Contextualizing Buccal Dental Microwear Variations During the Byzantine Period in Jordan

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ABSTRACT This study scanned 14 buccal surfaces of teeth casts microscopically from the Byzantine sites of Yajuz and Sa'ad in Jordan, and 7 samples from the Natufian site of El Wad in Palestine for the purpose of studying buccal microwear. The results show no differences in the pattern of dental microwear between the two byzantine sites, while a difference was existed when these sites compared to El Wad. The results indicate that subsistence economy did not trigger buccal microwear but cultural development. Although the economies during the Byzantine period were diversified, technological adaptation diffused into region, which eased food accession and procession.

INTRODUCTION

The Byzantine period (324–638 CE) in the Levant and particularly in Jordan has received influential thoughts by historians on both sociopolitical and economic levels (Jones, 1964). The archaeological studies refuted the historians' thoughts (Kingsley, 2001) but unfortunately few dealt with the subject in a broader economic view (Rose et al., 2007). However, local economic variations must have been existed, triggered by the varied subsistence economies. One of the best models in this regard is the Byzantine site of Natfieh, where agriculture and animal husbandry were the sources of food (Al-Bashaireh et al., 2010). Social stratification in terms of populace and elites was common during this period, which exerted a wider gap in wealth accumulation between urban and rural settlements, or even on a settlement level (Grossman, 1974; Garnsey and Saller, 1987). Therefore, self-sufficient economies that relied on land as the main source of food production and improvisation were presumably site-specific and might not be applied at other contemporaneous Byzantine settlements in Jordan. The function of a settlement might have possessed another check on economic success, such as, the late Roman/Early Byzantine military garrison discovered near Queen Alia International Airport (Ibrahim and Gordon, 1987), these sites did not excersiced a complex subsistence economy but mostly relied on aid from the central goverment.

Another unique Byzantine settlement, in this sense, is Khirbit Yajuz in the middle of Jordan. The site was proved to be a substantial producer of textile in the region (Khalil, 1998; Al-Shorman, 2003; Al-Shorman and Khalil, 2006) but it is not known yet if other subsistence economies were additionally practiced. During the same period, the people of the Byzantine site of Sa'ad -- at the edge of the arid zone -- in northern Jordan subsisted on agriculture, produced huge amounts of wine for export purposes, and believed to be self-sufficient (Rose et al., 1997). The two different economic models in Khirbit Yajuz and Sa'ad (fig. 1) would have created two different dietary forms for local consumption that could be reconstructed. Accordingly, this study investigates the type of diet among the people of these sites using buccal dental microwear depicted by scanning electron microscopy of teeth.

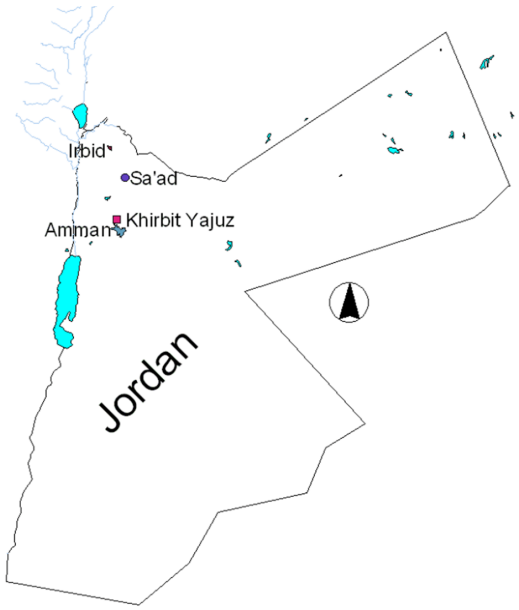

Fig. 1. The archaeological sites of Khirbit Yajuz and Sa'ad, Jordan.

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The buccal dental microwear analysis is one of the direct methods in reconstructing diet through examining the microscopic surfaces of teeth (Grine et al., 2002). Contrary to occlusal microwear, buccal microwear provides insights on diet over a longer time and is not affected by tooth-to-tooth contact (Pérez-Pérez et al. 1994; Pérez-Pérez, 2004; Romero et al., 2012). For this reason, buccal dental microwear has become very common and widely accepted as a tool for reconstructing primates' diet and ecology (Galbany et al., 2003; 2004; 2005; 2009), and dietary adaptation and behavior of extinct human populations (Romero et al., 2004; Martinez et al., 2004; Romero, 2005; Polo-Carda et al., 2007; Romero and De Juan, 2007; Alrousan and Pérez-Pérez, 2008; 2012 Estaberanz et al., 2008; 2009; Alrousan et al., 2009). The recent studies have focused on the experimental research to improve the quantification of buccal microwear analysis using precise digital techniques (Martinez and Pérez-Pérez, 2004; Galbany et al., 2005).

The abrasive particles in the diet induce microwear on the buccal surfaces of teeth. These particles are either intrinsic to diet, such as, phytoliths of plant tissues, which have hardness that exceeds dental enamel (Piperno, 1988; Lauleza and Pérez-Pérez, 1994) or extrinsic when dust, ash, or sand contaminates food during processing (Mahoney, 2006; Alrousan and Pérez-Pérez, 2008; 2012; Alrousan, 2011). Despite the source of these particles, they eventually cause both pits and striations on occlusal surfaces of teeth (Teaford and Oyen, 1989; Schmidt, 2001; Mahoney, 2006; Ungar et al., 2008; Alrousan, 2011) but only striations on the vestibular or buccal surfaces (Puech and Albertini, Pérez-Pérez 1983; Pérez-Pérez; 1994; 1999; 2003; Alrousan and Pérez-Pérez, 2008; 2012). Meat, for example, is correlated with a large number and longer vertical striations on the buccal surfaces of the teeth, whereas plant items tend to cause higher densities of longer horizontal striations (Puech, 1976; 1979; Puech and Albertini, 1981; 1984; Puech and Pant, 1980; Puech et al., 1980; 1983; 1986; Pérez-Pérez et la., 1994; Lalueza et al., 1996; Alrousan and Pérez-Pérez, 2012). Accordingly, the buccal microwear pattern is a reliable, nondestructive, and accurate method for dietary reconstruction because it can reflect dietary changes over the long term rather than providing evidence on the "last supper" (Pérez-Pérez et al., 1994; Alrousan, 2009; Romero et al., 2012).

The presence of microwear features on the occlusal surface depends on many factors; the mechanics of chewing, mastication forces, the position of analyzed wear facet, and the section of analyzed wear facet (Kay and Hiiemae, 1974; Gordon and Walker, 1983; Pérez-Pérez, 2004; Mahoney, 2006). On the other hand, buccal surfaces are not affected by tooth-to-tooth contact during chewing cycle, with minimal effect by the forces of mastication (Puech and Pant, 1980; Lalueza and Pérez-Pérez, 1993; Pérez-Pérez et al., 1994; Pérez-Pérez, 2004). The presence of extensive tooth wear or the use of teeth as a tool makes the analysis of occlusal microwear impossible. For these reasons, bioarchaeoligiests tend to extract dietary information from the enamel surface using buccal dental microwear technique.

MATERIALS AND METHODS

For the purpose of this study, buccal dental microwear patterns were collected from 14 individuals; 7 from the Byzantine site of Khirbit Yajuz in the middle of Jordan and 7 from the Byzantine site of Sa'ad in northeastern Jordan. A Single post-canine tooth was chosen to represent each individual, all individuals are right fully developed third molars (Alrousan and Pérez-Pérez, 2008; Pérez-Pérez et al., 2003). The samples have well-preserved enamel surfaces without dental pathologies. According to microwear standards, post-mortem changes, taphonomic changes, and unpreserved enamel surfaces were determined after Teaford (1988), Martinez and Pérez-Pérez (2004) and Pérez-Pérez et al. (2003). The surfaces of dental enamel were gently cleaned with pure acetone and then rinsed with 70% ethanol using cotton swabs. Molds of the original teeth were obtained using Polyvinyl-siloxane President Microsystems™ (Coltene Regular Body) (Galbany et al. 2006; Ungar et al. 2006). Positive casts of tooth molds were obtained using epoxy resin (Epo-Tek 301, By QdA) with a two-stage centrifugation procedure to prevent the formation of air bubbles.

Before examining the casts under SEM (Scanning Electron Microscope), the samples were mounted on aluminum stubs with carbon gum. The casts were then coated with a 400 Å gold layer. The SEM observation settings were 15 KV with 0^{o} tilt angle of the secondary electrons. The micrographs were obtained at 100X magnification on the medial aspect of the buccal surface of the cast at a distance from the occlusal rim of the cusps and the cement-enamel junction. The images were then cropped to cover an area of 0.56 mm2, where the measure of the side border of each square micrograph was 748.33 μm (Fig. 2) (Pérez-Pérez et al. 2003; Alrousan and Pérez-Pérez 2008; 2012).

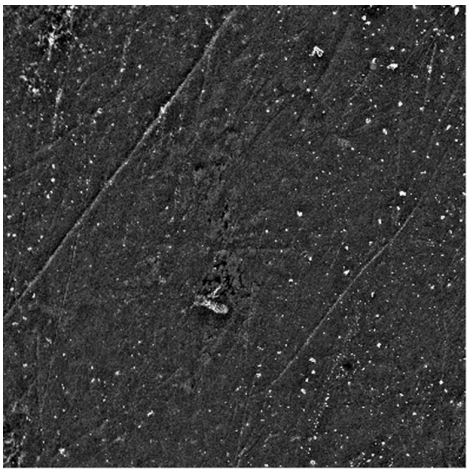

Fig. 2. Micrograph of buccal microwear

Each micrograph was processed using Adobe Photoshop by applying a "high pass" (50 pixels) filter and "automatic" level enhancement. In order to quantify buccal dental microwear pattern (striation length and density), Sigma Scan Pro 5 (SPSS) package was used. The slope and the length of striations in each micrograph were digitally measured. The orientations of the striations were measured according to Lalueza et al. (1996) and Pérez-Pérez et al. (1994; 2003). The orientation was measured from 0º to180º and classified as follows (Fig. 3):

1. Vertical (V): angle ≥ 67.5º and ≤ 112.5º.
2. Mesio-occlusal to Disto-cervical (MD): from 112.5º to 157.5º for the upper left and the lower right teeth.
3. Disto-occlusal to Mesio-cervical (DM): from 22.5º to 67.5º for the upper right tooth and lower left.
4. Horizontal (H): angle ≥ 0º and ≤ 22.2º, and angle ≥ 157.5º and ≤ 180º.

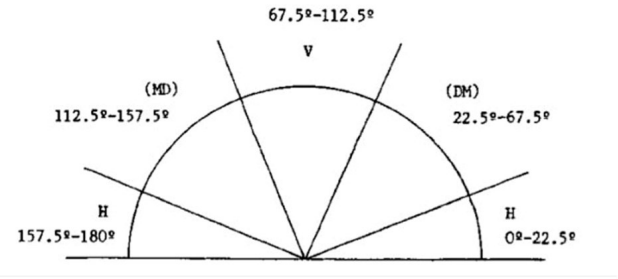

Fig. 3. Orientations of striation (Pérez-Pérez *et al*., 1994)

For all orientation categories (H, V, MD, DM),the total number of striations (T), the density (N), average length (X) and standard deviation of the length (S) of the striations were computed and, thus, a total of 15 microwear variables were derived for each sample (Pérez-Pérez et al. 1994). A second stage comparison was performed: the first stage is between the two sites; the normality of the frequency distributions of the 15 variables was tested with the Kolmogorov-Smirnov test for goodness of fit. Then, a one-factor ANOVA test was used to compare the 15 variables in the two sites. The second stage of comparison compared the microwear pattern of the Byzantine teeth with the Natufian teeth from El Wad after Alrousan and Pérez-Pérez (2012). EL wad is a hunter-gatherer site located in Palestine, and dated to 12,950 - 10,680 years bp based on relative and 14C dating (Garrod, 1931; Weinstein-Evron 1991). This comparison is aimed to understand the cultural development regarding food acquisition and processing from hunting and gathering to farming.

RESULTS

The means and standard deviations of the above variables are presented in table 1. The results of statistical analysis are presented in table 2. First stage of comparison results; Kolmogorov-Smirnov normality tests shows that none of the 15 variables differed significantly from normality for the two sites considered. Therefore, parametric statistical tests could be applied to the raw data. No significant differences were discovered between the two sites, Sa'ad and Yajuz, considering the 15 variables of buccal dental microwear (fig. 4).

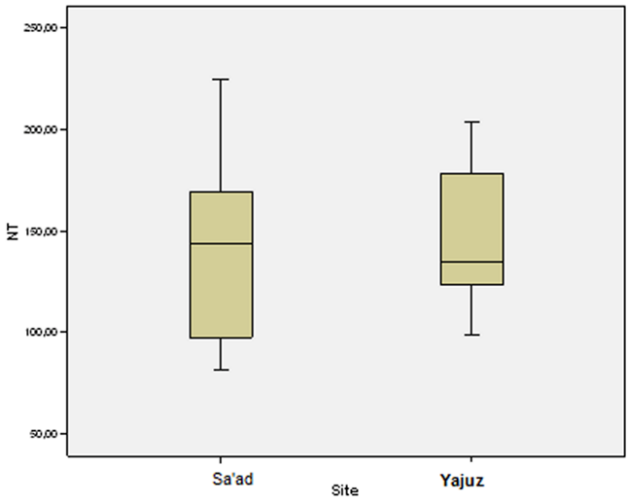

Fig. 4. Total number of striation of the Byzantain Sites Sa'ad and Yajuz.

The second stage of comparison indicates that there are significant differences between the Natufian people and the Byzantain people at least in ten variables; the length and the standard deviation of horizontal striations, vertical striations, Mesodistal striations, Distomesial striations, and total striations. The characteristic feature of the buccal dental microwear of the Natufian samples is the longer striations in a comparing with that of the Byzantine samples (Fig. 5).

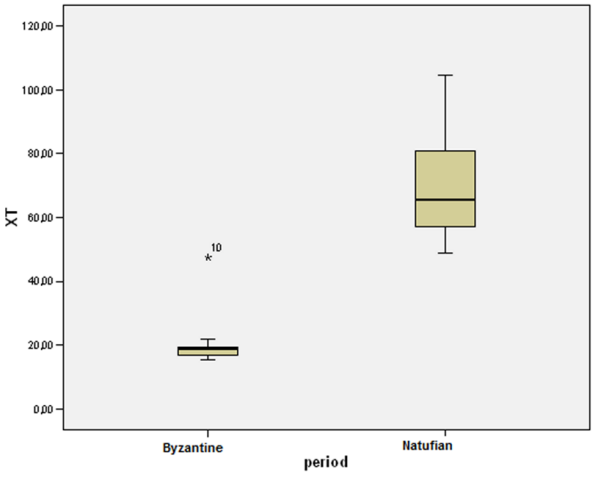

Figure 5: Length of all striations of the two periods

Site	Sa'ad No.=8		Yajuz (No.=7)		El Wad (No.=7)		Byz (No.=15)	
	Mean	Sd.	Mean	Sd.	Mean	Sd.	Mean	Sd.
NH	26.875	10.629	31.571	14.604	35.286	14.930	29.067	12.400
XH	19.779	3.090	20.447	11,009	83.043	40.215	20.091	7.539
SH	10636	2.990	10.394	7.374	59.094	46.071	10.523	5.271
NV	21125	14.759	26.000	8.869	30.143	19.651	23.400	12.205
XV	19.356	4.142	27.006	16.135	79.091	22.976	22.927	11.651
SV	11.657	4.033	18.069	10.914	66.237	23.140	14.649	8.375
NMD	48.125	18.849	55.286	24.088	66.571	39.136	51.467	20.976
XMD	17.394	2.433	22.342	13.331	60.633	13.067	19.703	9.255
SMD	11.309	5.913	14.170	10.674	35.056	10.597	12.644	8.276
NDM	44.750	22.487	35.857	10,946	44.000	14.674	40.600	18.035
XDM	17.065	1.896	18.832	7.539	61.189	17.519	17.890	5.195
SDM	9.113	3.888	8.660	4.714	41.134	15.621	8.902	4.140
NT	140.875	48287	148.714	38.156	176.000	63.765	144.533	42.499
XT	18.315	1.685	22.267	11.256	70.652	21.255	20.159	7.739
ST	11.515	2.841	14.156	8.489	55.063	24.310	12.747	6.065

Table 1: Descriptive statistics. El wad results after Alrousan and Pérez-Pérez (2012).

	Sum of squares	Degree of Freedoom	Mean of Squares	F	Probability
XH	18914.104	1	18914.104	36.029	.000
SH	11259.504	1	11259.504	17.158	.001
XV	15055.583	1	15055.583	59.417	.000
SV	12701.519	1	12701.519	60.560	.000
XMD	7995.701	1	7995.701	71.912	.000
SMD	2397.317	1	2397.317	29.366	.000
XDM	8948.033	1	8948.033	80.640	.000
SDM	4958.516	1	4958.516	58.196	.000
XT	12168.150	1	12168.150	68.573	.000
ST	8546.363	1	8546.363	42.093	.000

Table 2: ANOVA results

DISCUSSION

Diet is one of the most important aspects used to understand the paleobiology, evolution, and culture of extinct human populations. In order to reconstruct diet, Bioarchaeologists use teeth because of they are the most preserved human skeletal remains, where they are commonly found in ancient burials. The results of buccal dental microwear of this study are highly correlated with the archaeological data and records. The main sources of inter population variation in buccal dental microwear are the number and the length of striations that eventually depended on ecological factors including food availability and resources. For example, buccal microwear patterns from Pliocene Hominids, in comparison with modern Hunter-gatherers with relatively known diet, have showed higher density of striations in corresponding to higher abrasiveness of the diet (Pérez-Pérez et al., 1994; 2003). The patterns of buccal microwear from Neolithic and Natufian teeth in the ancient Near East showed that the longer striations in the Neolithic teeth is due to food processing technique and introduction of more cereals and plants in diet (Alrousan, 2009). The index of NH/NV is highly an indicator of the type of consumed diet; hunter -gatherers (meat dependant) and pastoralists tend to have a lower value of this index (Lauleza et al., 1996; Alrousan and Pérez-Pérez, 2012). Since there are no significant variations between Sa'ad and Yajuz, this study suggests that the diet in both sites is similar in relation to resource or even processing although the two sites practiced different subsistence economies. Sa'ad people depended on agriculture and animal husbandry, while Yajuz people practiced textual manufacturing. The previous study of occlusal dental microwear of the same samples of Yajuz (Al-Shorman and Khalil, 2006) did not extract any information regarding diet and/or dietary adaptation, where occlusal dental microwear pattern was masked by using teeth as tools. The length of striations here is positively correlated with the abrasiveness of diet, more abrasive diet tend to leave longer striations on the buccal surface due to the exerted heavy masticatory forces (Puech, 1978; 1982; Pérez-Pérez et al., 1994; Alrousan and Pérez-Pérez, 2008). Therefore, the people of El Wad probably consumed a harder diet compared to the Byzantine population.

The difference between the Natufian and the Byzantine periods is probably due to the differences in food intake and food processing (cultural development) rather than environmental conditions. The Natufian people of El Wad were hunter-gatherers; depending more on gathering than hunting (Alrousan and Perez- Pérez-Pérez, 2012). The gross wear that they had resembled that of Pre Pottery Neolithic people (Smith, 1970) as triggered by the presence of grinding tools (Henry, 1989; Bar Yosef, 1998). The large component of plant food created more abrasive materials that needed more masticatory forces and thus caused longer striations. Food processing is another factor that affects microwear pattern (Teaford and Lytle, 1996; Ungar and Spencer, 1999; Alrousan and Pérez-Pérez, 2008), where after the introduction of pottery in the Neolithic period, cooking was facilitated and the texture became softer, which required less maticatory forces.

CONCLUSION

Despite the variation in subsistence economy in rural Byzantine settlements, the inhabitants consumed diet that was probably similar in texture, which stresses on the diffusion of cultural development throughout the region. Throughout the history of the region, it seems that the technological innovation in cooking utensils reduced the abrasiveness on the enamel surfaces of teeth. The variation in the local economies in rural areas during the Byzantine period have imposed little if any restrictions on technological adaptation but does not negate the access to better quality and quantity of food items by the elites.

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LITERATURE CITED

Al-Bashaireh K, Al-Shorman A, Rose J, Jull A, Hodgins G. 2010. Paleodiet reconstruction of the human remains from the archaeological site of Natfieh, northern Jordan. Radiocarbon 52: 645–652.

Al-Shorman A. 2003. A Byzantine tomb from Khirbit Yaj uz, Jordan. J Paleopathol 15: 177-185.

Al-Shorman A, Khalil L. 2006. The evidenc of weaving at Khirbit Yajuz in Jordan using dental microwear. IJDA 8: 1-9.

Alrousan M. 2009. The Mesolithic-Neolithic transition in the Near East: biological implications of the shift in subsistence strategies through the analysis of dental morphology and dietary habits of human populations in the Mediterranean area 12,000-5,000 B.P. PhD Dissertation, University of Barcelona, Spain.

Alrousan M. 2011. Dental microwear and dietary adapta tion of the people of Ya'amun during the Middle/Late Bronze Age. In: El-Najjar MY, editor. Ya'amun: an archaeological site in northern Jordan. Irbid: Yarmouk University Press. p 197-206.

Alrousan M, Pérez-Pérez A. 2008. Non-occlusal microwear of the last hunter-gatherer from Near East and Europe. In: Nieto Amdada JL, Obón Nogués JA, Baena Pinilla S, editors. Gene, ambiente y enfermedades en los poblaciones humanas. Zaragoza: University of Zaragoza Press. p 45-59.

Alrousan M, Pérez-Pérez A, Molleson T. 2009. Buccal dental microwear pattern as an indicator of dietary behavior in a human Neolithic tooth sample from Abu

Abu Hureyra [abstract]. Am J Phys Anthropol Suppl 138: 76-76.
Estebaranz F, Marinez LM, Galbany J, Turbon D, Pérez-Pérez A. 2009. Testing hypotheses of dietary reconstruction from buccal dental microwear in Australopithecus afarensis. J Hum Evol 57: 739-750.
Estebaranz F, Martinez LM, Galbany J, Pérez-Pérez A. 2008. Anaylisis del patron de microestriacion dental de Australopithecus afarensis. In: Nieto Amdada JL, Obón Nogués JA, Baena Pinilla S, editors. Genes, ambiente y enfermedades en poblaciones humanas. Zaragoza: University of Zaragoza Press. p 127-142.
Galbany J, Estebaranz F, Martínez LM, Pérez-Pérez A. 2009. Buccal microwear variability in extant African Hominiodea: taxonomy verus ecology. Primates 50: 221 -230.
Galbany J, Martínez LM, López-Amor HM, Espurz V, Hiraldo O, Romero A, De Juan J, Pérez-Pérez A. 2005. Error rates in buccal-dental microwear quantification using scanning electron microscopy. Scanning 27:23-9.
Galbany J, Martínez LM, Pérez-Pérez A. 2002. Varia bilidad del patrón de microestriación dentaria en primates Hominoideos: ¿una cuestión de especie o de en torno ecológico? Rev Esp Antropol Biol 23: 77-83.
Galbany J, Martínez LM, Pérez-Pérez A. 2004. Tooth replication tecniques, SEM imaging and microwear analysis in primates: methodological obstacles. Anthropologie 42:5-12.
Galbany J, Pérez-Pérez A. 2004. Buccal enamel microwear variability in Cercopithecoidea Primates as a reflection of dietary habits in forested and open savanna environments. Anthropologie. 42: 13-19.
Galbany J, Estebaranz F, Martínez LM, Romero A, De Juan J, Turbón D, Pérez-Pérez A. 2006. Comparative analysis of dental enamel polyvinylsiloxane impression and polyurethane casting methods for SEM research. Microsc Res Tec 69:246-252.
Garnsey P, Saller R. 1987. The Roman empire: economy, society and culture. Berkeley: University of California Press.
Gordon KD, Walker AC. 1983. Playing 'possum: A microwear experiment. Am J Phys Anthropol 60: 109-112.
Grine FE, Ungar PS, Teaford MF. 2002. Error rates in dental microwear quantification using scanning electron microscopy. Scanning 24: 144-153.
Grossman G. 1974. Economic systems. Englewood Cliffs: Prentice Hall Inc.
Ibrahim M, Gordon R. 1987. A cemetery at Queen Alia International Airport. Institute of Archaeology and An thropology series 1
Jones A. 1964. The later Roman empire 284-602: social, economic and administrative survey. Oxford: Black well.
Kay RF, Hiiemae KM. 1974. Jaw movement and tooth use in recent and fossil primates. Am J Phys Anthropol 40: 227-256
Khalil L. 1998. University of Jordan's excavations at Khir bit Yajuz. ADAJ 42: 457-472.
Kingsley S. 2001. The economic impact of the Palestinian wine trade. In: Kingsley S, Decker M, editors. Late an tiquity economy and exchange in the east Mediterranean during late antiquity. Oxford: Oxbow Books. p 44-68.
Lalueza C, Pérez-Pérez A, Turbón D. 1996. Dietary inferences through buccal microwear analysis of middle and upper Pleistocence human fossils. Am J Phys Anthropol 100: 367-387.
Mahoney P. 2006. Dental microwear from Natufian hunter-gatherers and early Neolithic farmers: comparisons within and between samples. Am J Phys Anthro pol 130: 308-319.
Mahoney P. 2007. Human dental microwear from Ohalo II (22500-23500 cal BP), southern Levant. Am J Phys Anthropol 132: 489–500.
Pérez-Pérez A. 2004. Why buccal microwear? Anthropologie 42: 1-2.
Pérez-Pérez A, Lalueza C, Turbón D. 1994. Intraindividual and intragroup variability of buccal tooth striation pattern. Am J Phys Anthropol 94: 175-187.
Pérez-Pérez A, Bermúdez de Castro JM, Arsuaga JL. 1999. Nonocclusal dental microwear analysis of 300,000 year-old Homo heilderbergensis Teeth from Sima de los Huesos (Sierra de Atapuerca, Spain): implications of intrapopulation variability for dietary analysis of hominid fossil remains. Am J Phys Anthropol 108: 433-457.
Pérez-Pérez A, Espurz V, Bermúdez de Castro JM, de Lumley MA, Turbón D. 2003. Non-occlusal dental microwear variability in a sample of middle and upper Pleistocene human populations from Europe and the Near East. J Hum Evol 44: 497-513.
Piperno DR. 1988. Phytolith analysis: an archaeological and geological perspective. San Diego: Academic Press.
Polo M, Romero A, Casabó J, De Juan, J. 2007. The Bronze Age burials from Cova Dels Blaus (Vall d'Uixó, Castel ló, Spain): An approach to palaeodietary reconstruction through dental pathology, occlusal wear and buccal microwear patterns. Homo 58: 297-307.
Puech PF. 1976. Recherche sur le mode d'alimentation des hommes du Paléolithique par l'étude microscopique des couronnes dentaires. In: de Lumley H, editor. La Préhistoire Française I. Centre National de la Recherche Scientifique. p 708-709.
Puech PF. 1979. The diet of early man: evidence from abrasion of teeth and tools. Curr Anthropol 20: 590-592.
Puech PF, Albertini H. 1984. Dental microwear and mechanisms in early hominids from Laetoli and Hadar. Am J Phys Anthropol 65: 87-91.
Puech PF, Albertini H, Mills N. 1980. Dental destruction in Broken-Hill man. J Hum Evol 9: 33-39.
Puech PF, Albertini H, Serratrice C. 1983. Tooth micro-

-wear and dietary patterns in early hominids from Laetoli, Hadar, and Olduvai. J Hum Evol 12: 721-729.
Puech PF, Cianfarani F, Albertini H. 1986. Dental micro wear features as an indicator for plant food in early hominids: a preliminary study of enamel. Hum Evol 1: 507-515.
Puech PF, Pant R. 1980. Un modele d'etude de l'alimenta tion des hommes fossiles. Bull Mém Soc Anthropol Paris 7:61-64.
Romero A, Martínez-Ruiz N, De Juan J. 2004. Non-occlusal dental microwear in a Bronze-age human sample from East Spain. Anthropologie 42:65-70.
Romero A, De Juan J. 2007. Intra- and Inter-population human buccal tooth surface microwear analysis: inferences about diet and formation processes. Anthropologie 45: 61-70.
Romero A, Galbany J, De Juan J, Pérez-Pérez A. 2012. Brief communication: short- and long-term in vivo human buccal dental-microwear turnover. Am J Phys Anthropol 148: 467-472.
Rose JC, El-Najjar MY, Burke D. 2007. Trade and the acquisition of wealth in rural late antique North Jordan. In: Al-Khraysheh F, editor. Studies in the history and archaeology of Jordan IX. Amman: Department of Antiquities. p 61-70.
Rose JC, El-Najjar MY, Turshan N, Sari S. 1997. Sa'ad: preliminary report. Newsletter of the Institute of An thropology and Archaeology 2:
Schmidt C. 2001. Dental microwear evidence for a dietary shift between two nonmaize-reliant prehistoric populations from Indiana. Am J Phys Anthropol 114: 139-145.
Teaford MF. 1988. Scanning electron microscope diagnosis of wear patterns and artifacts on fossil teeth. Scanning Microsc 2: 1167-1175.
Ungar PS, Grine FE, Teaford MF. 2008. Dental microwear indicates that Paranthropus boisei was not a hard-object feeder. PLoS ONE 3: 1-6.