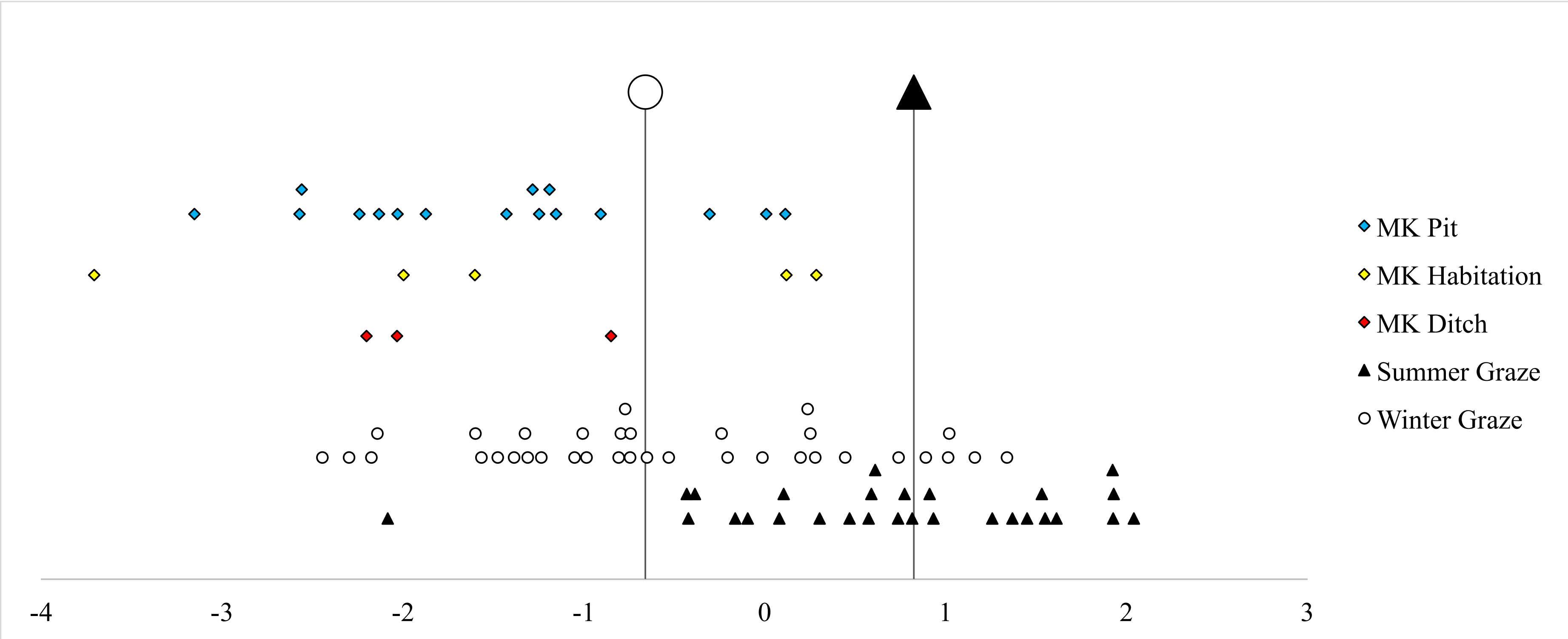


Figure 5.11: A plot of MK samples from pit and ditch contexts that were classified as graze (Table 5.18) compared to the discriminant analysis of two ethnographic dietary groups: winter graze and summer graze (large circle and triangle = central point of ethnographic groups).

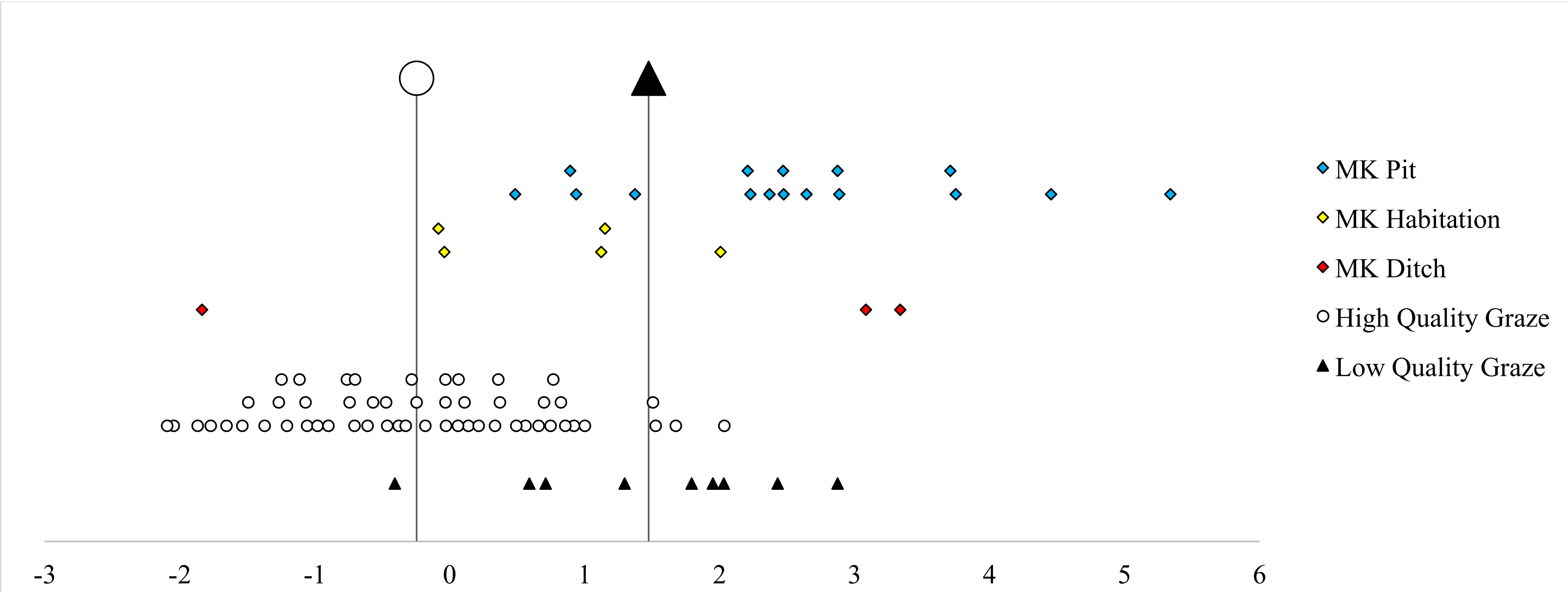


Figure 5.12: A plot of MK samples from pit and ditch contexts that were classified as ‘graze’ (Table 5.19) compared to the discriminant analysis of two ethnographic dietary groups: high quality graze and low quality graze (large circle and triangle = central point of ethnographic groups).

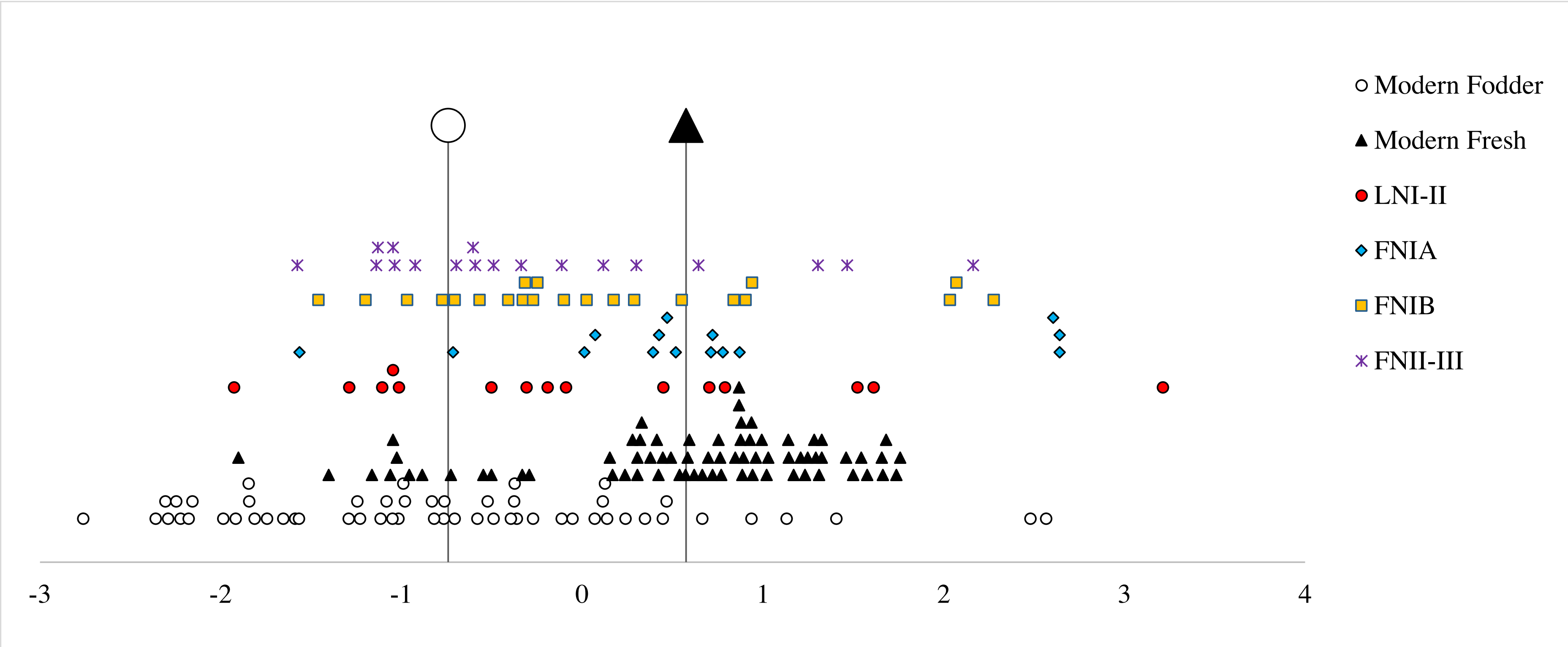


Figure 5.13: A plot of all KN samples four time periods; LNI-II, FNIA, FNIB and FNII-III when compared to the discriminant analysis of two ethnographic dietary groups: fodder (including leafy hay, grassy hay and cereal) and fresh (including browse and graze) (large circle and triangle = central point of ethnographic groups).

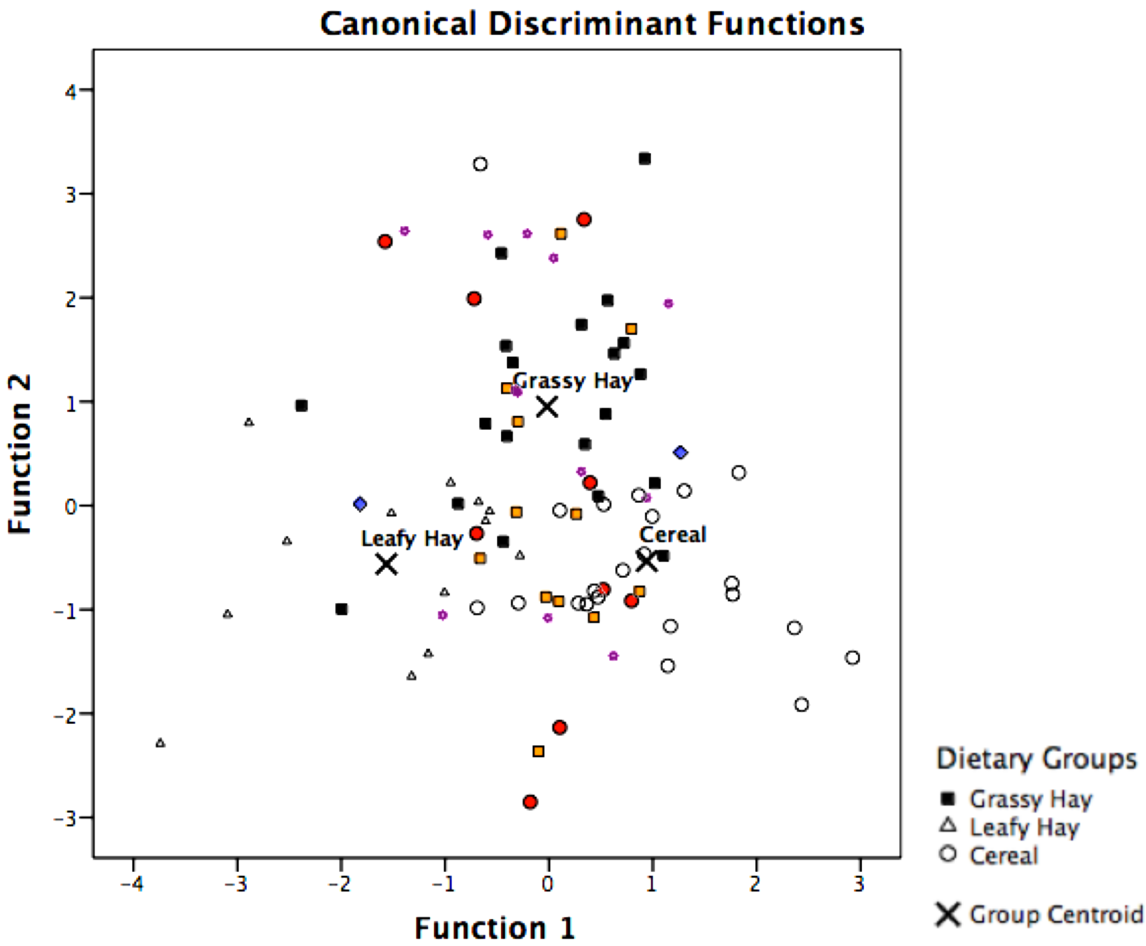


Figure 5.14: A plot of all KN samples from four time periods; LNI-II (red circles), FNIA (blue diamonds), FNIB (orange squares), and FNII-III (purple asterisks), previously classified as fodder (Table 5.22), when compared to the discriminant analysis of three ethnographic dietary groups: grassy hay, leafy hay, and cereal graze (**X** = central point of ethnographic groups (means of discriminant scores)).

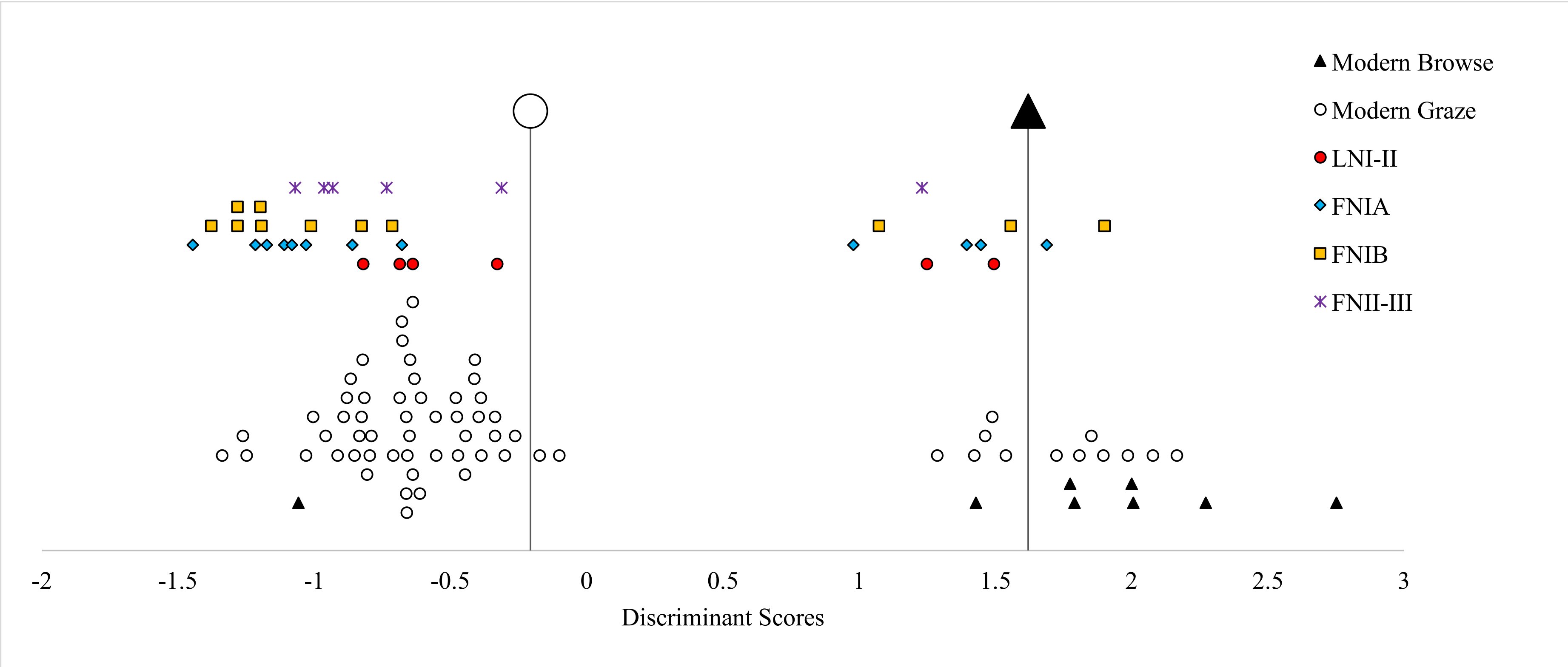


Figure 5.15: A plot of all KN samples four time periods; LNI-II, FNIA, FNIB and FNII-III that were classified as 'fresh' (Table 5.22) compared to the discriminant analysis of two ethnographic dietary groups: browse and graze (large circle and triangle = central point of ethnographic groups).

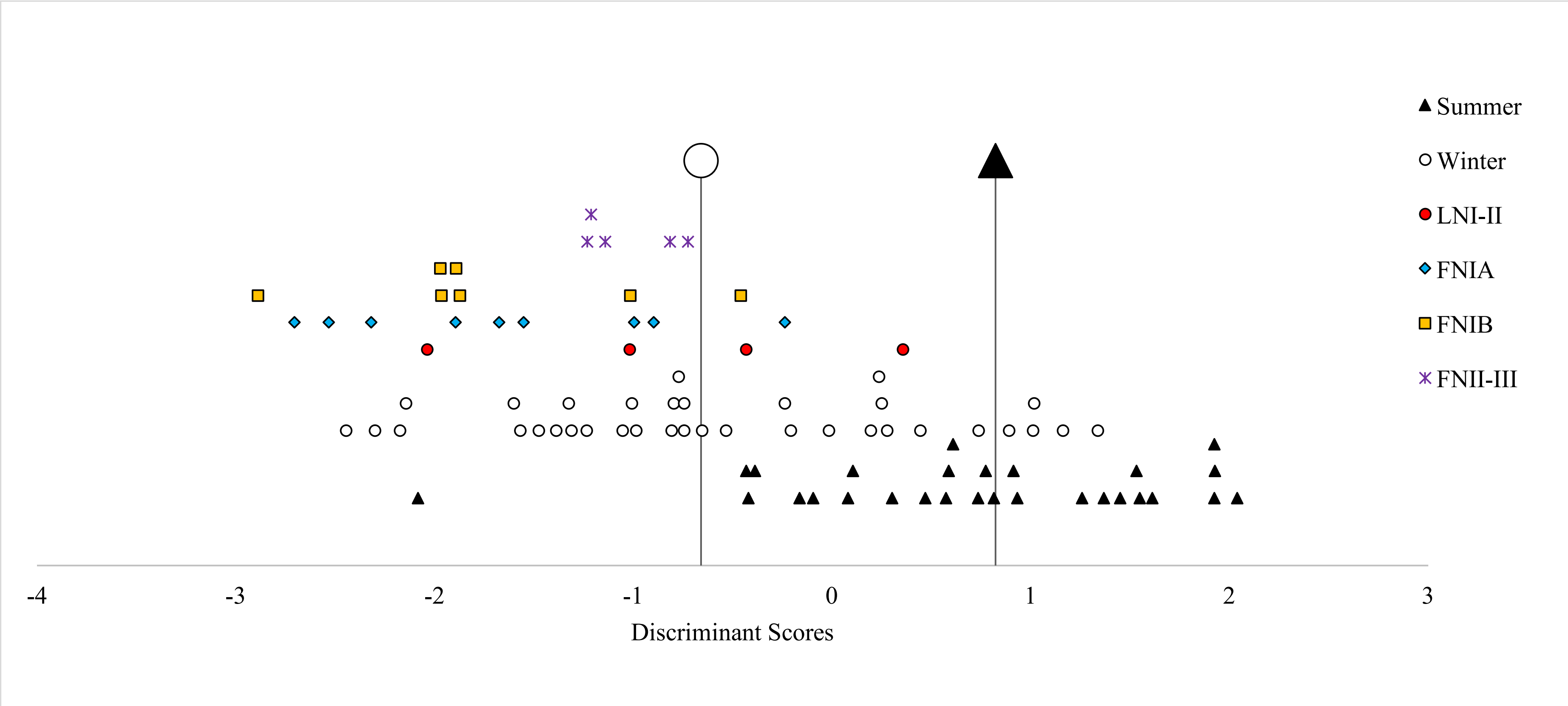


Figure 5.16: A plot of KN samples from four time periods; LNI-II, FNIA, FNIB and FNII-III, that were classified as 'graze' (Table 5.24) compared to the discriminant analysis of two ethnographic dietary groups: fresh summer graze and fresh winter graze (large circle and triangle = central point of ethnographic groups).

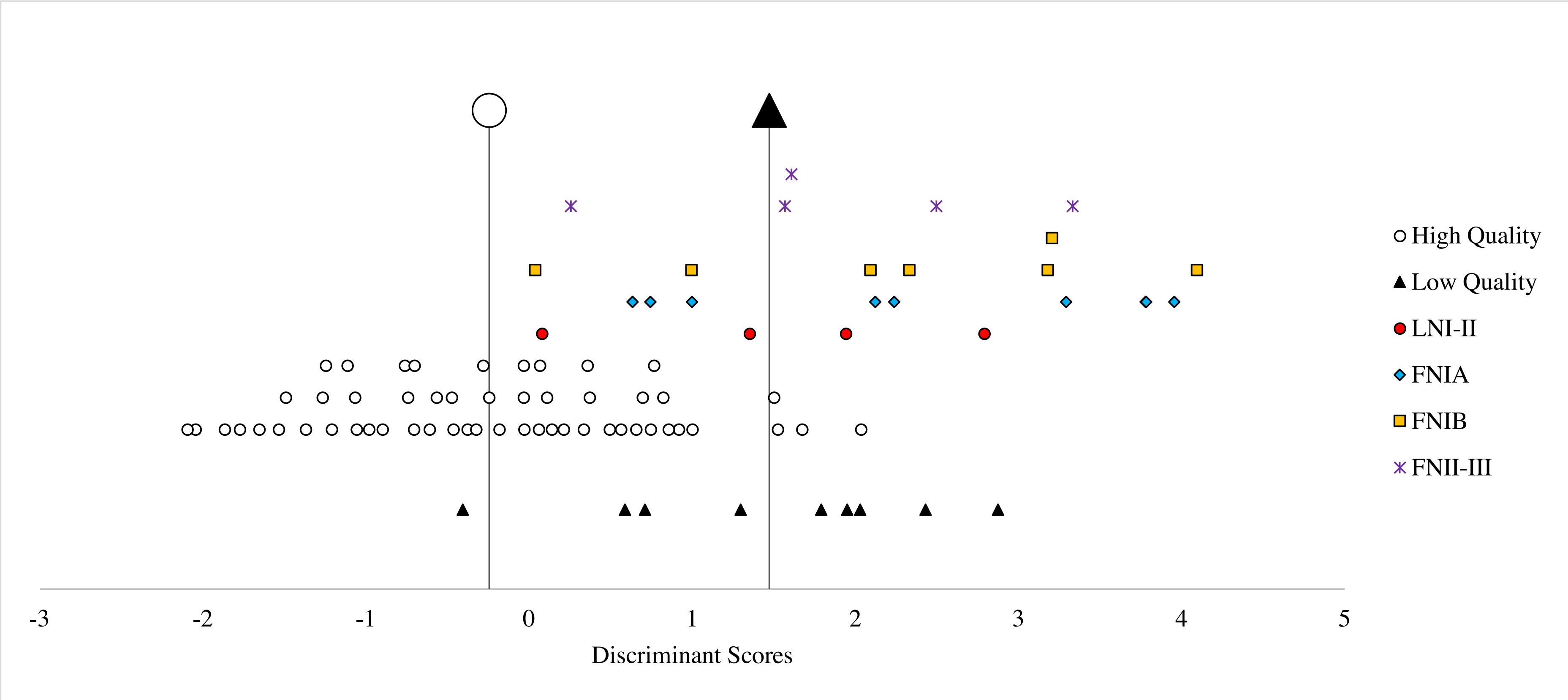


Figure 5.17: A plot of all KN samples four time periods: LNI-II, FNIA, FNIB and FNII-III that were classified as 'graze' (Table 5.24) compared to the discriminant analysis of two ethnographic dietary groups: high quality fresh graze and low quality fresh graze (large circle and triangle = central point of ethnographic groups).

Figure 5.18: Photograph of a mixed herd of sheep and goats grazing on stubble fields, to note the sheep feeding on weeds and fallen ears among the stubble (taken by author, Makriyalos, 2019).

Figure 5.20: photograph of the same herd of sheep and goats as shown in Figure 5.19, to note the goats straying to feed among the hedges and ruderal plants (taken by author, Makriyalos, 2019).

	Fresh Browse/Graze	Dried Fodder
TKK	**6** (12.5%)	**42** (87.5%)
MK	**26** (46%)	**30** (54%)
KN	**38** (50%)	**38** (50%)

Table 5.1: Table showing the classification results of samples from three archaeological sites TKK (n=48), MK (n=56) and KN (n=76) from the discriminant analysis presented in Figure 1. The cross-validated percentage of ethnographic samples correctly re-classified is 77% (for full ethnographic results see Table 4.4).

	Grassy Hay	Leafy Hay	Cereal
TKK	**18** (43%)	**5** (12%)	**19** (45%)
MK	**13** (43.3%)	**1** (3.3%)	**16** (53.3%)
KN	**20** (53%)	**4** (10.5%)	**14** (37%)

Table 5.2: Table showing the classification results of samples from three archaeological sites TKK (n=42), MK (n=30) and KN (n=38) from the discriminant analysis presented in Figure 5.2. The cross-validated percentage of ethnographic samples correctly re-classified is 71% (for full ethnographic results see Table 4.16).

	Fresh Browse	Fresh Graze
TKK	1	5
MK	**2** (8%)	**24** (92%)
KN	**11** (29%)	**27** (71%)

Table 5.3: Table showing the classification results of samples from three archaeological sites TKK (n=6), MK (n=26) and KN (n=38) from the discriminant analysis presented in Figure 5.3. The cross-validated percentage of ethnographic samples correctly re-classified is 82% (for full ethnographic results see Table 4.10).

	Fresh	Fodder
Pit	1	35
Ditch	5	7

Table 5.4: Table showing the classification results of TKK samples from two contexts; pit (n=36) and ditch (n=12), from the discriminant analysis presented in Figure 5.4. The cross-validated percentage of ethnographic samples correctly re-classified is 77% (for full ethnographic results see Table 4.4).

		Fresh	Fodder
Pit	Sheep	1	25
	Goat	0	10

Table 5.5: Table showing the number of sheep and goat samples from pit and ditch contexts classified as fresh or fodder from the results in Table 5.4.

	Grassy Hay	Leafy Hay	Cereal
Pit	15	3	17
Ditch	3	2	2

Table 5.6: Table showing the classification results of TKK samples (classified as 'fodder' in a previous analysis (Table 5.5)) from two contexts; pit (n=35) and ditch (n=7), from the discriminant analysis presented in Figure 5.5. The cross-validated percentage of ethnographic samples correctly re-classified is 71% (for full ethnographic results see Table 4.16).

		Grassy Hay	Leafy Hay	Cereal
Pit	Sheep	9	3	13
	Goat	6	0	4

Table 5.7: Table showing the number of sheep and goat samples from pit and ditch contexts classified as grassy hay, leafy hay or cereal fodder from the results in Table 5.6.

	Summer	Winter
Pits	0	1
Ditch	0	4

Table 5.8: Table showing the classification results of TKK sheep* (classified as ‘graze’ in a previous analysis (Table 5.3)) from two contexts; pit (n=1) and ditch (n=4), from the discriminant analysis presented in Figure 5.6. The cross-validated percentage of ethnographic samples correctly re-classified is 70% (for full ethnographic results see Table 4.12).

	High Quality	Low Quality
Pit	0	1
Ditch	4	0

Table 5.9: Table showing the number of TKK sheep* samples (classified as ‘graze’ in a previous analysis (Table 5.3)) from two contexts; pit and ditch, from the discriminant analysis presented in Figure 5.7. The cross-validated percentage of ethnographic samples correctly re-classified is 73% (for full ethnographic results see Table 4.12).

	Fresh	Fodder
Pit	16	13
Ditch	3	7
Habitation	7	10

Table 5.10: Table showing the classification results of MK samples from three contexts; pit (n=29), ditch (n=10), and habitation (n=17) from the discriminant analysis presented in Figure 5.8. The cross-validated percentage of ethnographic samples correctly re-classified is 82% (for full ethnographic results see Table 4.4).

		Fresh	Fodder
Pit	Sheep	14	11
	Goat	2	2

Table 5.11: Table showing the number of sheep and goat samples from pit, habitation and ditch contexts classified as fresh or fodder from the results in Table 5.10.

	Grassy hay	Leafy hay	Cereal
Pits	6	1	6
Ditch	3	0	4
Habitation	4	0	6

Table 5.12: Table showing the classification results of TKK samples (classified as fodder in a previous analysis (Table 5.10)) from three contexts; pit (n=13), ditch (n=10), and habitation (n=7) from the discriminant analysis presented in Figure 5.9 (the cross-validated percentage of ethnographic samples correctly re-classified is 71%, for full ethnographic results see Table 4.16).

	Browse	Graze
Pit	0	16
Ditch	0	3
Habitation	2	5

Table 5.13: Table showing the classification results of MK samples (classified as fresh in a previous analysis (Table 5.10)) from three contexts; pit (n=16), ditch (n=3), and habitation (n=7) from the discriminant analysis presented in Figure 5.10. The cross-validated percentage of ethnographic samples correctly re-classified is 82% (for full ethnographic results see Table 4.10).

	Summer	Winter
Pit	1	15
Ditch	0	3
Habitation	2	3

Table 5.14: Table showing the classification results of MK samples (classified as fresh graze in a previous analysis (Table 5.13)) from three contexts; pit (n=16), ditch (n=5), and habitation (n=3) from the discriminant analysis presented in Figure 5.11. The cross-validated percentage of ethnographic samples correctly re-classified is 70% (for full ethnographic results see Table 4.12).

	High Quality	Low Quality
Pit	1	15
Ditch	1	2
Habitation	2	3

Table 5.15: Table showing the classification results of MK samples (classified as fresh graze in a previous analysis (Table 5.13)) from three contexts; pit (n=16), ditch (n=3), and habitation (n=5) from the discriminant analysis presented in Figure 5.12. The cross-validated percentage of ethnographic samples correctly re-classified is 73% (for full ethnographic results see Table 4.12).

	Fresh	Fodder
LNI-II	6 (40%)	9 (60%)
FNIA	13 (87%)	2 (13%)
FNIB	10 (45%)	12 (55%)
FNII-III	6 (33%)	12 (67%)

Table 5.16: Table showing the classification results of KN samples from four time periods; LNI-II (n=15), FNIA (n=15), FNIB (n=22) and FNII-III (n=18) from the discriminant analysis presented in Figure 5.13. The cross-validated percentage of ethnographic samples correctly re-classified is 82% (for full ethnographic results see Table 4.4).

	Grassy hay	Leafy hay	Cereal
LNI-II	4	1	4
FNIA	0	1	1
FNIB	5	1	6
FNII-III	8	1	3

Table 5.17: Table showing the classification results of KN samples from four time periods; LNI-II (n=15), FNIA (n=15), FNIB (n=22) and FNII-III (n=18) (classified as fodder in a previous analysis (Table 5.16)) from the discriminant analysis presented in Figure 5.14. The cross-validated percentage of ethnographic samples correctly re-classified is 71% (for full ethnographic results see Table 4.16).

	Browse	Graze
LNI-II	2	4
FNIA	4	9
FNIB	3	7
FNII-III	1	5

Table 5.18: Table showing the classification results of KN samples (classified as ‘fresh’ in a previous analysis (Table 5.16)) from four time periods; LNI-II (n=6), FNIA (n=13), FNIB (n=10) and FNII-III (n=6) from the discriminant analysis presented in Figure 5.15. The cross-validated percentage of ethnographic samples correctly re-classified is 82% (for full ethnographic results see Table 4.10).

	Summer	Winter
LNI-II	1	3
FNIA	0	9
FNIB	0	7
FNII-III	0	5

Table 5.19: Table showing the classification results of KN samples (classified as ‘graze’ (Table 5.18) in a previous analysis from four time periods; LNI-II (n=4), FNIA (n=9), FNIB (n=7) and FNII-III (n=5) from the discriminant analysis presented in Figure 5.16. The cross-validated percentage of ethnographic samples correctly re-classified is 70% (for full ethnographic results see Table 4.12).

	High Quality	Low Quality
LNI-II	1	3
FNIA	0	9
FNIB	1	6
FNII-III	1	4

Table 5.20: Table showing the classification results of KN samples (classified as 'graze' (Table 5.18) in a previous analysis from four time periods; LNI-II (n=4), FNIA (n=9), FNIB (n=7) and FNII-III (n=5) from the discriminant analysis presented in Figure 5.17. The cross-validated percentage of ethnographic samples correctly re-classified is 73% (for full ethnographic results see Table 4.12).