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BUCCAL DENTAL MICROWEAR AS A DIETARY INDICATOR IN THE IRON AGE HUMAN POPULATION FROM SON REAL, SPAIN

ABSTRACT: Dental microwear has been studied in a sample of 26 individuals from Son Real, Mallorca (Spain). These individuals fall into the Iron Age; this is well recognized as Talayotic culture in Balearic Islands' periodization (7th to 6th century BC). Moulds of their molars and premolars were made and observed at 100× magnification in secondary electrons mode of scanning electron microscopy. The length, orientation and density of these striations have been analyzed with the image analysis software SigmaScan Pro 5.0. Results obtained from this sample were compared with previous studies from various modern hunter-gatherers, pastoralists, and agriculturists with different diets (Inuits, Fueguians, Bushmen, Australian aborigines, Andamanese, Indians from Vancouver, Veddahs, Tasmanians, Lapps, and Hindus) (Lalueza et al. *1996). The buccal microwear pattern in Son Real shows similarities with Bushmen, Tasmanians, and Veddahs, both from tropical and arid climates. The reconstruction of the dietary strategy of the Son Real population suggests that they were heavily depending on abrasive plant foods, with a reduced amount of meat intake; a significant difference in food gaining and processing by gender has been deduced as well.*

KEY WORDS: Buccal microwear – Scanning electron microscopy – Hunter-gatherers – Agriculturalists – Diet – Talayotic culture – Balearic Islands

INTRODUCTION

Dental microwear analyses have been abundantly performed in skeletal collections of various time periods, both on occlusal and buccal surfaces of teeth. Occlusal microwear research has yielded valuable information in both extant and fossil primates, as well as in hominid teeth (Teaford, Walker 1984, Teaford 1985, Teaford, Robinson 1989, Teaford, Glanger 1991, Teaford, Runestad 1992, Grine 1986, Ungar 1996, Ungar *et al.* 2001, 2004, El-Zaatari *et al.* 2005). Three dimensional microwear techniques and scale-sensitive fractal analyses have also been applied to microwear research (Scott *et al.* 2005). Research has also been focused on the microwear of occlusal surfaces in human posterior teeth (Schmidt 2001, Gügel 2003, Organ *et al.* 2005, Mahoney 2006a, b). Nevertheless, the interpretation of these analyses seemed to be a complex matter because inferences on jaw biomechanics, masticatory effort (Kay, Hiiemae 1974, Puech *et al.* 1980, Gordon 1982, Gordon, Walker 1983) and food character (Teaford, Runestand 1992) were lacking. On the other side, buccal microwear analyses seem to be more suitable for dietary interpretation because of the exclusion of tooth-to-tooth contact during mastication and the reduced number of microwear feature morphologies to be analyzed. Buccal microwear patterns have been studied in numerous past human populations, focusing on the characterization of the intra- and inter-populational variability of the postcanine dentition (Puech, Pant 1980, Pérez-Pérez *et al.* 1994, Lalueza *et al.* 1996, Pérez-Pérez 1990, 2004). Vestibular microwear patterns reflect differences in both diet composition and food processing techniques among the studied groups. The

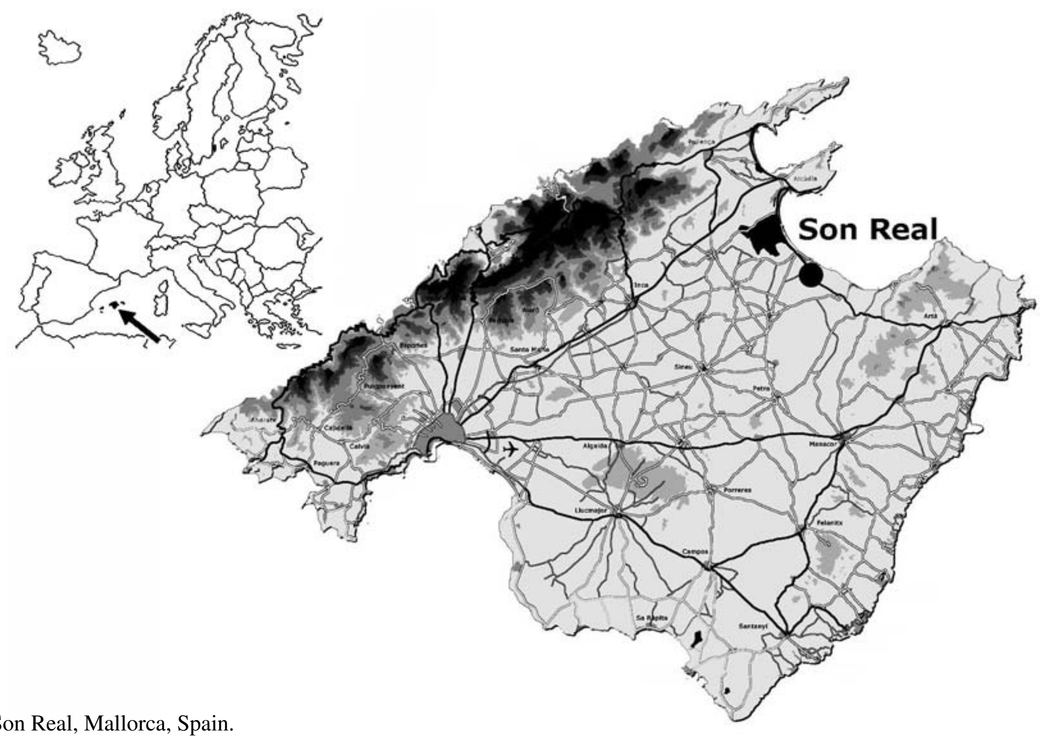


FIGURE 1. Son Real, Mallorca, Spain.

predominantly vertical mandible movements in meat eaters compared to vegetarians, and the high incidence of abrasive particles in plant foods result in higher scratch densities and an increasingly horizontally oriented vestibular microwear pattern in agriculturalist populations (Lalueza *et al.* 1996). Embedment and classification of phytoliths in enamel surfaces has proved a direct relationship between phytoliths and diet in previous research made by Lalueza Fox and his colleagues (1994) in the Middle Ages La Olmeda sample using SEM and X-ray microanalysis. In addition, buccal microwear is independent from the analyzed teeth and the interpopulation variability seems to be significantly larger than the intrapopulation one. Along these observations, buccal striation pattern also seems to be independent on seasonal variations in dietary habits that do not significantly affect vestibular surface because of its long-termed "turnover" effect in comparison to the occlusal one (Pérez-Pérez *et al*. 1994). Application of buccal microwear procedures seems to be very fruitful in dietary inferences for fossil human samples (Lalueza Fox, Pérez-Pérez 1993, Lalueza *et al.* 1993, Pérez-Pérez *et al.* 1999, 2003, etc.) and for primates as well (Galbany *et al.* 2004b, 2005). Topographic 3-D research has also been applied to buccal surfaces using interferometric quantification of enamel roughness (Estebaranz *et al.* 2006).

The choice of surface to analyze depends on the type of information that is foreseen by performing microscopic analysis of tooth enamel (Pérez-Pérez *et al.* 1994). In the present research we chose to analyze the buccal tooth striation pattern to study the archaeological human sample from Son Real, since comparative data was not available for occlusal surfaces. By carrying out this procedure, we tried to infer information on food gaining and processing with regards to ecological conditions, pointing out its intra-group variability within one geographical area in different chronological periods and comparing with previously studied modern human agriculturalists.

MATERIAL

Son Real

The north-eastern coast of Mallorca, the largest of the Balearic Islands (Spain) (*Figure 1*), is rich in archaeological remains of the prehistoric Talayotic culture. In excavations of 1957 and 1958 till 1969 remains of the ancient necropolis of Son Real near the shore of Alcudia Bay have been discovered, southeast of the modern touristic centre of Can Picafort. Seventy-four tombs and funeral-like constructions from Son Real were studied after the archaeological campaigns in the fifties and sixties when main archaeological documentation was made (Tarradell, Woods 1959, Tarradell 1964). Subsequent re-examinations of more than one hundred inhumations showed at least six types of tombs (Tarradell, Hernández Gasch 1998). As a result of this archaeological revision, mainly based on multi-approach sociocultural studies, two volumes dedicated to this site were published (Hernández Gasch 1996, 1998, Tarradell, Hernández Gasch 1998).

The necropolis occupies a relatively small area, considering the high number of tombs and size. The tombs are crowded close together without any fixed orientation (Tarradell, Woods 1959). The site shows evidence of an earlier pre-Roman occupation that, on the basis of ceramic remains, seems associated with the unique Talayotic culture, not exclusive in the Balearic Islands, but also in

TABLE 1. List of twenty-six studied individuals and moulds from Son Real, Spain (F=female, M=male, ?=ambiguous). Can Picafort is a location within the Son Real site.

Provenance	Skull No.	Gender	Age	Studied tooth
Son Real	6-1	?	12–15 yrs	M1UL
Son Real	65-8	?	35–50 yrs	M1UL
Son Real	S039	F	20–35 yrs	M1UL
Son Real	1-67-A; No. 1; 4408	F	20–35 yrs	M1UL
Son Real	70-1	F	20–35 yrs	M2 UL
Son Real	43-1	F	20–35 yrs	M1UL
Son Real	1-67-1; No. 2; 4409	M	20–35 yrs	M1UL
Son Real	47-3	M	20–35 yrs	M1UL
Son Real	56-1	M?	35–50 yrs	M1UL
Son Real	0001	?	15–19 yrs	M1UL
Son Real	4401	?	20–35 yrs	M1UL
Son Real	29-7	?	35–50 yrs	M1UL
Son Real	1	?	50+ yrs	M1UL
Son Real	4402	?	20–35 yrs	M1UL
Son Real	43-1	?	35–50 yrs	Pm3UL
Son Real	29-6	M?	35–50 yrs	M1UL
Son Real	71-1	F	35–50 yrs	M1UL
Son Real	2-3	M	35–50 yrs	M1UL
Can Picaford	20-1	M	20–35 yrs	M1UL
Can Picaford	36-1	M?	20–35 yrs	M1UL
Son Real	S070	?	35–50 yrs	M1UL
Son Real	1-67-A; No. 5; 6705	M	20–35 yrs	M2UL
Can Picaford	47-15	M	35–50 yrs	M1UL
Son Real	S-01	M	35–50 yrs	M1UL
Son Real	47-1	M	35–50 yrs	M1UL
Son Real	1-67-A; No. 3	M	20–35 yrs	M2UL

the Western Mediterranean area. This name, derived from the Spanish word *atalaya*, or watchtower, refers to the square or round towers of cyclopean masonry associated with the Bronze and Iron Ages of Mallorca's and Menorca's history. As shown by radiocarbon dates and supported according to the burial inventory, the time of greatest use of this necropolis would seem to fall between the turn of the seventh and sixth centuries BC. Its maximum date limit is placed to the first century BC, when some of these tombs were still sporadically re-used during the Roman period of this island. The main use of this necropolis falls into the Iron Age of the Balearic periodization, or "post-Talayotic" culture as well (Pericot 1975, Tarradell, Hernández Gasch 1998). This cemetery provided not only great amount of burial goods referring to contacts with Carthaginians and Phoenicians (Tarradell, Woods 1959), but it is also a site of exceptional importance owing to the anthropological collection unearthed, a unique series of complete skeletons.

This Son Real collection has been studied by various researchers who provided specialized results in anthropological investigation (Tejerina 1972, Font Serra 1973, Campillo 1977). Dr. Font Serra at Universitat de Barcelona (Font Serra 1973, 1977) performed the most precise and comprehensive study of the cranial adult series. Apart from these anthropological studies, a sex and age-at-death determination based on cranial remains was also done, with special attention to the appendicular skeletons. Unfortunately this unpublished work has been presented on mean data values, lacking any linkage between specific individuals and grave numbers, which complicates subsequent identification of these skulls within the burial ground. On this account, it was impossible to assign to our analysis precise grave numbers as was published in Hernández Gasch (1998) and Tarradell and Hernández Gasch (1998). Sex and age-at-death determinations were obtained from the incomplete unpublished sheets made by Dr. Font Serra that are currently stored at the Universitat de Barcelona archive. Ambiguous individuals were let undetermined because of fragmentary state of upper jaws. A random sample of 24 adults and two subadult individuals were finally studied (*Table 1*).

Comparative modern human samples

Buccal microwear has also been studied in a modern human sample from different parts all over the world and

TABLE 2. Data and symbols used for the comparative samples in this paper. All comparative data followed research made by Lalueza *et al.* 1996.

Population	Provenance	Number of studied individuals	Source of food (Lalueza, Pérez-Pérez 1993, Lalueza *et al.* 1996)	Ecological criterion (Lalueza, Pérez-Pérez 1993, Lalueza *et al.* 1996)	Used symbol	Used symbol according to the gender
Hindu	Bihar and Orissa, Central India	20	agriculturalist (farmers)	agriculturalist	AG_Hin	AG_F, AG_M
Fueguians	Tierra del Fuego, Argentina, Chile	20	hunter-gatherer	carnivorous	CR_Fue	CR_F, CR_M, CR_?
Inuit	Greenland	20	hunter-gatherer	carnivorous	CR_Inuit	
Vancouver islanders	Island of Vancouver, Canada	17	hunter-gatherer	carnivorous	CR_Van	
Lapps	Finland, Russia	5	hunter-gatherer (nomadic pastoralists)	carnivorous	CR_Lapp	
Andamanese	Andamand Islands, Gulf of Bengala	18	hunter-gatherer	tropical forest	TR_And	TR_F, TR_M, TR_?
Veddahs	Sri Lanka	9	hunter-gatherer	tropical forest	TR_Vedd	
Bushmen	Kalahari desert, mainly south Africa	15	hunter-gatherer	arid	AR_Bush	AR_F, AR_M, AR_?
Tasmanians	Tasmania	11	hunter-gatherer	arid	AR_Tasm	
Australian aborigines	central, west and north Australia	18	hunter-gatherer	arid	AR_Aust	
Son Real, Can Picaford	Mallorca, Balearic Islands, Spain; 7th-6th century BC	26	Iron Age sample	inferred	Son Real	SR_F, SR_M, SR_?

yielded unique anthropological material for interpretation of different alimentary strategies arisen from different ecological conditions and food gaining (Lalueza *et al.* 1996). These populations were classified into several distinct groups: meat eaters from high latitudes (Inuits, Fueguians), mix-diet hunter-gatherers, both from arid and tropical environments (Bushmen, Australian aborigines, Andamanese, Veddahs, and Tasmanians), fish-eaters (Indians from Vancouver), pastoralists (Lapps), and agriculturalists (Hindus). For a clear interpretation of microwear data with regard to ecological criteria, it is possible to cluster these samples into four broad groups (Lalueza *et al.* 1996): 1) agriculturalists (Hindu sample – strictly vegetarian due to their religion), 2) hunter-gatherer populations from the tropical forest (Andamanese and Veddahs), 3) carnivorous hunter-gatherer and pastoralists meat eaters, including Fueguians (mainly hunting and fishing), Inuits (exclusively hunting strategies), Vancouver Islanders (fishing and sea mammals hunting), and Lapps (predominantly reindeer herding); and 4) hunter-gatherer populations from arid and mesothermal environments, including Bushmen, Australian aborigines and Tasmanians, i.e. populations characterized as mix-diet hunter-gatherers (Gusinde 1937, De Poncins 1941, Vanstone 1962, Lee, DeVore 1968, Suttles 1968, Orquera *et al.* 1977, Draper 1978, Chapman 1986, Lanzeby, McCormack 1985, Reader 1988, In: Lalueza *et al.* 1996). These comparative groups show distinct alimentary strategies and their diet is assumed to be homogeneous according to dietary habits *(Table 2)*. These comparative samples, nowadays stored in various museum collections, consist of 153 molar teeth from which moulds were made and buccal surface analysis at 100× magnification in scanning electron microscope was performed (Lalueza *et al.* 1996). All this information and the results are borrowed from the elaborate work made by Lalueza and his colleagues (Lalueza, Pérez-Pérez 1993, Lalueza *et al.* 1996). Sample size of comparative samples corresponds to summary statistics for average values as it was published by Lalueza (Lalueza *et al.* 1996: Tables 3 and 4).

METHODS

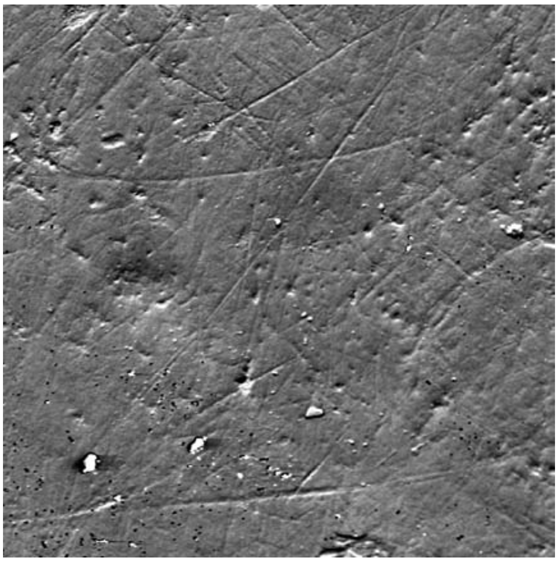
Data collection

Teeth moulding. The upper left first molar was preferably analyzed in all of 25 adults and one subadult from Son Real studied *(Table 1)*. If the M1UL was not present, the second upper left molar or premolar from the same row was studied. Only one tooth per individual was analyzed in order to characterize striation pattern of each individual.

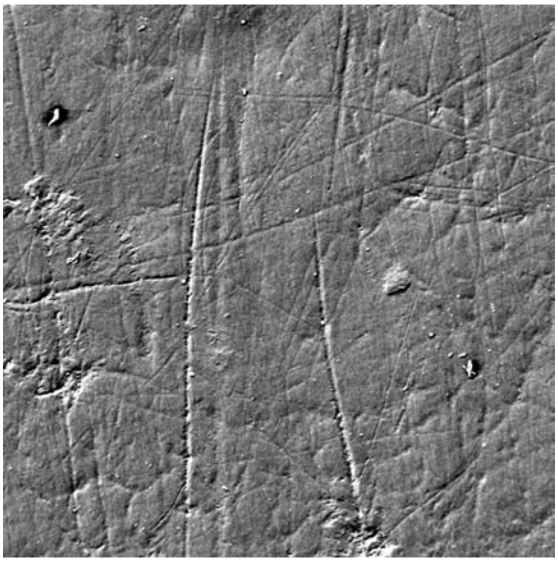
Prior to the tooth moulding, its enamel surfaces were cleaned with pure acetone, to remove chemical preservatives, and subsequently rinsed with 96% ethanol using a cotton ear-cube. All teeth with damaged enamel, presence of tartar deposits or other enamel defects were

FIGURE 2a–f. SEM images of selected individuals studied from Son Real, Spain. Each square surface analyzed covers exactly 0.56 mm^2 of buccal enamel surface. Occlusal surface faces the top of micrograph.

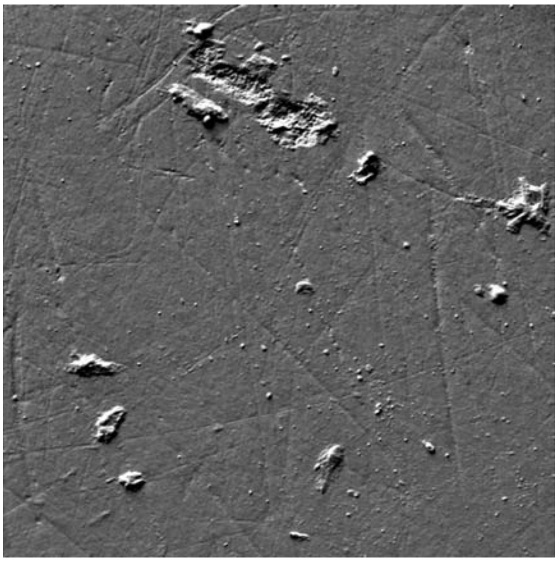
a: Young adult female from Son Real No. 70-1



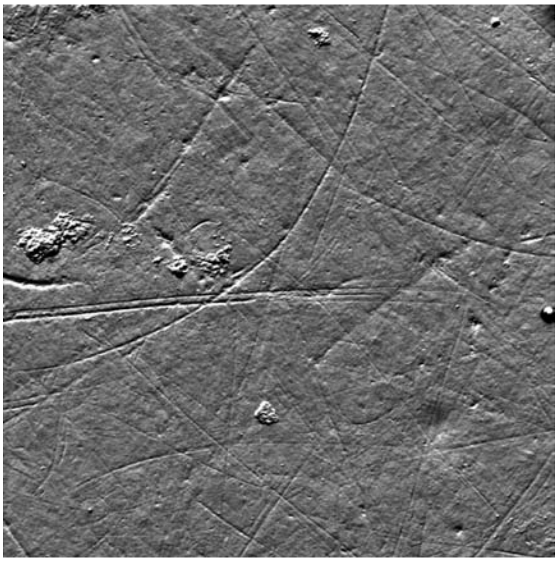
b: Young adult female from Son Real No. 43-1



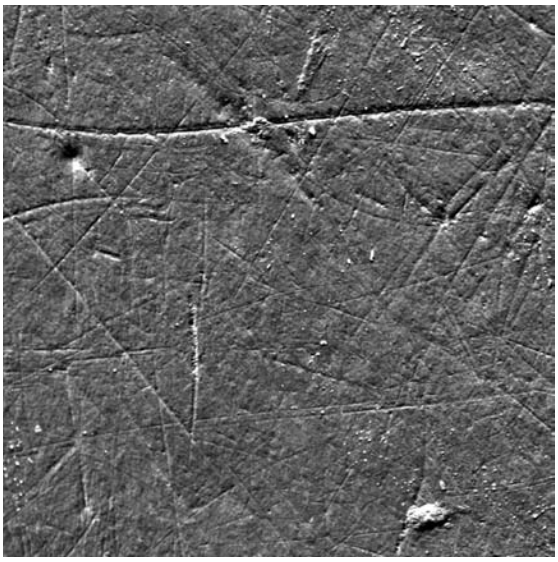
c: Adult female from Son Real No. 71-1



d: Subadult individual from Son Real No. 0001



e: Adult male from Son Real No. 56-1



f: Adult male from Can Picaford No. 47-15

excluded from analysis. A two-stage technique was used to make moulds of the original dental materials for preserving the original specimens (Beynon 1987). Negative replicas of the buccal surface of the analyzed teeth were obtained using polyvinylsiloxane *Regular Body* of *President microSystem™* (*Coltène®*) (Ungar 1996, Ungar, Spencer 1999, Galbany *et al.* 2004a). Before casting a wall was build around the mould with the moulding material (Rose 1983). Epoxies have been widely used for casting purposes in dental microwear research (*Epo-Tek #301* for instance) in order to make positive replicas (Teaford, Oyen 1989), as well as other materials (*Triafol* for instance – Lalueza, Pérez-Pérez 1993, Lalueza *et al.* 1993, 1996, Pérez-Pérez *et al.* 1994). In the present study, the positive moulds were made with the fast, bicomponent polyurethane resin *Feroca Feropur PR 55 + E 55* (parts A and B). The main advantages in using this resin are excellent fluidity, ease to work with, and speed in its complete hardening. In an experimental study made by Galbany (Galbany *et al.* 2004a) there were no proven differences in surface fidelity between Feropur PR-55 and its epoxy alternative Epo-Tek #301; moreover the total hardening time in room temperature was shorter for Feropur. Before pouring this resin into the negative casts, both parts of Feropur were thoroughly mixed in a 1:1 weight ratio, followed by a 2,500 rpm centrifugation in order to eliminate air bubbles from the positive replicas and ensure high quality casting, as shown by previous researches (Waters, Savage 1971, Rose 1983). It is recommended not to manipulate the mould until six to eight hours after making the positive cast, till the resin is not sticky to the touch (Rose 1983). The tooth replicas were mounted with term fusible gum on aluminum stubs and a colloidal argent belt (Electrodag 1415M-Acheson Colloiden) was applied for electron dispersal in the plastic cast, to prevent accumulation of electrostatic charges during SEM observation (Rose 1983). Finally, the sample was sputtered coated with a 400 Å gold layer using Polaron Equipment E5000 to allow observation into the SEM. All replicas were kept in dark inside plastic storage boxes to maintain them dust-free, clean and dry (Galbany *et al.* 2004a). All these procedures are necessary for obtaining high resolution positive casts of the original teeth, dimensionally precise and capable to resolve fine surface details (Beynon 1987).

SEM imaging. Before SEM imaging, all teeth were observed at 40× magnification with a VMT Zeys binocular magnifying glass in order to detect well-preserved enamel surfaces on each tooth. Damaged enamel surfaces were not included in the studied sample. However, some analyzed teeth finally proved to be useless because of their extensive enamel damage that was not observed until SEM analysis, showing clear evidence of erosive post-depositional or taphonomic processes affecting some enamel surfaces.

SEM pictures of well-preserved, non-damaged enamels surfaces were obtained with the Cambridge Stereoscan 120 Scanning Electron Microscope at the *Serveis Cientifico-Tècnics* (SCT) of the University of Barcelona. In all cases, casts were placed in a horizontal position, with zero degrees of tilt. SEM pictures were taken at 100× magnification on the medial third of the buccal surface of the tooth crown, avoiding both the occlusal and cervical thirds of the tooth, as this is the standard procedure for buccal microwear analyses in order to infer dietary habits (Pérez-Pérez *et al.* 1994). All images were obtained under SEM standardized conditions with low electron acceleration (10–15 KV), working distance (WD) ranging between 15–25 mm, and secondary electron mode. All SEM pictures were digitalized with a SEM Image Slave software, obtaining a 1024×832 pixels image. These images were subsequently enhanced with Adobe Photoshop v.5.0 using a standardized procedure throughout the whole sample: the selected area was cropped in order to cover an enamel surface area of 0.56 mm^2, a high-pass filter at 50 pixels was used to remove shade effects on the image, and an automatic adjustment level was applied to increase image contrast (*Figure 2a-f*), followed by microwear feature measuring with SigmaScan Pro 5.0 by SPSS (Pérez-Pérez *et al.* 2003, Galbany *et al.* 2004a). Using this image analysis software package, the length (X), standard deviation of the length (SD), the density (N) of all presented striations (T), as well as four categories orientationin 45-degree intervals were determined. These four categories of striation orientation were considered following the modification by Pérez-Pérez (1990) of the original methodology of Puech *et al.* (1980). The orientation was recorded as a continuous variable (from 0˚ to 180˚) with regard to the cemento-enamel junction of the tooth and then grouped into discrete categories depending on the tooth considered: V=vertical, MD=mesio-occlusal to disto-cervical, DM=disto-occlusal to mesio-cervical and H=horizontal (Pérez-Pérez 1990, Lalueza, Pérez-Pérez 1993, Lalueza *et al.* 1993, 1996). With this procedure, a total of 15 variables were considered: 1. NV Number of V (67.5˚–112.5˚) striations; 2. NH Number of H (0˚–22.5˚ and 157.5˚–180˚) striations; 3. NMD Number of MD (112.5˚–157.5˚ for the lower left and upper right teeth; 22.5˚-67.5˚ for the lower right and upper left teeth); 4. NDM Number of DM (22.5˚–67.5˚ for the lower left and upper right teeth; 112.5˚–157.5˚ for the lower right and upper left teeth); 5. NT Total number of striations; 6. XV Average length of the V striations; 7. XH Average length of the H striations; 8. XMD Average length of the MD striations; 9. XDM Average length of the DM striations; 10. XT Average length of all striations; 11. SV Standard deviation of XV; 12. SH Standard deviation of XH; 13. SMD Standard deviation of XMD; 14. SDM Standard deviation of XDM; 15. ST Standard deviation of XT. Variables NV, NH and NT were then combined and three indices were calculated: NH/NV, NH/NT and NV/NT. The procedure described was the same as that used in the comparative hunter-gatherer populations (Lalueza *et al.* 1996).

Data analysis: Quantification

Mean values for each individual were computed. Thus, each tooth was characterized by summary statistics of the fifteen

TABLE 3. Descriptive statistics of all 15 variables by 26 individuals from Son Real, Spain.

	Valid N (listwise)	Minimum	Maximum	Mean	Std. deviation
NH	26	5.00	43.00	19.92	10.07
XH	26	69.24	202.41	151.60	31.32
SDH	26	31.69	218.08	136.93	45.80
NV	26	5.00	66.00	23.81	16.24
XV	26	129.94	305.67	209.83	45.22
SDV	26	69.96	206.52	134.82	41.47
NMD	26	5.00	49.00	22.88	11.10
XMD	26	111.28	305.06	177.42	46.87
SDMD	26	49.36	246.99	132.29	46.48
NDM	26	5.00	36.00	21.08	8.74
XDM	26	74.49	195.86	138.27	28.66
SDM	26	45.94	224.37	112.20	44.12
NT	26	63.00	119.00	87.69	14.24
XT	26	136.50	223.55	173.65	25.86
SDNT	26	112.84	190.89	141.64	25.62

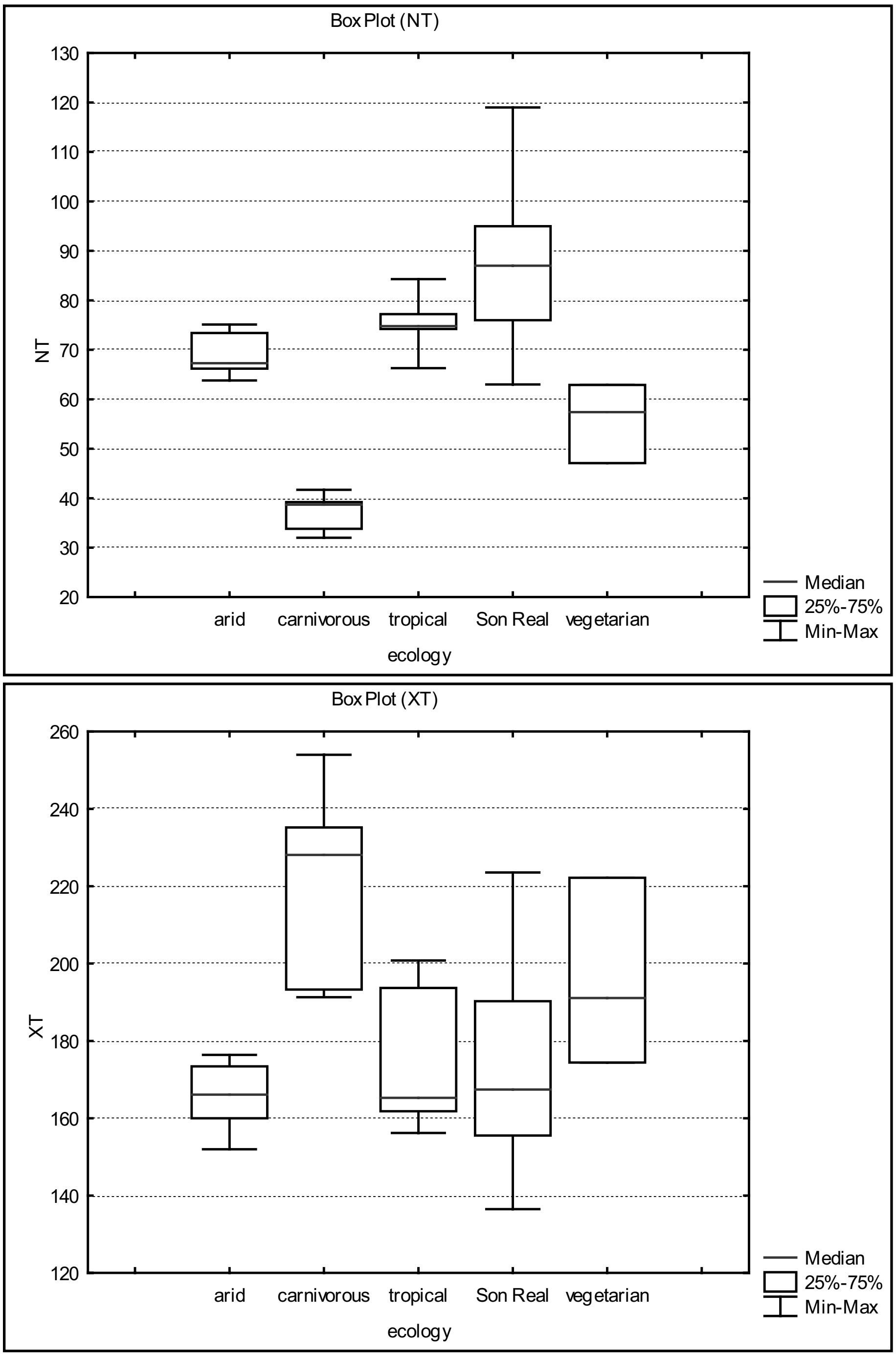
variables studied, including the density of striations, the average length, and the standard deviation of the length of all observed striations (Lalueza, Pérez-Pérez 1993, Lalueza *et al.* 1993). To compare the microwear patterns between the analyzed sample and the previously studied hunter-gatherer groups, one-way ANOVA and Cluster analyses were made. The normality distributions of all microwear variables were tested with the Kolmogorov-Smirnov normality test. All statistical analyses were performed with SPSS 14.0 Inc., and STATISTICA 7.0 StatSoft Inc. (2004) packages.

RESULTS AND DISCUSSION

The sample of 24 adults and two subadult teeth from Son Real had total of 2,280 determined striations; so the average number of striations per individual was 87.69 (NT). Kolmogorov-Smirnov normality test confirmed normal distribution for all the variables studied. Mean values, minimum, maximum, and standard deviation values for all fifteen variables of the twenty-six individuals from Son Real are shown in *Table 3*. Using multiple comparisons of mean ranks for all variables, Kruskal-Wallis ANOVA proved statistically significant difference between male and female individuals within the Son Real population only in one variable (XMD: $p = 0.0452$). A non-parametric test was used in this case, despite all variables followed normal distributions, because sample sizes by sex were significantly small. The descriptive statistics (mean values, minimums, maximums and standard deviation values) for NT and XT variables of the four comparative human groups are shown in *Figure 3* plots the same variables. Individuals from Son Real show the highest variability and density of striations (NT=87.7), followed by the populations from tropical and arid environments and the Hindu vegetarians, whereas the carnivorous hunter-gatherer and pastoralist populations, including Fueguians, Inuit, Vancouver Islanders, and Lapps show the lowest values (NT=37.1). The minimum and maximum ranges of Son Real overlap completely with the populations from arid and tropical environments for the total density of striations (NT) (*Figure 3a*). The length of scratches (XT) shows great dispersion ranges in the comparative collections. The striations length in Son Real is similar to that of the hunter-gatherers from both tropical forests (Andamanese and Veddahs) and arid and mesothermal environments, i.e. Bushmen, Australian aborigines and Tasmanians (*Figure 3b*).

TABLE 4. Analysis of variance of the 15 variables studied in all human populations analyzed (includes Son Real and all the hunter-gatherer groups). Eleven of the fifteen variables show significant between group differences at a 0.05 level of significance (marked with star).

Variable	F	Significance
NH	7.589	0.000*
XH	5.196	0.002*
SDH	5.268	0.002*
NV	0.802	0.531
XV	3.102	0.025*
SDV	1.525	0.212
NMD	8.106	0.000*
XMD	2.329	0.072
SDMD	5.709	0.001*
NDM	6.260	0.000*
XDM	8.621	0.000*
SDDM	1.453	0.234
NT	29.500	0.000*
XT	6.999	0.000*
SDNT	3.728	0.011*



a

b

FIGURE 3. Boxplot showing the density of striations (NT) (a), and their length (XT) (b) observed in the teeth of arid, tropical, vegetarian and carnivorous populations in comparison with human population from Son Real. The central line in boxes indicates sample median, the boxes include 25 to 75 percentiles and the whiskers represent minimum and maximum values observed.

Significant between-groups differences at a 0.05 level of significance in eleven of fifteen variables of the buccal microwear patterns were observed using one-way ANOVA (*Table 4*). The Bonferroni post hoc test within the ANOVA (*Table 5*) shows that the population from Mallorca is the most similar to the arid and tropical populations, whereas the carnivorous group showed significant differences with regard to Son Real, being the most distinct group of all. Consequently, exclusive high meat intake in the inferred diet of Son Real was obviously excluded.

To illustrate further populations affinities based on buccal microwear patterns, a cluster analysis using Euclidian distances was performed using the 15 variables studied. *Figure 4* shows the cladogram obtained. Close clustering of groups indicate similarities in abrasiveness mostly due to composition of eaten food. The sample from Son Real shows some similarities with tropical Veddahs and the arid Bushmen and Tasmanians groups, and great dissimilarities with the carnivorous populations.

Using the same analysis according to gender, sex-related intragroup differences in microwear pattern were observed in the Son Real sample compared to the other populations analyzed. The women from the Talayotic culture have a microwear pattern similar to that of the Tasmanians and Bushmen, whereas the rest of Son Real sample, including men and some unclassified samples,

TABLE 5. Multiple Comparisons: Bonferroni post hoc test showing significant between-group differences. (* The mean difference is significant at the 0.05 level; ** the mean difference is significant at the 0.01 level). Only the variables and groups where differences have been detected are presented.

Variable	vegetarian vs arid	vegetarian vs carnivorous	vegetarian vs Son Real	arid vs carnivorous	arid vs Son Real	carnivorous vs tropical	carnivorous vs Son Real	tropical vs Son Real
NH		**				**	**	
XH	**	*	**					
SDH							**	
XV		*						
NMD			*				**	*
SDMD					*			*
NDM			*				**	
XDM		*		*		*	*	
NT			*	*	*	*	*	
XT				**		*	**	
SDNT								*

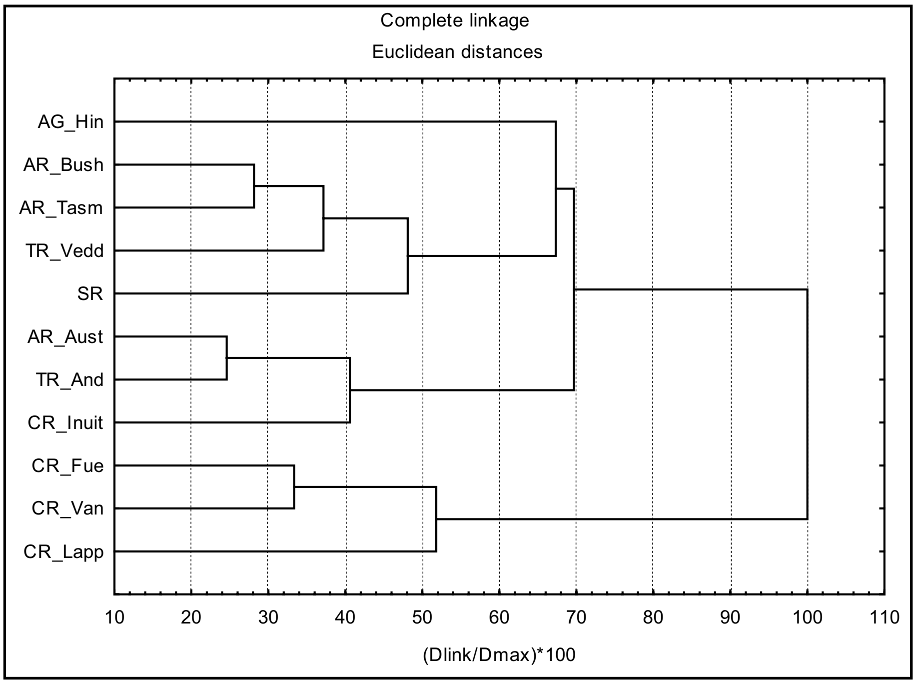


FIGURE 4. Joining Tree-clustering (Euclidean distances, complete linkage) – final configuration of recently studied populations in comparison with Son Real. Symbols for studied samples follow *Table 2*.

showed a homogeneous microwear pattern that was closer to other populations from arid and tropical environments (*Figure 5, Table 6*). No age-related analysis of microwear pattern was performed due to the small size of the subadult group. However, the two subadults, one infant and one juvenile included in the analysis, did not differ significantly in their microwear patterns from the rest of the Son Real adult sample.

An extensive research of the Veddah population has shown that this population is more inclined to gather than to hunt because of its insecure success (Lee, DeVore 1968). Studies made on Bushmen (Lee 1973, Lee, DeVore 1976) concluded that vegetable matter is generally about 60–80% of the total consumed food (Hart 1978). Thus it is possible to conclude that the dietary composition of Son Real females predominantly consisted of large amounts of vegetable foods. This is consistent with agriculturalist activity similar to that described for the Middle Ages sample from La Olmeda. However, Son Real has a scratch density that more closely resembles that of the hard objects chewing hunter-gatherers. An intense agriculturalist subsistence pattern, mainly based on cereal consumption, has been suggested for Son Real based on trace elements analyses (Subirà 1989). However, important pastoralist activity, based on goat, has also been proposed (Pericot, 1975). The microwear pattern obtained indicates that plant foods, most likely cereal based with large amounts of silica phytoliths, were the main food resource eaten. The diet of the Son Real population was probably highly dependent on this resource since meat consumption did not seem to significantly reduce the striation density in the studied sample as might be expected. The microwear pattern observed is thus in

TABLE 6. Means and Standard deviations of Joining Tree-clustering according to studied groups and gender. Symbols for studied samples follow *Table 2*.

	Mean	Std. dev.
AG_Hin	98.0200	68.29185
AG_F	105.1333	82.17101
AG_M	94.1933	61.80416
AR_M	97.0600	56.35014
AR_F	92.5533	57.60872
AR_?	98.6800	64.02509
AR_Bush	102.9467	64.78525
AR_Tasm	96.5800	59.29127
AR_Aust	89.0267	54.34644
CR_F	91.6333	70.07795
CR_M	110.5067	85.11676
CR_?	128.6933	97.13924
CR_Fue	110.0800	85.53517
CR_Inuit	90.3933	67.58336
CR_Van	116.9933	90.93184
CR_Lapp	106.9667	83.91850
TR_F	90.7867	56.00041
TR_M	89.9933	57.23384
TR_?	114.4800	70.62511
TR_And	85.9800	53.20939
TR_Vedd	108.2200	68.76991
SR_F	102.5795	57.14342
SR_M	115.9155	65.96196
SR_?	112.7859	62.88453
SR	112.2675	62.90258

agreement with the expected results and contributes to the knowledge of the buccal microwear variability in an agricultural population, which will allow future analyses of Mesolithic-Neolithic transitional populations.

CONCLUSION

A joint analysis of the buccal microwear patterns of the Son Real Talayotic (7th and 6th centuries BC) population along with modern hunter-gatherers from different geographic areas was performed in order to reconstruct the dietary strategies of the Son Real sample. Mixed food with predominant vegetarian and reduced meat intake has been shown for the studied sample. According to gender, a certain degree of intrapopulational variability within the Son Real sample has been shown. It seems clear that females had dietary habits distinct from males and other individuals of undetermined sex, the female microwear pattern being similar to that of human hunter-gatherers living in arid environments, such as Tasmanians and Bushmen. An increased vegetal or cereal food intake by females in comparison to males can be hypothesized.

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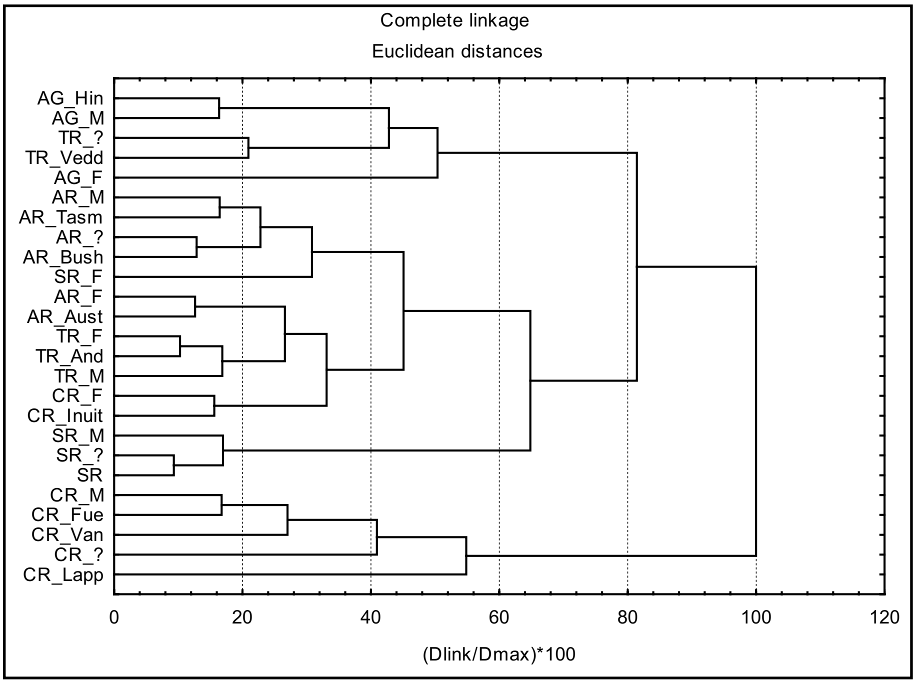

FIGURE 5. Joining Tree-clustering (Euclidean distances, complete linkage) – final configuration of recently studied populations according to sex in comparison with Son Real. Symbols for studied samples follow *Table 2*.

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