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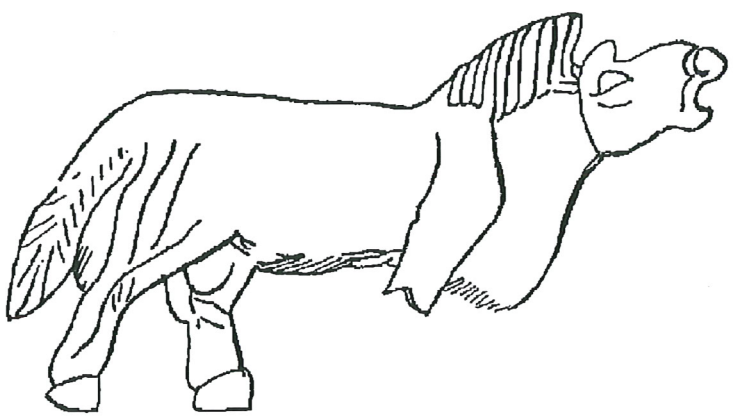

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VOLUME B

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VOLUME A

PRESENT-DAY TRADITIONAL OVICAPRINE HERDING AS A RECONSTRUCTIONAL AID FOR UNDERSTANDING HERDING AT ROMAN SAGALASSOS

Ingrid Beuls[1], Bea De Cupere[2], Paul Van Mele[3], Marleen Vermoere[1], Marc Waelkens[1]

Abstract

A study of the dental microwear patterns and cementum incremental bands of teeth is conducted in order to reconstruct the former diet, absolute age and season of death of sheep and goats from the Roman site of Sagalassos (Turkey). Modern herds of sheep (*Ovis ammon* f. *aries*) and goats (*Capra hircus* f. *aegagrus*) have been observed for comparative purposes in the territory of Sagalassos in June 1996, February 1997 and August 1997. Their qualitative and quantitative dietary intake were noted using the direct observation method. A preliminary qualitative analysis of the dental microwear patterns indicated firstly that significantly fewer goats showed striations in winter (February 1997) compared to summer (June 1996 and August 1997). Secondly, a significantly higher number of goats in winter compared to summer showed the presence of pit lines. A possible explanation could be the lower intake of grasses and herbs by goats in February 1997. In the case of the sheep no qualitative differences were noted between the sample of June 1996 and August 1997. Interspecies comparisons in the samples of June 1996 and August 1997 indicated a significantly higher number of goats display a visible prism structure in June 1996. These observations reflect the well documented differences in dietary intake between goats, with their tendency to browse, and sheep, which are almost exclusively grazers.

Résumé

Une étude des schémas d'usure dentaire et des cernes de croissance du cément est menée afin de reconstituer le régime alimentaire, l'âge absolu et la saison de mort des moutons et des chèvres du site de Sagalassos (Turquie). En vue d'une approche comparative, des troupeaux modernes de moutons (*Ovis ammon* f. *aries*) et de chèvres (*Capra hircus* f. *aegagrus*), ont fait l'objet d'une observation dans le territoire de Sagalassos en juin 1996, février 1997 et août 1997. Leur alimentation a été notée du point de vue qualitatif et quantitatif par observation directe. Une analyse qualitative préliminaire des schémas de micro-usure dentaire montre en premier lieu que les striations sont moins accentuée chez la chèvre pendant l'hiver (février 1997) que pendant l'été (juin 1996 et août 1997). En outre, un nombre significativement élevé de chèvres présentent plus de lignes de puits en hiver qu'en été. Une explication possible pourrait être une moindre consommation d'herbe et de fourrage par les chèvres en février 1997. Dans le cas du mouton, aucune différence qualitative n'a été notée entre les échantillons de juin 1996 et d'août 1997. Les comparaisons inter-spécifiques entre les échantillons de juin 1996 et d'août 1997 montrent qu'un nombre significativement plus élevé de chèvres présentent une structure en prismes en juin 1996. Ces observations reflètent les différences, bien documentées, entre l'alimentation des chèvres, qui ont tendance à brouter des feuilles, et celle des moutons, qui broutent presque exclusivement de l'herbe.

Key Words: Dental Microwear, Goat, Sheep, Qualitative Analysis

Mots Clés: Micro usure dentaire, Chèvre, Mouton, Analyse qualitative

Introduction

The site of Sagalassos, situated in the Western Taurus Mountains (Province of Burdur, Turkey), has been excavated since 1990 under the directorship of Prof. Dr. M. Waelkens. The aim is to describe daily life in Sagalassos during the Roman period (1st century BC- AD 6th century) in as de-

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tailed a manner as possible, using a multidisciplinary approach. Several aspects of the city and its environment are studied involving the disciplines of geology, geomorphology, palaeobotany, archaeology, agricultural engineering, archaeozoology etc.

The examination and identification of the excavated animal remains (about 200,000 to date) by archaeozoologists, have already revealed information on several aspects related to the way the city functioned and their environment (De Cupere 1993; De Cupere *et al.* 1993; Degeest *et al.* 1993; Van Neer and De Cupere 1993; De Cupere *et al.* 1995; Van Neer *et al.* 1997; De Cupere and Waelkens 1998). Based on this research, it was found that wild animal species were of no importance in the subsistence of the city of Sagalassos. The relative importance of the preferentially consumed domestic species (sheep, goat, cattle, pig, chicken), however, changed through time. During periods of great stability and prosperity, beef consumption increased, while in intermediate periods sheep and goats were slaughtered more frequently (De Cupere and Waelkens 1998).

The relative importance of ovicaprines in Sagalassos during the Roman period and their common presence today in the surroundings of the site, led to a new archaeozoological study in 1997 aimed at delivering a more detailed picture of their historical use and management.

Some theoretical considerations about the use of dental research in studies of ancient herding practices are presented below, followed by preliminary results of the qualitative analysis of dental microwear on the occlusal surfaces of modern ovicaprines culled in three different seasons (June 1996, February 1997 and August 1997).

The potential of dental studies

To provide insights into the use and management of ovicaprines in Roman Sagalassos, an attempt was made to reconstruct their diet, absolute age and season of death. Teeth, with their high durability and high incidence in the archaeological record, seemed to promise the most in the achievement of this goal. The analysis of cementum surrounding the roots of teeth can indicate the age at and the season of death. Cementum, being a bone-like connective tissue, is formed appositionally throughout the life of an animal or until the tooth falls out (Hillson 1990). When studying the cementum under transmitted, polarized light, alternating opaque and translucent incremental bands can be observed. Taking into account the moment of tooth eruption, the number of bands can indicate the age at death, while the nature of the outermost band can provide information on the season of death (Lieberman 1994; Burke and Castanet,1995). Microscopic defects or dental microwear, present on the surfaces of teeth, can be linked to the diet of the animal. Microwear has already proven its potential for dietary reconstructions in studies of humans, primates, carnivores and ruminants (e.g. Solounias *et al.* 1988; van Valkenburgh *et al.* 1990; Mainland 1994; Ungar and Teaford 1996). The latter studies stress the fact that for purposes of reconstruction, an unambiguous relationship needs to be established between the diet and the dental microwear in recent relatives of the species in question. Prior to the interpretation of dietary preferences and the age at and season of death of historical sheep and goats, it is necessary to be able to distinguish fossil teeth from the two different species. Macroscopic morphological differences between sheep and goat mandibulae or teeth, especially in the case of adult animals, are not decisive (Boessneck *et al.* 1964; Payne 1985). To be able to differentiate between the fossil teeth, the method developed by Grine *et al.* (1986; 1987) was chosen. In this method the ultrastructural prism packing pattern of the enamel is visualized. In addition, a number of metrical parameters are determined and compared statistically, thus, permitting the identification of sheep versus goat teeth.

Materials and methods

A standardised method was designed to assess the dietary patterns of sheep and goats. The method involved a vegetation study of the grazing area for the determination of the forage availability and the grazing land structure. To this end quadrats with a surface of 100 m^2 were set out randomly in the grazing area. The species composition, cover and abundance were determined in each quadrat (three in the grazing area of goats, three in the grazing area of sheep) using Londo's scale. Plant species were collected for identification using the Flora of Turkey (Davis 1965-1988). Secondly, a study was conducted of the grazing behaviour of the sheep and goats using the direct observation method (Van Mele and Anthonysamy 1994; Van Mele *et al.* 1994a; Van Mele *et al.* 1994b; Van Mele 1997). This method was developed to determine the food intake of sheep and goats in a qualitative and quantitative way. The sheep and goat herds were observed over 10 days and special attention was paid to individuals (10 sheep and 10 goats) selected at the beginning of the study for slaughtering. The food plants were identified and the time spent on each plant was measured to the nearest second using a chronometer. Distances travelled were determined using a pedometer To learn more about the present-day management of sheep and goat herds, an interview was conducted with the respective sheep and goat herders.

In June 1996, sheep and goat herds were observed in the valley of Peçenek near Çeltikçi (37°32'N 30°31'E), located about 11 km south of Sagalassos. The valley of Peçenek is situated at an elevation of 900 to 1000 m above sea level. The average June temperature in the region is 25 °C. The grazing land could be characterised as a mixed vegetation of dispersed, isolated low shrubs and deteriorating herbs and grasses.

During winter, sheep were kept in folds and foddered with, for example, maize, beet. Since these fodder types were not present in Roman times (Smart and Simmonds 1995) we decided not to observe sheep herds in February 1997. Goat herds observed in February grazed the hills around Lake Egirdir. In August 1997, a sheep and a goat herd were observed which had their grazing areas close to the village of Aglasun, on the flanks of Mount Akdag (37°41'N 30°31' E). After the observational period, the animals were slaughtered, their skulls and skeletons prepared and consequently transported to the Royal Museum of Central-Africa (Belgium) for further research.

The dental microwear present on the occlusal surface (buccal phase I shearing facet) of the right M_1 of sheep and goats, was studied. Since microwear patterns are affected by facet type and molar position (Gordon 1982), we decided to study the same facet used in previous studies (Mainland 1994). To study the dental microwear, a replica of the tooth is made in order to conserve the actual tooth. The procedure involves three steps: the construction of a negative replica of the tooth using the Coltène President microsystem™ regular body, the positioning of the negative replica in putty (mixture of a base and catalyst of Provil®P Bayer Dental) and the construction of a positive replica (resin: Araldite D with Hardener HY 956, Ciba) using the negative replica as a mould. The positive replica is sputter-coated (sputter-coater Baltec, SCD-005) for 90 s at 35 mV (gold layer of 200 Å). The coated replica is examined in a scanning electron microscope (Jeol 5400 LV). To conduct the qualitative analysis, a micrograph of the aforementioned facet is made at 10 kV at a magnification of 350 X. The image analysis is conducted using AnalySIS.

In the qualitative analysis, the dental microwear present on the occlusal surface of the tooth is described by indicating the presence or absence of 18 qualitative categories (Mainland 1994 with modifications) for each individual tooth examined. The teeth of 60 animals (20 sheep from June 1996 and August 1997, as well as 40 goats from June 1996, February 1997 and August 1997) were examined qualitatively.

Results

Qualitative analysis of dental microwear

When comparing the distributions of the qualitative categories in the goat samples from June 1996, February 1997 and August 1997 (Fig.1), it is obvious that two types of categories (features with a definite shapes and shallow features) are present in 100 % of the teeth from all three periods. In June 1996, the most common are pits (100 %), non-parallel striations (89 %) and features with a mesio-distal orientation (78 %). A porous surface is very rare (11 %) and lined up pits are not present in the microwear of the goats grazing in June 1996. Most individual goats observed in February 1997 showed the presence of a smooth surface (94 %) and of pits (89 %). Features having a mesio-distal or bucco-lingual orientation were also highly represented, the former in 84 % of goats and the latter in 83 % of individuals respectively. No cracked surfaces could be found in this sample and the presence of abraded surfaces was very rare (17% of individuals). The goat samples from August 1997 were characterised by the presence of pits, non-parallel striations and features with a bucco-lingual orienta-

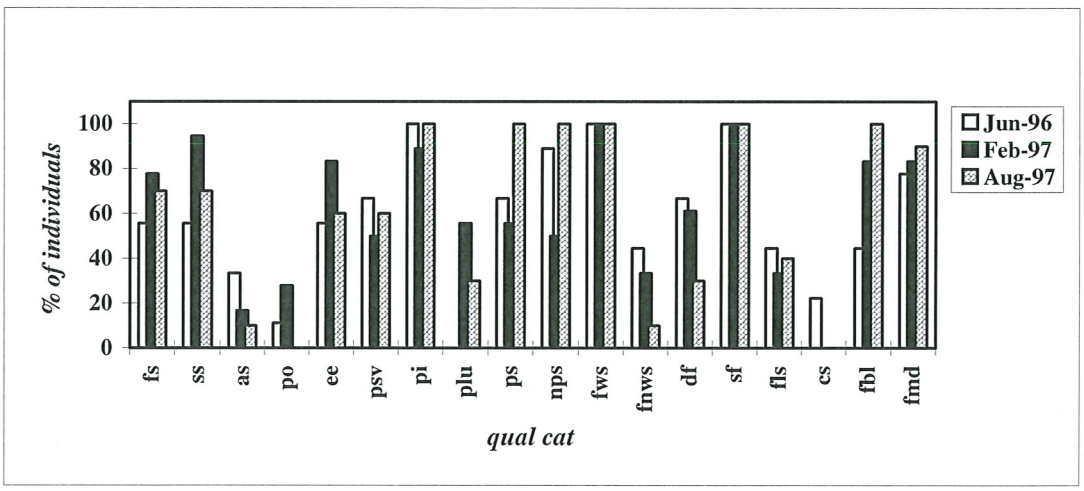

Fig 1. Distribution of qualitative categories in the goat sample, (*fs= flat surface, ss= smooth surface, as= abraded surface, po= porous surface, ee= empty enamel, psv= prism structure visible, pi= pits, plu= lined up pits, ps= parallel striations, nps= non-parallel striations, fws= features with a definite shape, fnws= features without a definite shape, df= deep features, sf= shallow features, fls= flaking surface, cs= cracked surface, fbl= features with a bucco-lingual orientation, fmd= features with a mesio-distal orientation*)

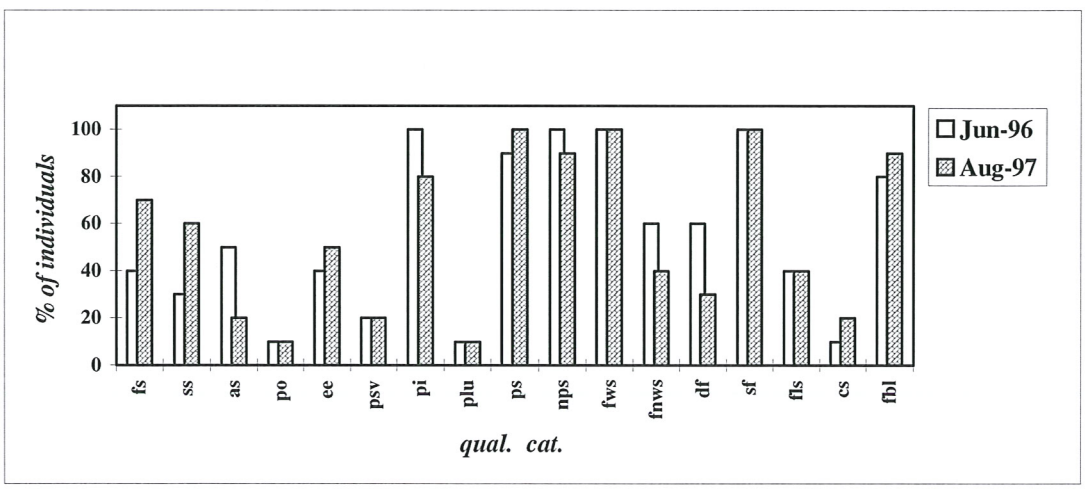

Fig 2. Distribution of qualitative categories in the sheep sample (For abbreviations: see Fig. 1)

tion (100 % of individuals in all 3 cases) while features with a mesio-distal orientation were present in 90 % of teeth examined. Porous or cracked surfaces were not found. Abraded surfaces and features without a definite shape had a very low incidence (both only 10 %).

A discriminant analysis (backward stepwise discrimination) showed the emergence of three groups (June-February-August) in the goat sample based on the presence or absence of the non-parallel striations. A Fisher exact test indicated the presence of significantly fewer individuals with lined up pits ($p< 0.05$) and a significantly higher number with non-parallel striations ($p<0.05$) in June 1996 compared to February 1997. In August 1997, significantly more goats showed non-parallel and parallel striations compared to February 1997. No significant differences, however, were noted in the distribution of qualitative categories between June 1996 and August 1997.

The distribution of qualitative categories in the sheep sample from June 1996 and August 1997 is very similar. In both periods pits, parallel striations and non-parallel striations are common (Fig. 2). As in the goat sample, features with a shape and shallow features are present in all individuals examined. A porous surface, surfaces with the underlying prism structure visible and cracked surfaces are very rare. There were no significant differences found between the two periods in the distribution of the qualitative categories in the individuals examined (Fisher exact test, $p>0.05$).

When comparing the distribution of qualitative categories over the individuals examined between the goat and sheep samples from June 1996 and August 1997, it was found using the Fisher exact test, that in June 1996 significantly more goats than sheep ($p<0.05$) had teeth where the underlying prism structure was visible. In August 1997, however, no significant differences were found (Fisher exact test, $p>0.05$).

Preliminary analysis of dietary intake

Discussion of the vegetation is restricted to broad plant classes ("grass", "herb", "shrub" and "tree") since the identification to species level has not yet been completed. It is obvious that in both June 1996 and August 1997, sheep consume proportionally more grasses and herbs than trees or shrubs, while goats, although they consume grasses and herbs as well, feed on a higher proportion of trees and shrubs. In June 1996 sheep and goats together consumed 39 different plant species, representing 22 different plant families. Goats consumed 22 different plant species while sheep ate 20 different plant species. Goats ate significantly more herb species (63 % of total number° of species eaten) than trees or shrubs (28 %) and grasses (10 %; χ^2 goodness-of-fit, $p<0.01$; Fig. 3). Looking at the feeding times in February 1997 we noted that 90 % was spent on the consumption of shrubs or trees. In August 1997 goats spent significantly more feeding time on shrubs and trees (73%) than on grasses and herbs (9 % and 18 % of time respectively; χ^2 goodness-of-fit, $p<0.01$; Fig. 4).

Of the total number of species eaten, sheep's diet was 15 % grasses, 75 % herbs and 10 % trees (Fig. 3). Considering the time spent eating each species in August 1997 sheep spent 53 % of their time eating grasses, 38 % herbs and 9 % shrubs. The χ^2 goodness-of-fit test showed these differences were again significant (Fig. 4).

When comparing the feeding habits of sheep and goats in June 1996, it was found that the differences in the number of species eaten in the various plant classes was not significantly different (χ^2 goodness-of-fit, $p>0.05$). However, in August 1997, goats spent significantly more time eating shrubs and trees and significantly less time consuming grasses and herbs than did sheep (χ^2 goodness-of-fit, $p<0.01$).

Discussion and conclusions

Although the qualitative analysis of dental microwear patterns has often been criticised as being too rough to indicate subtle differences in microwear patterns or being too subjective (Gordon 1988; Teaford 1991), the study of Mainland (1994) demonstrates the value of qualitative analyses as a complement to quantitative analyses of dental microwear. Qualitative analysis can indicate the presence of features or indicate differences in texture that, using only the quantitative analysis, would have remained unnoticed. In our study, the qualitative analysis indicated a difference in the dental

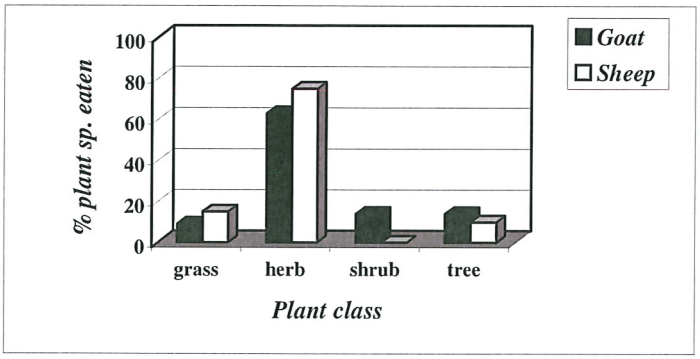

Fig 3. Proportion of different plant classes eaten by sheep and goat in June 1996

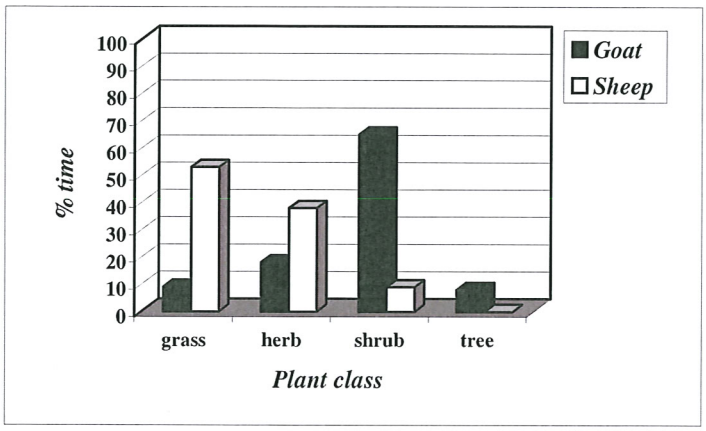

Fig 4. Proportion of plant classes eaten by sheep and goats in August 1997

microwear patterns of goats between the winter (February 1997) and summer (June 1996 and August 1997) periods. In the winter period more goats had pit lines on the occlusal surface of their teeth but fewer goats displayed parallel or non-parallel striations on their teeth than in the summer period. A similar discrimination between periods, based on the category of non-parallel striations, was revealed by a discriminant analysis. For June 1996, the qualitative analysis of the dental microwear also indicated that a significantly higher number of goats compared to sheep had a visible prism structure on their teeth.

To be able to interpret these data, a thorough study of the feeding habits of sheep and goats has been conducted. When the number of plant species eaten is considered (as in June 1996) it appears that both goats and sheep consume mostly herbs. However, when the time of feeding is considered, sheep can clearly be described as grazing animals and goats as browsers. This observation is in accordance with other studies on the feeding behaviour of sheep and goats. Papachristou (1997) studying sheep and goats ranging on Mediterranean kermes oak (*Quercus coccifera*) shrublands found browsed plant material constituted less than 30 % of the total number of species eaten by sheep while for goats this constituted between 51% and 90 % of the diet. Similarly Dumont *et al.* (1995) found that the goats diet (in % of dry matter intake) was composed of 89 to 90 % browsed material. The very low consumption of grasses and herbs by goats in February 1997 may possibly explain the significantly lower number of goats with non-parallel striations compared to June 1996 and August 1997 and the significantly lower number of goat teeth with parallel striations compared to August 1997. Grasses are known to contain phytoliths, calcium oxalate or opal crystals which can scratch the enamel (Baker *et al.* 1959; Bullington 1991).

The use of such results to make predictions about the diet consumed by historical sheep and goats based on their dental microwear, is however very small. Although the qualitative analysis indicated

the existence of significant differences in the number of individuals whoseteeth displayed the presence or absence of certain qualitative categories in the three periods considered, no unambiguous relationship between diet and dental microwear patterns could be established as yet. Subsequent quantitative analyses will hopefully help to establish such an unambiguous relationship and will add to the predictive value of the microwear patterns.

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