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The predictive value of dental microwear in the assessment of caprine diet

THE PREDICTIVE VALUE OF DENTAL MICROWEAR IN THE ASSESSMENT OF CAPRINE DIET

Ingrid Beuls[1,2], Leo Vanhecke[3], Bea De Cupere[4], Marleen Vermoere[5], Wim Van Neer[4,1], Marc Waelkens[1]

Abstract

Over the last decades, much progress has ben achieved in the field of dietary reconstructional studies, not least in the use of the analysis of microscopic defects or microwear present on tooth surfaces. This technique is comparative in nature in that it is based on the characterisation (qualitative and/or quantitative) of the microwear patterns found in recent animals with known diets to infer data on the diet of archaeological animals. In 1996, based on previous archaeozoological findings in the classical city of Sagalassos (Burdur Province, Turkey), an experimental study was set up to gain a more detailed insight in the former use and management of caprines. Dental microwear studies were used to detect patterns in the dietary intake of the modern caprines but a secondary aim was to discover the resolution boundaries of the technique. In June '96, February and August '97, and May and August '98, herds of sheep and goats were observed and the dietary intake of selected animals noted. The resulting microwear patterns present on a shearing facet of the right mandibular first molar were analysed qualitatively. Results of this analysis are presented and the implications for the analysis of archaeological teeth are discussed.

Résumé

Depuis les dernières decennies, les études dans le domaine de la reconstitution de la diète ont beaucoup progressé et pas dans les moindre en utilisant les analyses des défauts microscopiques ou encore la micro-usure présent sur la surface des dents. Cette technique est comparative car elle est fondée sur la caractérisation (qualitative et/ou quantitative) des schémas de la micro-usure chez les animaux actuels avec une alimentation connue, en vue d'une application sur les animaux archéologiques. En 1996, une étude expérimentale a été mise au point sur la base des vestiges archéozoologiques récoltés auparavant dans la cté classique de Sagalassos (Burdur Province, Turkey), afin d'acquérir connaissance plus détaillée des modes d'exploitation et de gestion des caprinés. Les micro-usures dentaires ont été utilisées pour détecter les schémas de consommation des caprinés modernes, mais le second but de ce travail était de mettre en évidence les limites de la technique. En Juin 1996, février et août 1997 et mai et août 1998 des troupeaux de moutons et de chèvre ont été observé et la consommation d'animaux séléctionnés enregistré. Les schémas des micro-usures résultant de cette consommation ont ensuite été analysé qualitativement sur une surface de friction de la première molaire inférieure droite. Le résultat des analyses est présentée ici et les implications pour l'étude des dents archéozoologiques sont discutées.

Keywords: Dietary reconstruction, Caprines, Dental microwear, Qualitative

Mots Clés: Reconstitution de la diète, Caprinés, Micro-usure dentaire, Qualitative

Introduction

Faunal assemblages in the Near East, from the Neolithic onwards, usually comprise large numbers of sheep and goat remains. This is also the case at Sagalassos, a Roman-Byzantine city situated about 7 km north of the small village of Ağlasun in the Province of Burdur (Turkey). From the onset of excavations in 1990 about 300,000 bones were examined. A preponderance of caprine material (41.4 % of the total number of identified bones) was observed (De Cupere, 2001).

The importance of these caprines in the subsistence of villages and cities poses the question of their management and use in those settlements. A possible way to approach this type of problem is to try to determine the dietary pattern of the animals through a study of dental microwear. Dietary patterns tell a lot about feeding habits, and consequently also on the management of the animals. Thanks to their structure and durability, teeth represent about 14% of the total caprine material identified in Sagalassos (De Cupere, 2001). Dental microwear has been used extensively over the past decades in the study of dietary or even non-dietary marks on occlusal and non-occlusal surfaces of teeth of various species

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(e.g. Walker *et al*. 1978; Teaford and Walker 1984; Van Valkenburgh *et al*. 1990; Puech 1992; Solounias *et al*. 1988; Solounias and Moelleken 1992; Lalueza-Fox and Frayer 1997; King *et al*. 1999; Pérez-Pérez *et al*. 1999). The use of microwear as a dietary marker on teeth of domestic animals however, has been very limited. Mainland (1994, 1995a, 1995b, 1998a, 1998b), using quantitative and qualitative analytical techniques, managed to demonstrate a distinction between fodder-fed and naturally grazing domestic sheep. These animals were grazing on pastures in a temperate climatic zone. The present study differs in approach from this previous work in that sheep and goats were kept under extensive management in a Mediterranean semi-arid environment. In dental microwear studies there has been an emphasis on the use of quantitative techniques to detect the relationship between the microwear and diet. Mainland (1994, 1995a, 1995b) however, has shown the possible usefulness of combining the quantitative and qualitative approaches. In this study, the results of the qualitative analysis of the dental microwear will be presented. A preliminary qualitative analysis using the data from June 1996, February 1997, and August 1997 was already conducted (Beuls 2000a). This study showed a difference between individuals grazing in winter or summer and between sheep and goats. The former data were integrated with the data from 1998 and reanalysed. The results of the quantitative analyses will be presented in a forthcoming article.

Sagalassos and its natural environment: past and present

The ultimate goal of the dental microwear research is to transpose the data recorded on modern reference material to the archaeological material excavated on site. These observations would be irrelevant if the plant species grazed upon today by the caprines would be noncomparable to ones present during the archaeological period under study (1st century BC-AD 7th century). The 'Sagalassos Archaelogical Research Project' tries to reconstruct in as much detail as possible the natural environment in the territory of the city. In this article, the ‘territory’ of the city implies an area of about 1800 km^2, defined by the borders during the heyday of the city. The city proper is situated at an altitude of 1490 m above sea level (a.s.l.) to 1600 m a.s.l. on an undulating platform of limestone and ophiolites in the Turkish Taurus mountain chain.

The palynological analysis of three sediment cores extracted from wetlands in the vicinity of Sagalassos (Gravgaz and Çanaklı) yielded pollen diagrams which could be divided into several pollen assemblage zones (Vermoere *et al*. 2000a; Vermoere *et al*. submitted). One of these zones roughly coincides with a cultivation phase (~410-240 BC til AD 660-770) comprising the Roman-Early Byzantine period. A number of primary (e.g. *Olea europaea*, *Juglans regia*, *Fraxinus ornus*) and secondary anthropogenic indicators (e.g. *Polygonum aviculare*, *Centaurea solstitialis*) are well represented. The species shown in the pollen assemblages indicate a number of plant species still commonly present today, e.g. evergreen oak species (*Quercus coccifera* type), *Juniperus*, non-cultivated grasses, *Sanguisorba minor*, *Plantago lanceolata* etc.. (Vermoere *et al*. 2000a; Vermoere *et al*. submitted). The grazed vegetation and flora presented here probably very well reflects the vegetation and flora of the Roman-Byzantine period. Climatological and orohydrographical limitations still dominate the composition and structure of the vegetation. No major changes in those factors have taken place since this historic period. The grazed vegetation is not or only marginally suitable for farming purposes. The use of these lands for sheep and goat herding, as well as the farming on the arable fields, is still very traditional.

Material and Methods

Characteristics of the caprine herds and their grazing area

Extensively managed herds of sheep (*Ovis ammon* f. aries) and goat (*Capra hircus* f. aegagrus) were observed in a standardized manner during three consecutive years (1996, 1997 and 1998) covering 3 seasons (winter, spring and summer). A detailed description of the observation methods and a description of the study areas in June 1996 and February 1997 is given in Beuls *et al*. (2000a). Detailed data on the animals observed and their consumption habits expressed as the percentage time spent on each plant class relative to the total feeding time are presented in Tables 1-5. In the case of the plant classes ‘shrub and tree’, the animals mainly consumed the young shoots and leaves. The consumption of tree leaves proved to be negligible (Table 3-5) in comparison to the consumption of shrub leaves. In the statistical analyses, the variable of diet was always determined by the dietary class eaten most frequently. It was therefore decided to use the dietary class ‘leaves’ instead of ‘shrub and tree’ in the qualitative analyses of the dental microwear. The first time sheep were observed, August 1997, they were very approachable allowing us to record data for each individual animal selected. In contrast, in May and August 1998 the sheep proved to be too shy to be observed individually for an extended period of time. For those months, average time-consumption data were used in the analyses.

In August 1997, the vegetation analysis was conducted using quadrats with a surface of 100 m^2 set out randomly in the grazing area. The species composition, cover and abundance were determined in each quadrat (3 in the grazing area of goats, 3 in those of sheep) using the decimal scale of Londo (Londo 1984). In the last two observational periods (May 1998 and August 1998), a different approach was adopted using smaller circular quadrats (1 m^2) set out at random as well as selectively (in spots where animals had eaten). The species composition, cover and abundance in these spots were assessed using the Braun-Blanquet scale (Kent and Coker 1995). The relative position of the different grazing areas are indicated on the forest map of the region (Ağlasun Orman Işletme Şefliği 1997) (Fig. 1).

The climate today in the region can be characterized as being Mediterranean with mild wet winters and dry hot summers (Paulissen *et al*. 1993). In the immediate vicinity of Sagalassos the climate can be described in more detail as being Oro-Mediterranean (cold to very cold and humid to subhumid). The physically most comparable weather station for Sagalassos is located in Isparta at 1000 m a.s.l.

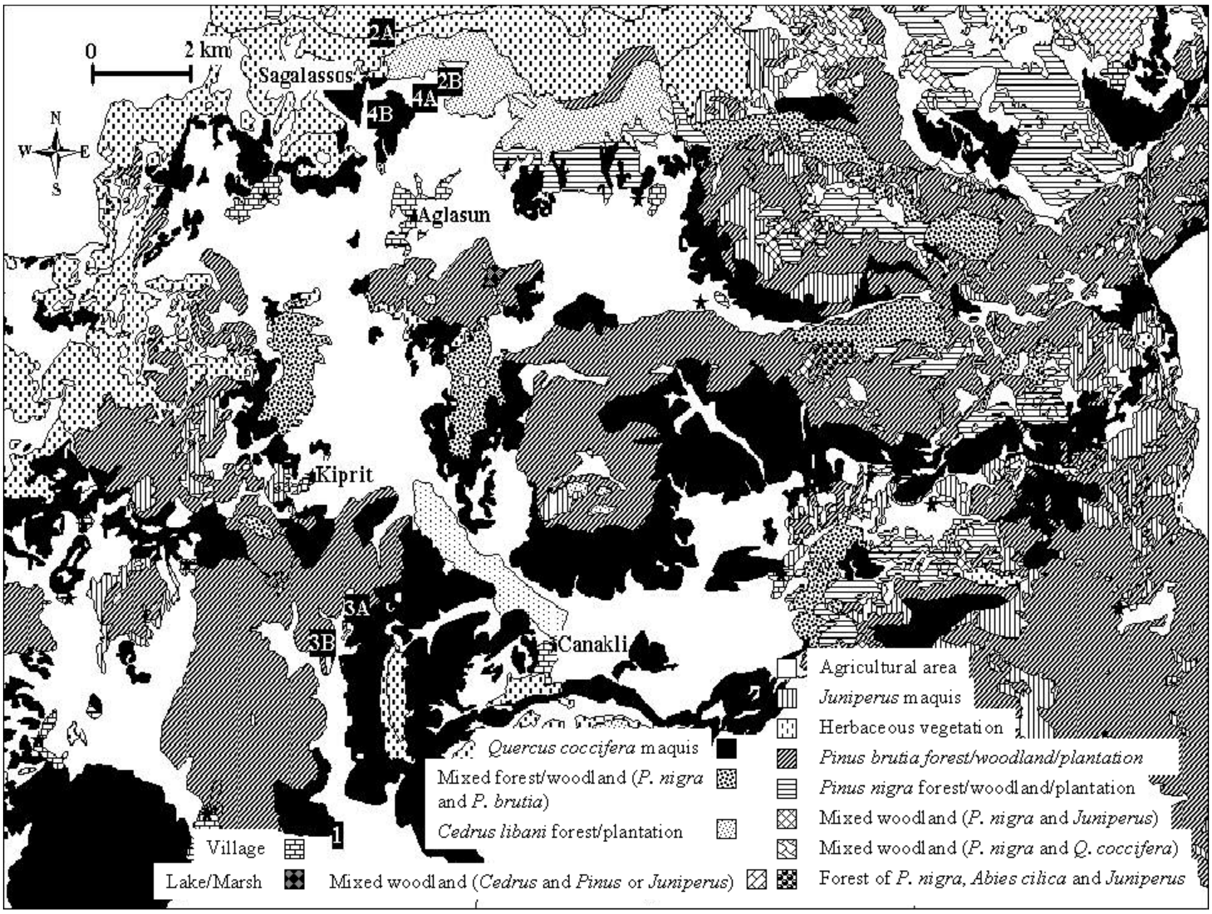

Fig. 1. Positioning of grazing areas on the forest map of the eastern territory of Sagalassos (1= grazing area of sheep and goats in June 1996, 2A= grazing area of sheep in August 1997, 2B= grazing area of goats in August 1997, 3A= grazing area of sheep in May 1998, 3B= grazing area of goats in May 1998, 4A= grazing area of sheep in August 1998, 4B= grazing area of goats in August 1998).

(Paulissen *et al*. 1993; Donners *et al*. 2000). The mean annual precipitation for Isparta is estimated at 628 mm/yr with a mean annual temperature of 12 °C. The vegetation in the eastern part of the territory of Sagalassos today is presented in figure 1. The map shows a mozaic type of landscape with agricultural areas interspersed with areas of overgrazed and degraded maquis patches, degraded herbaceous vegetation, steppe-like vegetation at higher altitudes and some reafforested areas and remnants of natural woodlands (Vermoere *et al.* 2000 b).The soils present in our grazing areas were produced from a flysh or limestone underground (Degryse *et al.* submitted a, submitted b). The clay present on the flysh underground contains a lot of quartz particles with a hardness of 7 on Moh's scale. Enamel, on the other hand, scores 4.5 to 5 on Moh's scale meaning the soil present on a flysh underground can scratch the enamel. The clay soil on a limestone underground contains mainly calcite and very little quartz. Calcite scores 3 on Moh's hardness scale and is not able to scratch the enamel. From Tables 1-5 it is obvious that the soil in the grazing area of goats in August 1997 and for both sheep and goat in August 1998 had a scratching capacity. The presence or absence of this soil scratching capacity is included as an additional environmental variable influencing the microwear.

The qualitative analysis of dental microwear

The posterior buccal facet of the occlusal face of the right first mandibular molar was investigated. For a detailed description of the techniques used to produce the replica and SEM micrographs the reader is referred to Beuls *et al*. (2000a). The qualitative analysis adopts the approach and definitions of the qualitative categories as developed by Mainland (1994) with some modifications. This type of analysis describes the texture of the occlusal surface of the tooth under study by noting the presence or absence of 19 qualitative categories (see Fig. 2 for types of categories and explanation of abbreviations). Features having a northeast-southwest orientation are oriented oblique, in a direction going from the upper right side to the lower left side of a micrograph. The reverse is true for features having a northwest-southeast orientation. It is important to note that, based on the preliminary qualitative analysis (Beuls *et al*. 2000a), it was decided to use a different set of qualitative categories to describe more aptly the texture on the occlusal surfaces of the teeth. The teeth of 100 animals (40 sheep from June 1996, August 1997, May 1998 and August 1998, 60 goats from June 1996, February 1997, August 1997, May 1998 and August 1998) were examined. Three animals (2 sheep and 1 goat) were not retained for study because of the numerous artefacts or brittleness of the facet. A second difference with the preliminary analysis is that more data were available for the present analysis so that the com-

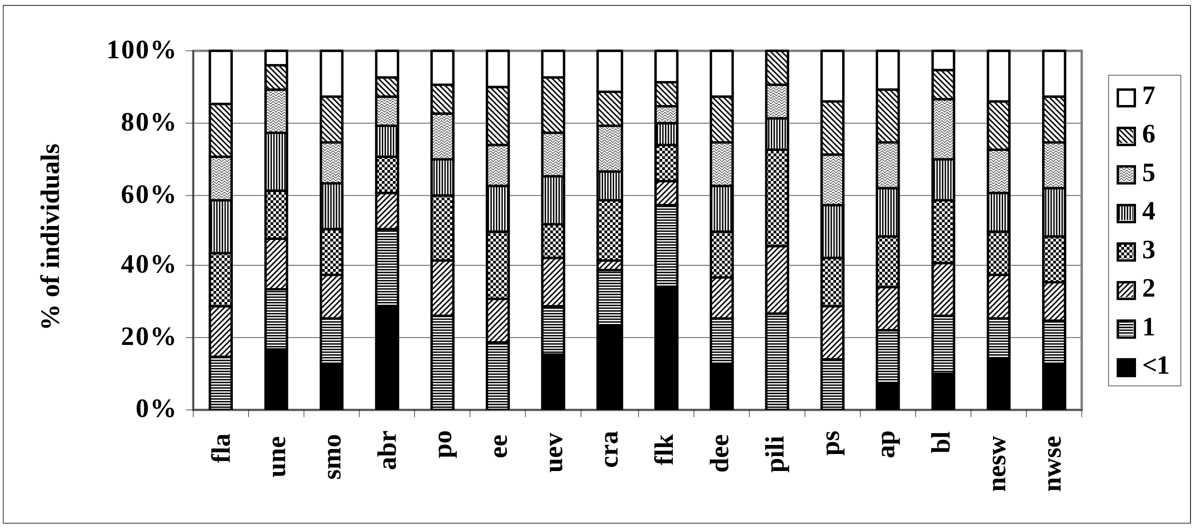

Fig 2. Distribution of qualitative categories (qual cat) in the variable 'absolute age' (year) (*fla= flat surface, une= uneven surface, smo= smooth surface, abr= abraded surface, po= porous surface, ee= areas of empty enamel, uev= underlying enamel visible, cra= cracked surface, flk= surface with flakes, dee= deep features, sha= shallow features, pi= pits, pili= pit-lines, ps= parallel striations, ap= features with an anterio-posterior orientation, bl= features with a bucco-lingual orientation, nesw= features with a northeast-southwest orientation, nwse= features with a northwest-southeast orientation*).

parison between years could be replaced by the comparison of seasons. This last approach is more meaningful archaeologically speaking. As a result, however, the preliminary and current analysis are not directly comparable.

The nature of our data-set (nominal variables, the number of variables involved and their non-conformity with the assumptions of multivariate analysis) necessitated keeping the statistical part of the analysis fairly simple (Siegel and Castellan Jr. 1988; Sokal and Rohlf 1995; Hair *et al*. 1998). The exploratory correspondence analysis (CA) was applied to achieve a perceptual mapping of all the cases and variables involved (Hair *et al*. 1998). A non-parametric Spearman rank correlation test was conducted on both data-sets to see how significant were the associations between variables noted in the CA. The non-parametric Pearson $\chi 2$ was used, sometimes with the Yates correction for small sample sizes applied, to test the statistical significance of differences (Siegel and Castellan Jr. 1988; Sokal and Rohlf 1995). All statistics were conducted using the statistical software package STATISTICA.

Results

The grazing analysis

The detailed presentation and discussion of the vegetation analyses carried out during the observational periods will be discussed elsewhere. Only results relevant to the microwear data will be discussed here. No quantitative assessment of the consumption patterns are available for the two first observational periods. However, a list of species seen to be consumed in June 1996 could be assembled (Beuls *et al*. 2000b). Both sheep and goats showed a wide variety in their dietary choice with 20 species and 22 species consumed respectively. On the other hand, a very small number of plant species was eaten very frequently by either sheep or goats. Goats particularly preferred the leaves of *Quercus coccifera*, at that time the newly formed first year leaves, and to a lesser extent the leaves of *Juniperus excelsa*. Sheep especially preferred small herbs and grasses in the undergrowth of *Q. coccifera*, although on occasion the leaves of *Quercus coccifera* were eaten as well. As a result of the very limited time we could spend following the goat herds in wintertime (February 1997), no plant species seen to be eaten were sampled. In this season, the goats in general ate the leaves of *Quercus coccifera* and of *Juniperus excelsa*.

Considering the consumption data for the 3 consecutive observation periods (August 1997, May 1998 and August 1998), it was noted that goats, in all 3 periods, mainly consumed leaves. In August 1997, 61.3% of their feeding time was dedicated to leaves of shrubs while another 9.3% of their time was spent on tree leaves. In springtime, dietary preferences shifted slightly with less time spent on the leaves of shrubs (54.5%). The consumption of tree leaves was completely negligible (0.1%) but surprisingly, herbs were consumed more frequently (29.4% of total feeding time). In August 1998, the picture was again quite similar to the data of August 1997 with 59.8 % of time spent on shrubs and 7.1 % of time spent on trees (total consumption time: ± 67%). Interestingly, when comparing the foraging time data for each plant (compared to total feeding time in percentages) it is obvious that just a few species in each observational period prevail. In August 1997, *Astragalus* spec. dominate (46% of total feeding time), considerably surpassing *Cedrus libani* (7% of feeding time). *Quercus coccifera* again is generally preferred during spring (almost 50%) as in the summer of 1998 (28%). The second most important species in August 1998 is *Crataegus* spec. (± 9.5%) followed by the dry seeds of several *Medicago* spec. and *Trifolium* spec. comprising about 9% of total feeding time. The sheep, mainly preferred the expected grasses in the summer months (47.7% and 65% respectively), although herbs also proved to be important (46.5% and 33% of total feeding time respectively). In contrast, in May 1998, herbs were the most consumed plant class (almost 86% of total feeding time). The identification of the plant species consumed by sheep was more difficult than in the case for goats. Sheep were much more shy in general and needed several days to get accustomed to the observers. An additional problem was the way these animals feed. Since they eat mainly grasses and herbs, their heads are always pointed to the ground. When they are shy, a herd of sheep will vigorously stick together making a proper observation of consumed plant species very difficult. In addition they always grasp a mouthful of herbs and grasses containing several species at a time. The often degraded state in which the vegetation was found during summer also hampered precise identification. In the observational period of August 1997, 46% of total feeding time was spent on unidentified grasses, about 15 % of time on unidentified herbs and 11% of time on *Verbascum* spec. The identification of plant species, recorded in the vegetation analysis, showed that only 11 grass species were present in the grazing area. They all belonged to the family of the Poaceae (*Bromus cappadocicus*, *B. tectorum*, *B. tomentellus*, *Elymus tauri*, *Festuca jeanpertii*, *F. pinifolia*, *F. valesiaca*, *Koeleria cristata*, *Phleum montanum*, *Poa angustifolia* and *P. compressa*). The herbs favoured in spring were several types of Fabaceae (62.5% of total feeding time) in addition to *Coronilla parviflora*, *Medicago minima*, *M. rigidula* and other Medicago species, *Trifolium scabrum*, *T. hirtum*, *T. speciosum*, *T. spumosum* and *Trigonella monspeliaca*. In the last observational period (August 1998), about 52% of the total feeding time of sheep was spent on unidentified grasses, almost 22% on unidentified herbs, 6.5% on the grass *Cynodon dactylon* and 6% on a horsetail (*Equisetum ramossissimum)*. The unidentified grasses will probably contain portions of all grasses commonly found in the area (*Bromus japonicus*, *B. tectorum*, *Cynodon dactylon*, *Elymus repens*, *Hordeum vulgare*, *Phleum subulatum* and the cultivated *Triticum durum*)

The qualitative analysis of the dental microwear

From the start, the intention of this study has been to observe extensively managed sheep and goat herds in their natural habitat, in this case an eastern Mediterranean degraded environment. An attempt is made to establish to what extent microwear can distinguish dietary features from other species specific and environmental specific characteristics.

A first animal-linked variable to note (Table 1-5) is the sex of this individual. Most animals were females (89 females as opposed to 11 males). Because of the low number of males, their different ages and the fact that they include castrates as well as non-castrates, it was decided to leave the sex variable out of the analysis. A second variable to be considered is age. The shepherds provided the age of each individual and it is therefore not impossible that over- or under-estimations have occurred, especially in the case of older animals. As a result, the Mandibular Wear Stage, as defined by Grant (1982), was included in the analysis as an alternative to the absolute age. An additional argument in favor of the MWS is that gross wear, and not the age of the animal as such, is responsible for the possible differences in texture on the occlusal surfaces of teeth, due to changes in occlusion and in the shape of the occlusal surface. Trends in the qualitative data for age and MWS are presented in Figure 2 and 3. For each MWS class and each absolute age the distribution of the qualitative categories is considered. The trends within categories remain largely similar regardless whether the absolute age or the Mandibular Wear Stage is used, except in the case of the qualitative category 'uneven surface'. In the old individuals there is an marked decline in this category while such a clear trend is not seen in the data-set using the MWS. In the interpretation of these distributions it is important to keep in mind the low number of individuals in the lowest age range (<1 year: 2 individuals) and in the lowest MWS classes (0-5 and 6-10: 2 and 3 individuals respectively). No major trend in the distribution of the qualitative categories is obvious for 9 out of 16 categories in variable of 'age' and 'MWS'. In both the individuals who were older either in absolute or relative terms (higher MWS class), fewer individuals show the presence of the qualitative categories 'flakes' and 'abrasion'. Considering these arguments together with the similarity in the presence or absence of qualitative categories it was decided to use the MWS as an estimate of age in the remainder of the analyses.

The third variable to be considered is the factor 'species' (Fig. 4). This factor does not seem to yield substantial differences in any of the qualitative categories. Categories worth mentioning are 'pit-lines' (pili) and 'underlying enamel visible' (uev), both of which occur more in goats than in sheep. On the other hand, relatively more sheep show the presence of the features 'cracks' (cra) and 'abraded surface' (abr) compared to goats. Other differences are apparently negligible.

'Season' (winter, spring, summer) is another variable considered here. The graphic display of the different qualitative categories is given separately for goats (Fig. 5) and sheep (Fig. 6) since no sheep were observed in winter. Looking at the goats it is evident that individuals slaughtered in winter are qualitatively characterized by having the features 'abraded surface' (abr), 'porous surface' (po), 'pit-lines' (pili) and 'features with a bucco-lingual orientation' (bl) present. Animals from spring, on the other hand, distinguish themselves by the lowest presence of the qualitative categories, 'cracks' (cra),

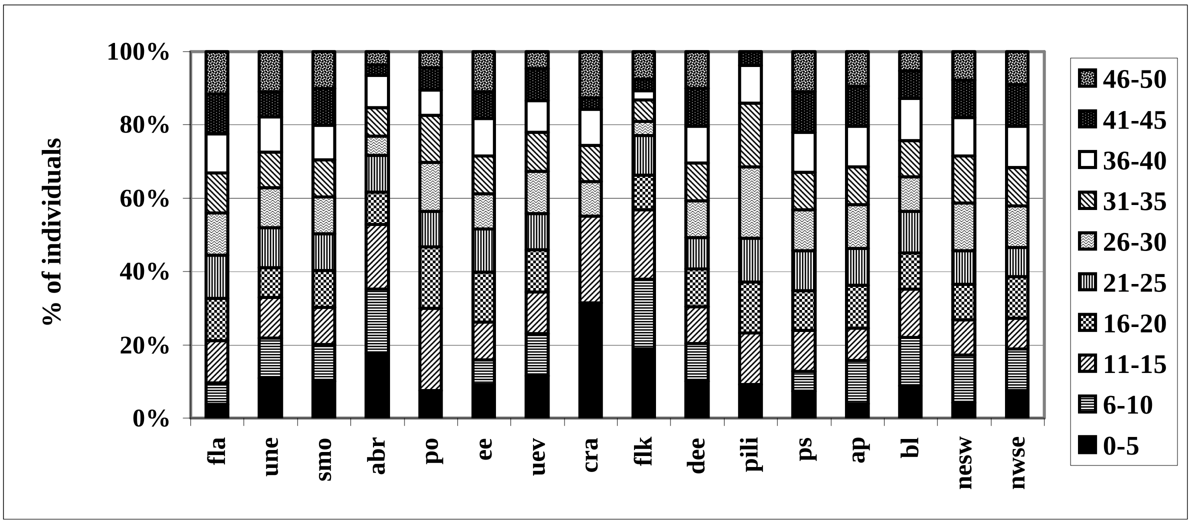

Fig 3. Distribution of qualitative categories in the variable 'Mandibular Wear Stage (MWS) classes'.

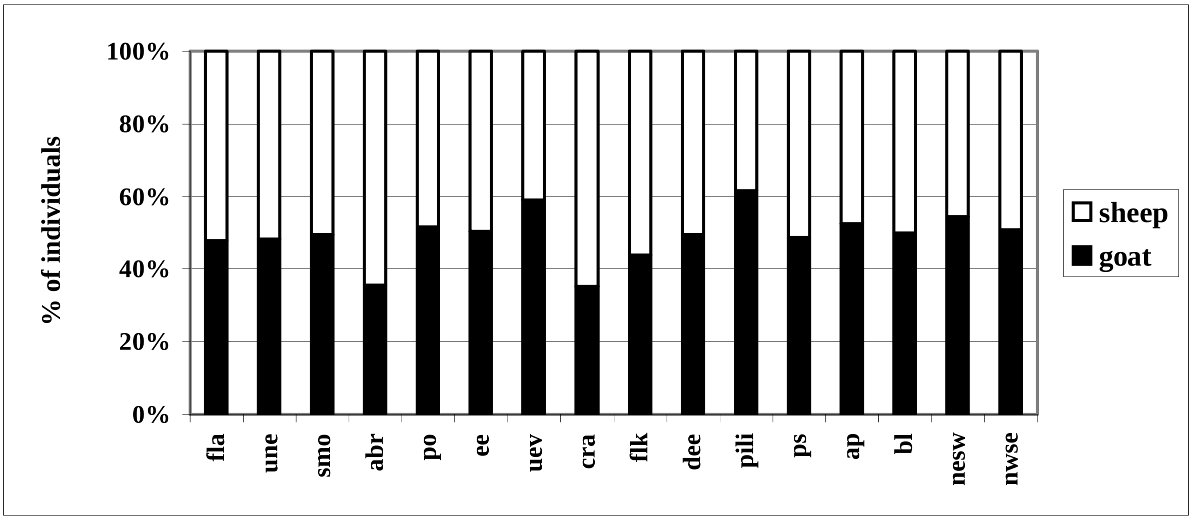

Fig 4. Distribution of qualitative categories in the variable 'species'.

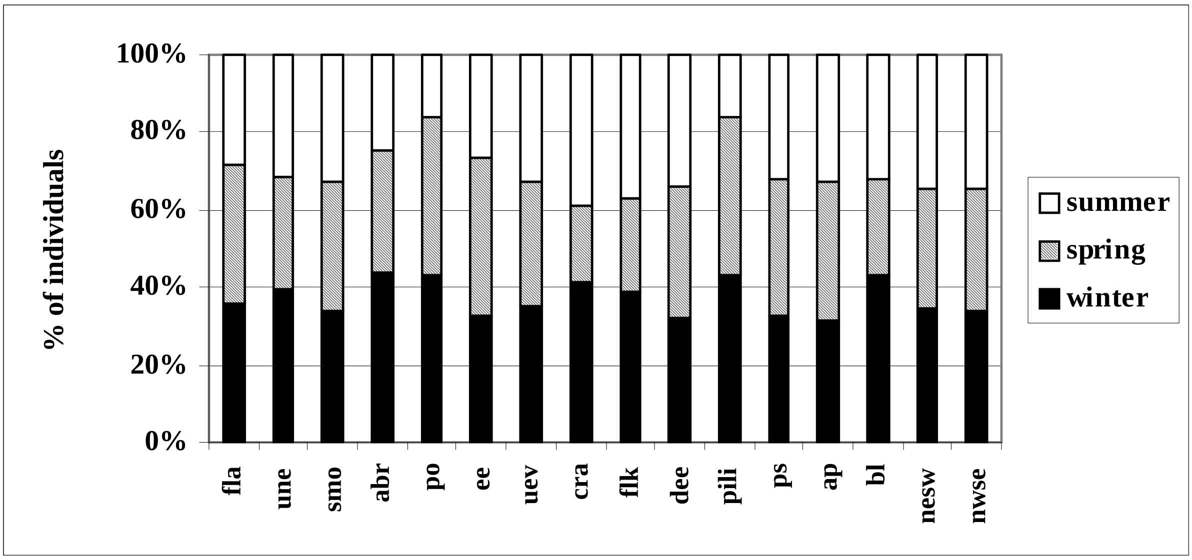

Fig 5. Distribution of qualitative categories in the variable 'season' for goats.

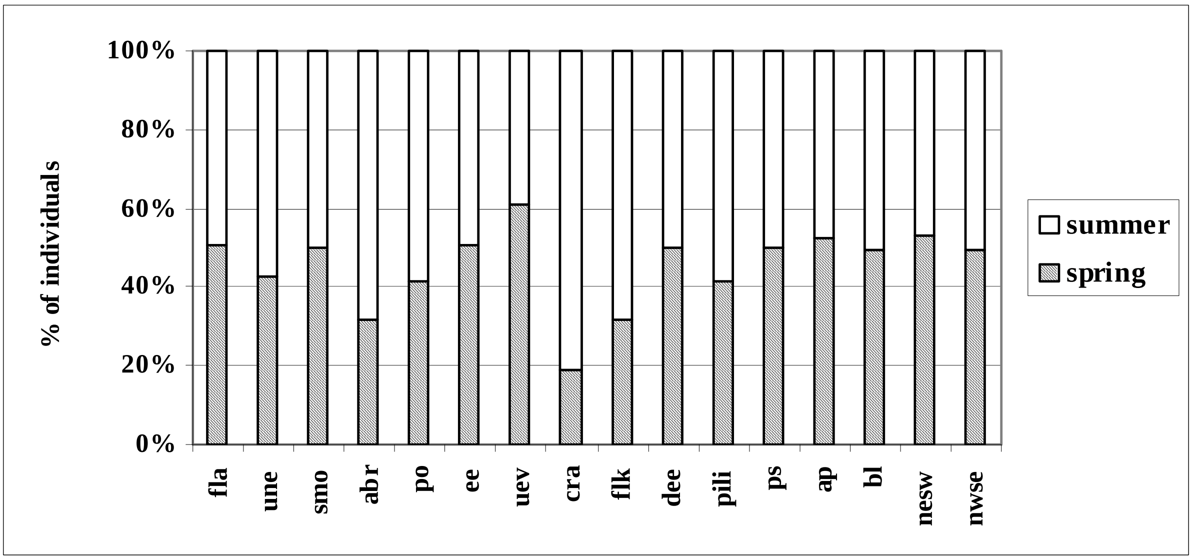

Fig 6. Distribution of qualitative categories in the variable 'season' for sheep.

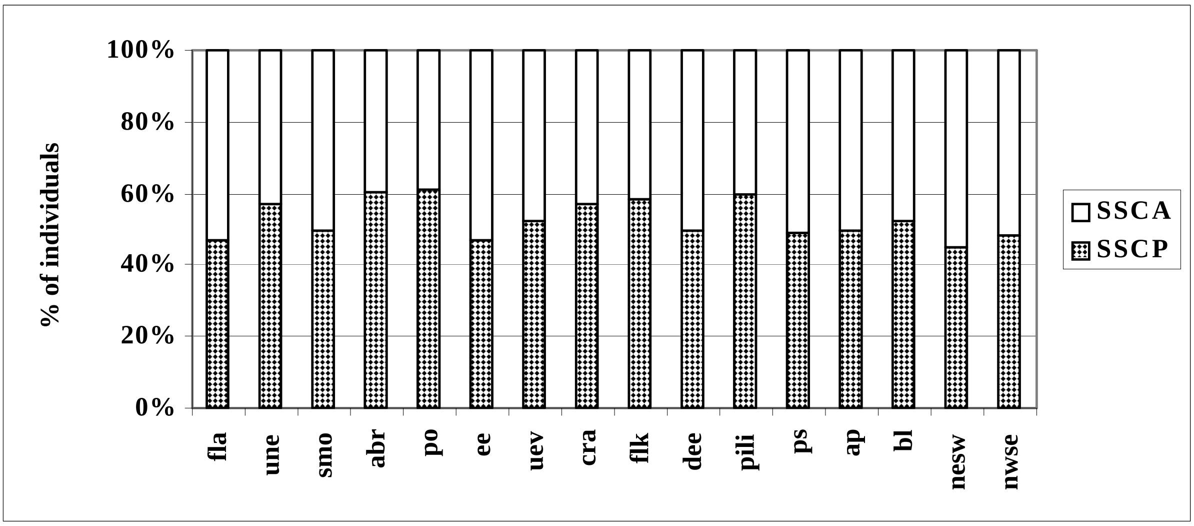

Fig 7. Distribution of qualitative categories in the variable 'Soil Scratch Capacity' (SSC) (SSCA= Soil Scratch Capacity Absent, SSCP= Soil Scratch Capacity Present).

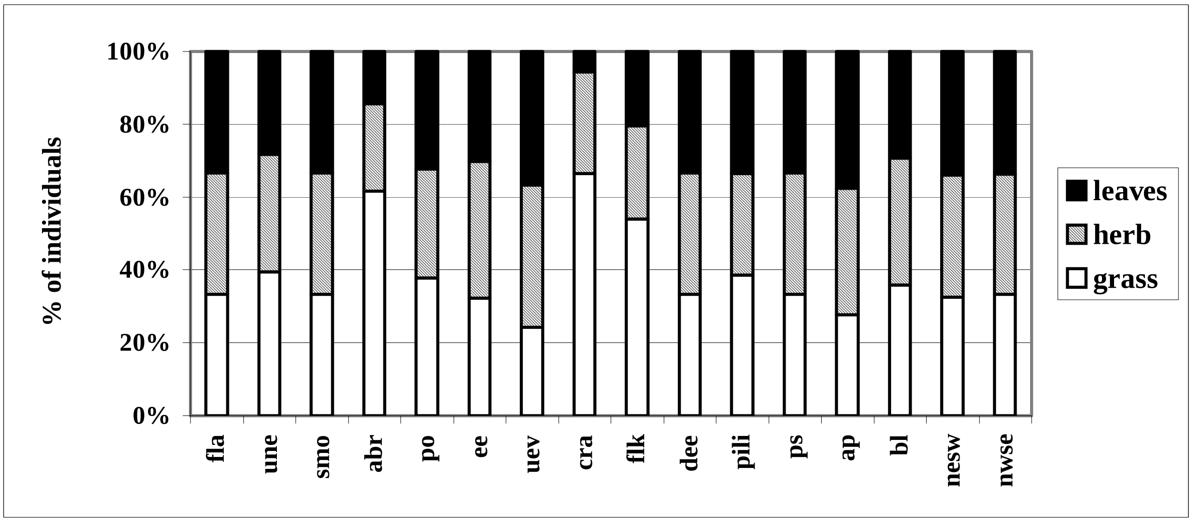

Fig 8. Distribution of qualitative categories in the variable diet.

‘flakes’ (fla) and ‘features with a bucco-lingual orientation’ (bl). The sheep, only observed and slaughtered in spring and summer, had many fewer much less individuals with an ‘abraded’ (abr), ‘cracked’ (cra) or ‘flaking’ (fla) surface in spring as compared to summer.

A last variable to be considered in this data-set is the soil scratch capacity (Fig. 7). The graphic display of the data indicates no obvious differences between individuals grazing in an area where the soil did have a scratching capacity (in the flysh area) or did not (in the limestone area).

The diet of the animals is of course an important last variable to be considered. This variable is only available for the observational periods of August 1997, May 1998 and August 1998. The distribution of qualitative categories is shown in Figure 8. The relatively high percentage of individuals having abraded and cracked tooth surfaces with flakes mainly when consuming grasses is immediately evident

The perceptual mapping of the data from all observational periods is presented in Figure 9. The first two axes in this correspondence analysis (CA) explain only about 31% of the variability in the data. To be able to further interpret this CA, it is important to note that the MWS classes have been reduced to 5 relative age categories.The very young individuals were proven to be outliers in a preliminary CA

MWS class	CA variable (relative age)
0-10	Very young (veyo)
11-20	Young (yo)
21-30	Middle aged (mid)
31-40	Old (old)
41-50	Very old (veold)

(not presented here) and were excluded from further analyses. The first dimension (x-axis) of the CA, explaining about 17% of the variability in the data-set, is determined by the variables of 'species' (sheep), 'season' (winter) and 'MWS class' (very old). The second dimension (y-axis) explaining about 14% of the variability in the data-set, is defined by the feature categories of ‘cracked’ (cra), ‘abraded’ (abr) and ‘flaked’ (fla). The cases are divided into three groups (A, B and C). Group A and B, to the left of the y-axis, are mainly goats of which group A are individuals from winter and spring. Apparently part of group A, goats slaughtered in winter, are closely associated with the qualitative categories of 'porous surface' and 'pit-lines'. Group B, very close to the y-axis, comprises goats from summer. Sheep are placed to the right side of the y-axis (group C). A positive association is evident between several of the variables considered. The variables 'sheep' and individuals slaughtered in 'summer' are associated as are the 'very old' individuals and individuals having grazed in an area where the 'soil had a scratching capacity'. 'Goats' are also tightly linked with 'middle aged' individuals and the animals slaughtered in 'winter' with 'young' individuals. In short the CA reveals some association between the factors 'age' and 'species' and between the factors of 'species' and 'season'. These associations confirm some observations made in the previous graphic analysis of the data.

The CA on the data-set incorporating the dietary consumption shows a good grouping of cases linked to their distinctive variables (Fig. 10). The first axis of the CA explains almost 19% of the variability in the data and is defined in order of importance by the variables 'grass', 'goat', and 'sheep'. The second axis explains 14 % of the variability and is defined by the variable 'herb'. The individual cases are indeed grouped according to the variables 'species' and 'diet'.

Group A is formed by sheep consuming mainly grasses, group B are the sheep consuming mainly herbs and slaughtered in spring and group C are the goats consuming mainly leaves. The sheep eating grasses and slaughtered in summer, being of relatively old age, are characterised by a ‘cracked’ (cra), ‘abraded’ (abr) surface with ‘flakes’ (fla). An association is evident between the variables 'goat', 'leave' and 'young' and between the variables 'herb', 'very old' and 'spring'. The sheep slaughtered in spring and of a relatively very old age are negatively linked with the categories of ‘porous’ surface (po) and the presence of ‘pit-lines’ (pili).

In the data-set with all observational periods included, a significant correlation was noted ($p<0.05$) between all 3 variables (season, MWS and species). On the other hand, in the data-set including the variable 'dietary intake' (observational periods: August 1997, May 1998 and August 1998) only one significant correlation ($p<0.05$) was present (species and dietary intake).

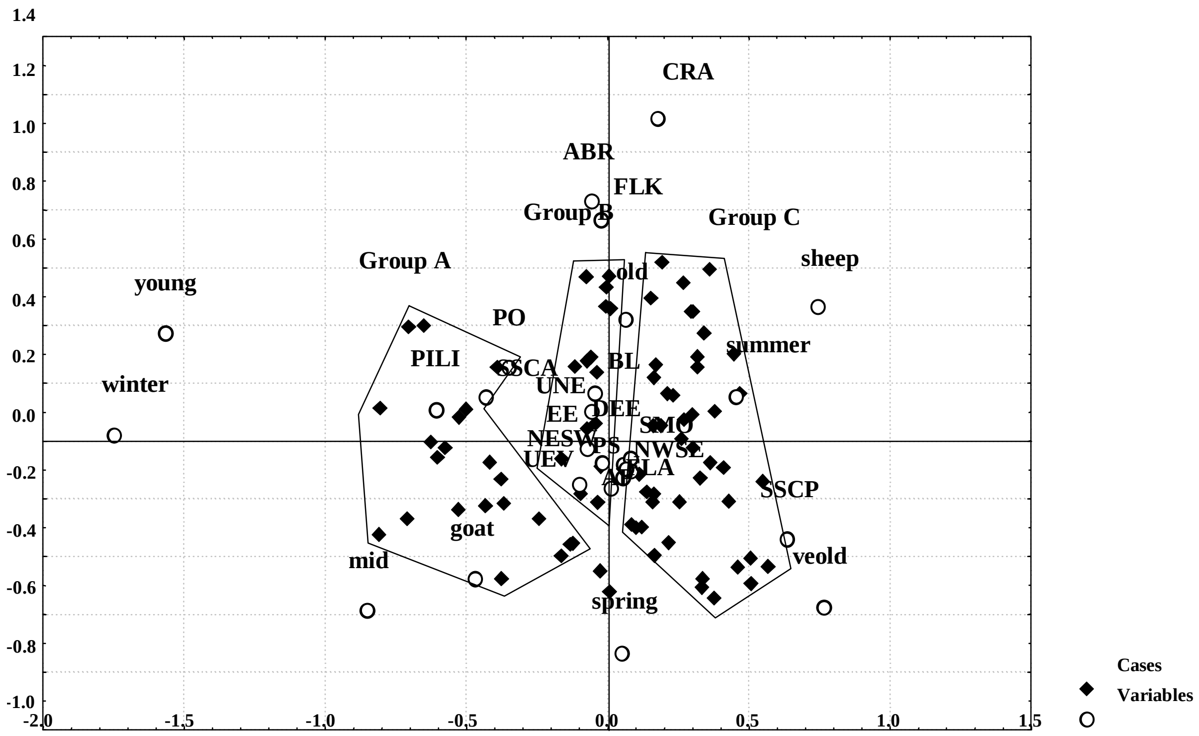

Fig 9. Correspondence analysis on the dataset covering all observational periods (1996-1998).

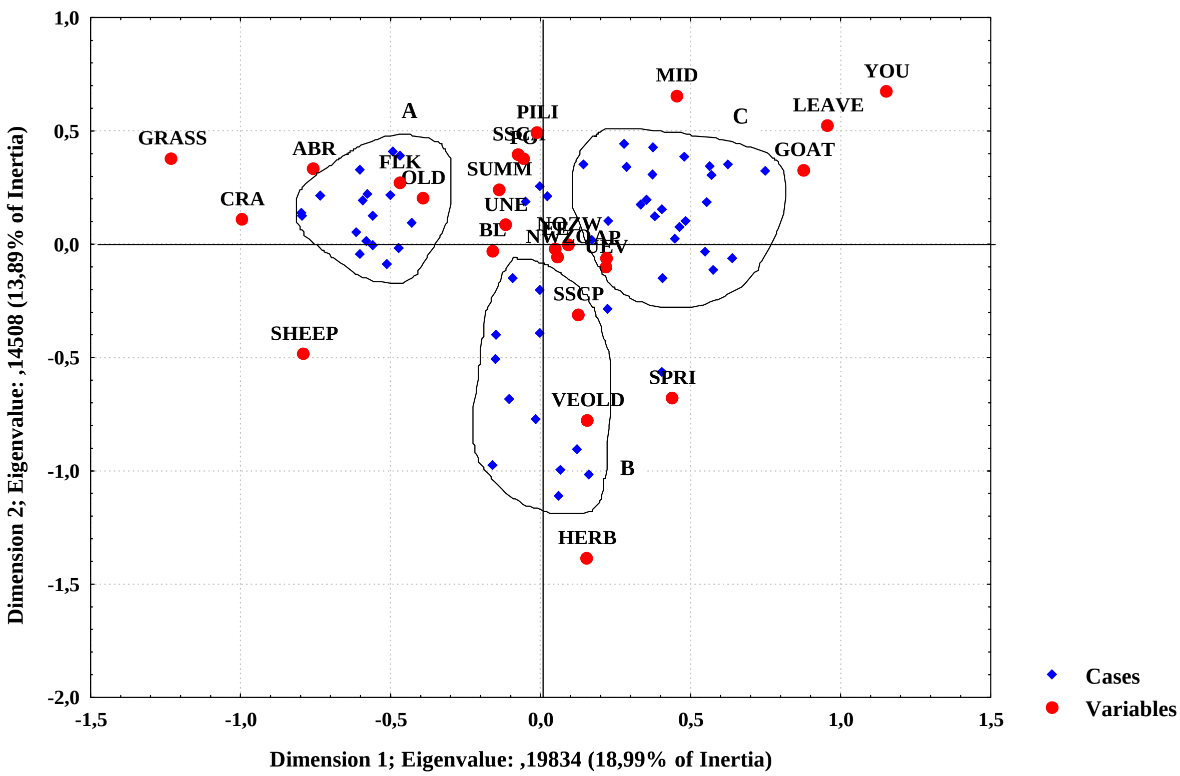

Fig. 10. Correspondence analysis on the dataset of the 3 last observational periods (August 1997, May 1998, August 1998).

To test the statistical significance of differences noted in the graphical analyses, the Pearson $\chi 2$ test was conducted. Starting with the variable 'species' the test indicated that significantly more sheep than goats have ‘abraded’ tooth surfaces ($p < 0.05$) while significantly more goats have their ‘underlying enamel visible’ ($p<0.001$). The main difference between older and very young to young individuals (MWS classes 0-5 and 11-15) is in the presence of defaults on the surface. They show 'cracks', 'flakes' or an 'abraded' surface significantly more frequently than the older individuals (starting from MWS class 21-25) while the opposite is true for the presence of a 'flat' surface or features with an 'anterior-posterior orientation'. The MWS classes showing significant differences are presented in Table 6. Additionally the MWS classes of the relatively middle ranges (26-30 and 31-35) when compared with the relatively older animals show significantly more 'pit-lines' and have their 'underlying enamel visible'. The goats slaughtered in winter showed a significantly higher number of individuals with a 'flat' surface ($p<0.05$), ‘pit-lines’ ($p<0.01$) and a ‘porous’ surface ($p<0.01$) when compared to individuals slaughtered in summer. When the dental surfaces of these winter goats were compared to the ones slaughtered in spring the former showed significantly more features with a 'bucco-lingual' orientation ($p<0.05$). Significantly more goats from spring as compared to summer had 'pit-lines' and a 'porous' surface present ($p<0.05$). When comparing the presence or absence of the different qualitative categories for sheep slaughtered in different seasons (summer and spring), however, no significant differences could be found. The Pearson $\chi 2$ test also noted a significant difference in the presence of a ‘flat’ surface ($p<0.05$), an ‘uneven’ surface ($p<0.01$) and features with a 'bucco-lingual orientation' between individuals grazing in an area where the soil did or did not have a scratching capacity. If the soil has a scratching capacity fewer individuals have teeth with ‘flat’ surface and features with a 'bucco-lingual orientation' but more individuals show an ‘uneven’ surface. Considering the dietary differences, a significant distinction between grass eating and herb eating individuals was noted in the higher presence of 'abraded' surfaces ($p<0.05$) and the lower presence of surfaces with the 'underlying enamel visible' ($p<0.05$) in grass eating animals. When comparing the grass with leaf consuming animals, the same distinction as with herb eating individuals was noted. Significantly more grass eating individuals showed an 'abraded' ($p<0.001$) surface and significantly less a surface with the 'underlying enamel visible' ($p<0.05$). In addition, significantly more animals showed 'cracks' ($p<0.001$) but significantly fewer had features with an' anterior-posterior orientation'.

Discussion

The first conclusion which can be drawn from these analyses is that 10 of the 19 qualitative categories are found to be important in defining a significant difference between the texture in the variables under consideration ('species', 'season of slaughtering', 'relative age of slaughtering', 'Soil Scratch Capacity' or 'diet'). The other categories are not significantly different for any of the independent variables. Considering the significant differences, sheep seem to be characterised by the presence of an 'abraded' surface, while goats have their 'underlying enamel visible'. Interestingly, when examining the dietary data and comparing individuals with mainly a grass diet to individuals with a leaf or herb diet, the former can be recognised by having an 'abraded' surface but no 'underlying enamel visible'. This close association between the variables 'species' and 'dietary intake' was also shown by the correspondence analysis. When combining all dietary data for the 3 observation periods (Tables 3-5) it appears that 57% of the sheep spend most of their time on grasses as opposed to 39% on herbs and 4% on the consumption of shrubs. On the other hand, only 4% of goats show a preference for grasses, 20% of them eat mainly herbs but the majority (80%) like the leaves of shrubs best. This explains the agreement between the two variables. One could be tempted to conclude that an individual eating grasses will always be a sheep and be characterised by having an 'abraded surface' present and no 'underlying enamel visible'. When examining the consumption data in the different seasons the picture corresponds with the expectations for the sheep, eating in summer (94% of sheep eating mainly grass, 0% herb, 6% shrub respectively) but in spring the situation changes dramatically (100% eat mainly herb, 0% grass, 0% shrub). The goats, very conveniently, keep favouring the consumption of shrubs in summer and spring (82% of individuals in summer, 32.5 % of individuals in spring, no data available for winter). Consequently the concordance between the qualitative characterisation of the 'species' factor and the 'diet' factor is not absolute.

Mainland (1995a, 1995b, 1998) could distinguish individuals (sheep or goats) who have been fed leafy hay from the ones having eaten grassy hay by the absence of a porous surface and deep features, by the absence of a polished surface and by the invisibility of the underlying enamel structure. Secondly, the distinction between grazing and grassy-hay eating individuals was based on the presence of an abraded surface with areas devoid of features and deep features without an anterior-posterior orientation in the grazing individuals and a porous surface in the grassy-hay eating individuals. A comparison with the results reported here is not straightforward since in none of our observation periods did the animals eat only hay (grassy or leafy). In summer, conditions of the vegetation were in general very dry but the animals often managed to locate the green shoots between the dried out vegetation and showed a preference for them. Some agreement is clearly evident between both studies, for example in the visibility of the underlying enamel in grass eating as compared to leaf eating individuals. On the other hand, the differences found are not always between the same dietary classes as for example in the case of the qualitative category 'abraded'. In both studies an abraded surface is characteristic for grass eating individuals. In Mainland's studies (1995a, 1995b, 1998) however, this is compared to grassy-hay eating individuals while in this study it is compared to leaf and herb eating individuals. A porous surface was characteristic for grassy-hay eating individuals in the study by Mainland (1995a, 1995b, 1998) but in the present case it is characteristic of goats slaughtered in winter. As previously mentioned, goats slaughtered in winter could not be observed extensively. The information gathered from our brief observations was that the goats mainly consumed the leaves of *Quercus coccifera* and *Juniperus excelsa*. The shepherd of the different herds did not mention any foddering of the goats in this season.

To explain the various structures observed, all factors involved in the process of creating character differences on the occlusal surfaces of teeth should be considered. In sheep and goats, the cell wall fibre of food plants is digested through microbial attack by retaining it in an expanded fore-gut for a considerable amount of time. A mechanical breakdown of the food prior to fermentation in the gut is necessary since it is directly dependent on the food particle size and volume (Janis 1976; Lanyon and Sanson 1986). The efficiency of this mechanical breakdown is under the control of the masticatory apparatus (the teeth, tongue and jaw muscles). The dentition exerts a concentrated bite force on the food but at the same time, the pressure must not be so great as to cause cracks in the enamel (Fortelius 1985; Hiiemae and Crompton 1985; Popowics 1999). The enamel is, in fact, designed to withstand shearing and compression forces and to prevent cracks from appearing or if they do appear, to prevent these from propagating too far (Fortelius 1985; Koenigswald *et al*. 1987; Young *et al*. 1987; Kierdorf *et al*. 1991; Maas 1991). Two factors are involved in the potential production of a worn occlusal surface, the shearing and the compression forces during chewing. Another factor to consider is the food itself. A large number of different plant species contain calcium oxalate or silica phytoliths. The calcium oxalate deposit in the cell can occur in several parts of the plant leaf, stem, root, and inflorescence. They have a crystalline form and can be present in various shapes (solitary, as druses, as raphides), while the silica deposits are mainly opaline and amorphous in nature (Franceschi and Horner Jr. 1980; Sangster and Parry 1981; Fahn 1990). A number of microwear studies have proven that both calcium oxalate (Danielson and Reinhard 1998) and silica phytoliths (Lalueza Fox *et al*. 1994; Lucas and Teaford 1995) can scratch enamel and cause microwear. A number of studies have shown that microwear can be produced by grit if it has a greater hardness on Moh's scale than enamel (e.g. Peters 1982; Ungar 1994; Teaford and Lytle 1996). It has been mentioned previously that the soil in the grazing area of goats in August 1997 and for both sheep and goat in August 1998 had a scratching capacity. It remains to be verified to what extent grit was present in the higher reaches of the vegetation where goats are browsing. A study by Ungar *et al*. (1995) has shown that grit was present in the canopy of the vegetation where primates were feeding in the forests of Indonesia and Costa Rica. In our case, conditions in August 1997 were dry and the grazing area of the goats was located in a newly reforested area of mainly *Cedrus libani* stands with a strongly eroded soil on a flysh underground. An abrasive action of grit on their teeth can thus not be completely excluded. The grazing area of sheep in May 1998 was also located in an area with a flysh underground. During and before the observational period rain was superfluous. The assumption was made, based on these observations, that most of the grit would probably be washed away from the plants' surfaces and would not be blown up again because of the wet conditions. Plants in May additionally were in their optimal growing period, often in bloom, as a result of which grazing did not take place so close to the soil as compared to the summer observation periods. These assumptions lead to the suggestion that the abrasive action of grit is probably of more importance in summer.

An aspect not treated in the previous qualitative research of dental microwear (Mainland, 1995a, 1995b, 1998) was the influence of the factor age or, in our case relative age, through the Mandibular Wear Stage. Results presented here show a possible interference of age related factors with diet related factors. The occlusal surfaces of teeth in younger individuals show a greater amount of roughness and defaults while in older individuals teeth are seemingly flattened. These findings may be the result of the decrease in the height of teeth as a result of the wear process. This wearing down of the tooth implies a less tight fit of the occlusal surfaces against one another which might lead to a decreased compressive load during mastication, in turn resulting in a decreased occurrence of texture on the occlusal surface (Rensberger 1973; Fortelius 1985; Hiiemae and Crompton 1985).

Conclusions

The conducted qualitative analysis was based on the presence and absence data of 19 qualitative categories. The study revealed a strong, although not absolute, agreement between the variable of species (sheep, goat) and the variable of dietary intake (grass, herb or leaf). Sheep were distinguished from goats by the presence of an abraded tooth surface and the invisibility of the underlying enamel as was the case for individuals (sheep, goat) consuming grasses compared to the ones eating leaves or herbs. Individuals eating grasses were additionally distinguished from animals eating leaves by the presence of cracks and by the absence of features with an anterior-posterior orientation. The goats slaughtered in winter differ from the ones slaughtered in spring and summer by the presence of pit-lines and a porous surface. The age of the caprines also seemed to play a role of some significance. The overall texture of the occlusal surface diminished as the tooth was worn down. Animals grazing in an area where grit had a scratching capacity were distinguished by the presence on their teeth of a flat and uneven surfaces. An attempt at explaining some of these differences is made by discussing the observed differences in the light of characters inherent to the diet (phytoliths), the environment (grit) and the animal itself (mastication, dentition). As to the predictive value of this type of analysis of dental microwear in the determination of dietary habits of archaeological animals, one must keep in mind the following consideration: Although significant differences were found between the variables under study using several of the qualitative categories, the same categories often recurred in the determination of these differences. Additionally the differences in the frequencies of observation of the qualitative categories, when expressed as a percentage of the total number of individuals observed, although statistically significant, were not on the order of 90 or 100% but at most in the order of 50%. This justifies the conclusion drawn that a qualitative analysis of dental microwear can possibly aid in predictions based on a quantitative analysis of dental microwear. It is, however, not advisable, to use this type of analysis on its own to make predictions on either of the variables considered in the reported study on an individual slaughtered in archaeological times.

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Table 1**.** Characteristics of sheep and goats observed in June 1996 and of the location and the type of grazing area (MWS = Mandibular Wear Stage) (Peçenek: 37°32'N/30°31'E).

Register number	Species	Breed	Age	MWS	Sex	Location	Soil type
96-55 M1	Goat	Kıl Keçi	5 yr	40	F	Peçenek	Limestone
96-55-M2	Goat	Kıl Keçi	5 yr	43	F	Peçenek	Limestone
96-55-M3	Goat	Kıl Keçi	5 yr	41	F	Peçenek	Limestone
96-55-M4	Goat	Kıl Keçi	5 yr	41	F	Peçenek	Limestone
96-55-M5	Goat	Kıl Keçi	5 yr	44	F	Peçenek	Limestone
96-55-M6	Goat	Kıl Keçi	4-5 mo	3	F	Peçenek	Limestone
96-55-M7	Goat	Kıl Keçi	4-5 mo	3	M	Peçenek	Limestone
96-55-M8	Goat	Kıl Keçi	4-5 mo	4	M	Peçenek	Limestone
96-55-M9	Goat	Kıl Keçi	4-5 mo	3	M	Peçenek	Limestone
96-55-M10	Goat	Kıl Keçi	4-5 mo	6	F	Peçenek	Limestone
96-55-M11	Sheep	Karagöz	2 yr	34	F	Peçenek	Limestone
96-55-M12	Sheep	Karagöz	1 yr	23	F	Peçenek	Limestone
96-55-M13	Sheep	Karagöz	3 yr	49	F	Peçenek	Limestone
96-55-M14	Sheep	Karagöz	3 yr	45	F	Peçenek	Limestone
96-55-M15	Sheep	Karagöz	4 yr	45	F	Peçenek	Limestone
96-55-M16	Sheep	Mandak	3 yr	47	F	Peçenek	Limestone
96-55-M17	Sheep	Mandak	4 yr	43	F	Peçenek	Limestone
96-55-M18	Sheep	Karagöz	1 yr	26	F	Peçenek	Limestone
96-55-M19	Sheep	Karagöz	4 yr	46	F	Peçenek	Limestone
96-55-M20	Sheep	Mandak	2 yr	32	F	Peçenek	Limestone

Table 2. Characteristics of sheep and goats observed in February 1997 and of the location and type of grazing area (Eyüplar Köyü: SE of Eğirdir, Bedre Boluk: NW of Eğirdir, Bagoren Bedre: NW of Eğirdir, Yukari Gökdere: SE of Eğirdir, Eğirdir:37°51’45”N/30°48’55”E).

Register number	Species	Breed	Age (yr)	MWS	Sex	Location	Soil type
97-011-M1	Goat	Kıl Keçi	1	17	F	Eyüplar Köyü	Limestone
97-11-M2	Goat	Kıl Keçi	2	25	F	Eyüplar Köyü	Limestone
97-011-M3	Goat	Kıl Keçi	3	35	F	Eyüplar Köyü	Limestone
97-011-M4	Goat	Kıl Keçi	3	33	F	Eyüplar Köyü	Limestone
97-011-M5	Goat	Kıl Keçi	5	42	F	Eyüplar Köyü	Limestone
97-011-M6	Goat	Kıl Keçi	1	12	M	Bedre Boluk	Limestone
97-011-M7	Goat	Kıl Keçi	2	24	F	Bedre Boluk	Limestone
97-011-M8	Goat	Kıl Keçi	7	44	F	Bedre Boluk	Limestone
97-011-M9	Goat	Kıl Keçi	1	14	M	Bagoren Bedre	Limestone
97-011-M10	Goat	Kıl Keçi	1	14	F	Bagoren Bedre	Limestone
97-011-M11	Goat	Kıl Keçi	2	26	-M	Bagoren Bedre	Limestone
97-011-M12	Goat	Kıl Keçi	3	36	M	Bagoren Bedre	Limestone
97-011-M13	Goat	Kıl Keçi	3	33	F	Bagoren Bedre	Limestone
97-011-M14	Goat	Kıl Keçi	4	45	-M	Bagoren Bedre	Limestone
97-011-M15	Goat	Kıl Keçi	4	39	F	Bagoren Bedre	Limestone
97-011-M16	Goat	Kıl Keçi	5	41	M	Yukari Gök-dere	Limestone
97-011-M17	Goat	Kıl Keçi	6	35	M	Yukari Gök-dere	Limestone
97-011-M18	Goat	Kıl Keçi	2	26	F	Yukari Gök-dere	Limestone
97-011-M19	Goat	Kıl Keçi	4	36	F	Yukari Gök-dere	Limestone
97-011-M20	Goat	Kıl Keçi	1	15	F	Yukari Gök-dere	Limestone

Table 3. Characteristics of sheep and goats observed in August 1997 and of the location and the type of grazing area (Ugr= Intake of grass in % of total feeding time, Uhe= Intake of herbs in % of total feeding time, Ushr= Intake of shrubs in % of total feeding time, Utr= Intake of trees in % of total feeding time, %ft= % of total feeding time) (Ağlasun 1: 37°41'03"N/30°31'31"E, Ağlasun 2: 37°40'47"N/30°32'44"E).

Register number	**Species**	**Breed**	**Age (yr)**	**MWS**	**Sex**	**Ugr (%ft)**	**Uhe (%ft)**	**Ushr (%ft)**	**Utr (%ft)**	**Location**	**Soil type**
97-070-M1	Sheep	Karagöz	5	45	F	54	38	8	0	Ağlasun 1	Limestone
97-070-M2	Sheep	Karagöz	3	39	F	51	43	5	2	Ağlasun 1	Limestone
97-070-M3	Sheep	Karagöz	1	24	F	65	34	1	0	Ağlasun 1	Limestone
97-070-M4	Sheep	Karagöz	5	43	F	72	26	2	0	Ağlasun 1	Limestone
97-070-M5	Sheep	Ala Kuyun	1	26	F	83	16	0	1	Ağlasun 1	Limestone
97-070-M6	Sheep	Karagöz	>4	39	F	13	40	46	0	Ağlasun 1	Limestone
97-070-M7	Sheep	Karagöz	4	42	F	56	39	5	0	Ağlasun 1	Limestone
97-070-M8	Sheep	Mandak x Karagöz	4	43	F	71	27	1	0	Ağlasun 1	Limestone
97-070-M9	Sheep	Mandak	2	32	F	54	38	8	0	Ağlasun 1	Limestone
97-070-M10	Sheep	Kuyuruksuz	5	46	M	17	81	2	0	Ağlasun 1	Limestone
97-070-M11	Goat	Kıl Keçi	3	33	F	10	24	56	11	Ağlasun 1	Flysh
97-070-M12	Goat	Kıl Keçi	2	29	F	0	29	64	7	Ağlasun 1	Flysh
97-070-M13	Goat	Kıl Keçi	2	28	F	11	13	64	12	Ağlasun 1	Flysh
97-070-M14	Goat	Kıl Keçi	1	19	F	7	27	57	9	Ağlasun 1	Flysh
97-070-M15	Goat	Kıl Keçi	1	22	F	10	57	25	8	Ağlasun 1	Flysh
97-070-M16	Goat	Kıl Keçi	4	44	F	8	3	70	19	Ağlasun 1	Flysh
97-070-M17	Goat	Kıl Keçi	2	29	F	0	28	65	7	Ağlasun 1	Flysh
97-070-M18	Goat	Kıl Keçi	>4	43	F	16	54	27	2	Ağlasun 1	Flysh
97-070-M19	Goat	Kıl Keçi	4	43	F	4	7	84	5	Ağlasun 1	Flysh
97-070-M20	Goat	Kıl Keçi	4	37	F	7	27	57	9	Ağlasun 1	Flysh

Table 4. Characteristics of sheep and goats observed in May 1998 and of the location and type of grazing area (Canaklı: 37°34'55"N/30°31'12"E, Kıprıt: 37°34'16"N/30°30'54"E).

Register number	**Species**	**Breed**	**Age (yr)**	**MWS**	**Sex**	**Ugr (%ft)**	**Uhe (%ft)**	**Ushr (%ft)**	**Utr (%ft)**	**Location**	**Soil type**
98-35-M1	Sheep	Unknown	5	42	F	10	86	4	0	Canaklı	Flysh
98-35-M2	Sheep	Unknown	5	43	F	10	86	4	0	Canaklı	Flysh
98-35-M3	Sheep	Unknown	5	39	F	10	86	4	0	Canaklı	Flysh
98-35-M4	Sheep	Unknown	3	33	F	10	86	4	0	Canaklı	Flysh
98-35-M5	Sheep	Unknown	4	45	F	10	86	4	0	Canaklı	Flysh
98-35-M6	Sheep	Unknown	2	45	F	10	86	4	0	Canaklı	Flysh
98-35-M7	Sheep	Unknown	2	22	F	10	86	4	0	Canaklı	Flysh
98-35-M8	Sheep	Unknown	6	45	F	10	86	4	0	Canaklı	Flysh
98-35-M9	Sheep	Unknown	3	44	F	10	86	4	0	Canaklı	Flysh
98-35-M10	Sheep	Unknown	4	35	F	10	86	4	0	Canaklı	Flysh
98-35-M11	Goat	Kıl Keçi	2	17	F	23	31	46	0	Kıprıt	Limestone
98-35-M12	Goat	Kıl Keçi	1	21	F	1	38	59	2	Kıprıt	Limestone
98-35-M13	Goat	Kıl Keçi	>4	40	F	16	32	52	0	Kıprıt	Limestone
98-35-M14	Goat	Kıl Keçi	5	45	F	16	32	52	0	Kıprıt	Limestone
98-35-M15	Goat	Kıl Keçi	1	33	F	52	11	37	0	Kıprıt	Limestone
98-35-M16	Goat	Kıl Keçi	3	26	F	13	44	43	0	Kıprıt	Limestone
98-35-M17	Goat	Kıl Keçi	1	19	F	5	49	46	0	Kıprıt	Limestone
98-35-M18	Goat	Kıl Keçi	5	44	F	0	40	59	0	Kıprıt	Limestone
98-35-M19	Goat	Kıl Keçi	2	29	F	16	23	62	0	Kıprıt	Limestone
98-35-M20	Goat	Kıl Keçi	2	26	F	20	18	62	0	Kıprıt	Limestone

Table 5. Characteristics of sheep and goats observed in August 1998 and of the location and type of grazing area (Ağlasun 3: 37°41'27"N/30°32'06"E, Ağlasun 4: 37°40'27"N/30°31'31"E).

Register number	**Species**	**Breed**	**Age (yr)**	**MWS**	**Sex**	**Ugr (%ft)**	**Uhe (%ft)**	**Ushr (%ft)**	**Utr (%ft)**	**Location**	**Soiltype**
98-83-M1	Sheep	Karagöz	4	40	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M2	Sheep	Karagöz	3	34	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M3	Sheep	Karagöz	7	46	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M4	Sheep	Karagöz	3	36	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M5	Sheep	Karagöz	6	32	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M6	Sheep	Karagöz	3	31	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M7	Sheep	Karagöz	2	37	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M8	Sheep	Karagöz	3	37	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M9	Sheep	Karagöz	4	38	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M10	Sheep	Karagöz	3	44	F	65	33	1	1	Ağlasun 3	Flysh/limestone
98-83-M11	Goat	Kıl Keçi	5	43	F	2	21	56	20	Ağlasun 3	Flysh/limestone
98-83-M12	Goat	Kıl Keçi	3	32	F	9	48	37	6	Ağlasun 3	Flysh/limestone
98-83-M13	Goat	Kıl Keçi	6	37	F	11	25	59	4	Ağlasun 3	Flysh/limestone
98-83-M14	Goat	Kıl Keçi	7	44	F	3	15	79	3	Ağlasun 3	Flysh/limestone
98-83-M15	Goat	Kıl Keçi	5	42	F	11	31	52	6	Ağlasun 3	Flysh/limestone

Table 6. Results of the Pearson $\chi 2$ test for the MWS classes.

Test between	Qualitative category	P value
0-5 and 21-25	cra	<0.05
0-5 and 36-40	flk	<0.05
0-5 and 41-45	fla	<0.05
0-5 and 41-45	abr	<0.05
0-5 and 41-45	cra	<0.01
0-5 and 41-45	flk	<0.05
0-5 and 41-45	ap	<0.05
11-15 and 21-25	cra	<0.05
11-15 and 26-30	flk	<0.05
11-15 and 36-40	flk	<0.01
11-15 and 41-45	cra	<0.05
11-15 and 41-45	po	<0.05
11-15 and 41-45	abr	<0.01
21-25 and 41-45	nwse	<0.05
26-30 and 41-45	pili	<0.01
26-30 and 46-50	pili	<0.05
26-30 and 46-50	uev	<0.05
31-35 and 41-45	pili	<0.01
31-35 and 46-50	uev	<0.05
36-40 and 41-45	abr	<0.05