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TOOTH CROWN SIZE AND DENTINE EXPOSURE IN *AUSTRALOPITHECUS* AND EARLY *HOMO*: TESTING HYPOTHESIS OF DIETARY RELATED SELECTIVE PRESSURES

ABSTRACT: Preliminary analyses of total crown area and dentine exposure surfaces in a sample of hominid teeth seem to indicate that a significant correlation between tooth size and occlusal abrasion occurs, most probably related to dental occlusal function rather than to normal food mastication. Dental microwear on the buccal surfaces of teeth might be determined by foodstuffs abrasiveness whereas occlusal gross wear could be more dependent on either cultural practices with teeth or food processing. The effect of occlusal function of teeth on diet determination and ecological interpretation of hominid behaviour is dealt with, considering that habitat occupation and diet might affect differently and distinctly to tooth wear rate patterns.

KEYWORDS: Teeth – Size – Dentine exposure – Diet

INTRODUCTION

Dental remains constitute a very important source for hominid taxonomy assessment. At the same time, they provide a very valuable tool for reconstructing the paleodiets and paleoecology of fossil hominid specimens, testing the hypotheses derived from paleontological analyses (Teaford 1994, Teaford, Glander 1991, Ungar 1992, Pérez-Pérez *et al.* 1994, Lalueza, Pérez-Pérez 1993). Tooth shape (Lucas, Teaford 1995) and size have been generally considered as adaptations to ecological conditions through food handling and consumption. Large and thick enamelled teeth have been seen as indicative of hard food items mastication. For instance, *P. boisei* has usually been thought to be a good candidate for open savannah environments, exploiting tough foods such as roots, bark, and nuts. However, despite occlusal function of teeth is probably related to mastication forces during food chewing, dietary indicators such as dental microwear on vestibular facets of teeth might be indicative of actual diet composition. If so, tooth size and food composition might be independent events in maxillary biomechanics: tooth size might be dependent on biting forces whereas enamel thickness might be dependent on food particles abrasiveness. The present paper presents a preliminary analysis of the correlation between tooth size and occlusal tooth wear. If eating foodstuffs with a high abrasive potential may require thicker enamelled teeth, larger sized teeth, or both, hominids adapted to hard foods consumption are expected to show larger teeth, as well as thicker enamel. Therefore, all other factors remaining stable (age, sex, diet, etc.), enamel occlusal wear and dentine exposure should be minimized in hard food eaters. Testing hypotheses of interaction between adaptive morphological traits of teeth and food consumption indicators will allow confirming or rejecting the established relationships between tooth

TABLE 1. Sample size studied by tooth and taxa.

		Tooth								All
		I1	**I2**	**C**	**P3**	**P4**	**M1**	**M2**	**M3**	
Taxa	*A. afarensis*	6	9	10	21	22	26	26	21	141
	A. africanus	8	10	12	15	10	17	17	12	101
	P. aethiopicus				4	2	1	3	5	15
	P. robustus				1	1	1		1	4
	P. boisei	9	12	12	11	23	22	23	23	135
	H. habilis					1	1	2	2	6
	H. neanderthalensis	4	5	4	5	6	11	9	3	47
All		27	36	38	57	65	79	80	67	449

morphology and hominid habitats. These analyses made will serve to decide if higher densities of striations on the buccal surfaces need to be correlated to higher tooth sizes given the generally accepted paradigm. Otherwise, a clear distinction between occlusal function of teeth and food chewing forces responsible for buccal microwear formation would be necessary.

MATERIAL AND METHODS

Well-preserved tooth crowns of fossil hominid specimens from both Africa and Europe were studied. Full crown casts were obtained in the course of an international collaborative project on dental microwear (Galbany *et al.* 2004). Tooth crown measurements were obtained from the high fidelity casts, made with EpoTek 301 epoxy resin, as part of the buccal microwear analyses, to correlate buccal microwear densities with tooth size and shape. The initial sample consists of 2,284 teeth, not completely studied yet. Thus, the sample studied here includes only 449 teeth (*Table 1*). Pictures of the occlusal view of tooth crowns were obtained with a digital camera perpendicular to the tooth occlusal surfaces, including a millimetre scale. All measurements were obtained with the IMAT™ image analysis package of the University of Barcelona. Automatic measurements were derived after manually drawing the crown contour of each tooth as well as the contour of all dentine exposure surfaces on occlusal view. Total crown area, maximum crown diameters, and total dentine exposure areas were measured (*Figure 1*). For the moment, only total crown size and dentine exposure surfaces have been analyzed. Valid variables and reliable taxa and tooth attribution for each studied tooth were only obtained at this point of the research in 91 (20%) of the 449 initial teeth. Final sample sizes by tooth and taxa are shown in *Figure 2*.

RESULTS AND DISCUSSION

Dentine exposure surface showed a clear regression with total crown size (*Figure 3*). Independently of the taxa and the tooth considered, larger teeth showed larger dentine exposure surfaces. The *P. robustus* teeth showed the highest absolute values of dentine exposure, and *A. afarensis* the lowest. However, absolute measures greatly depend on the age distribution within each taxa, and the present sample is too low to draw definitive conclusions. Nevertheless, within each taxa analyzed, the larger dentitions showed

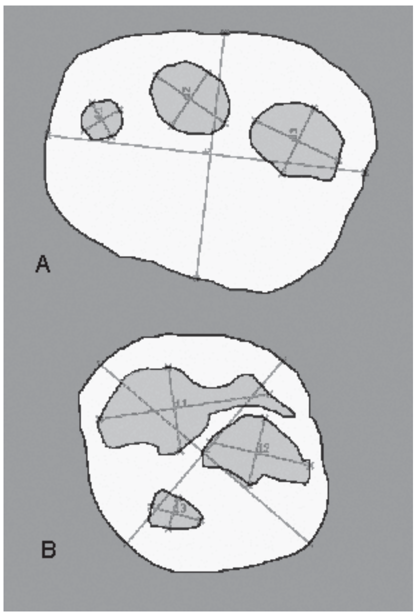


FIGURE 1. Occlusal measurements on tooth crowns: TOA, total occlusal area; TDE, total dentine exposure; MCD, maximum crown diameter; MPD, maximum diameter perpendicular to MCD; DES, total dentine exposure surfaces.

FIGURE 2. Final sample sizes of measures by taxa and tooth.

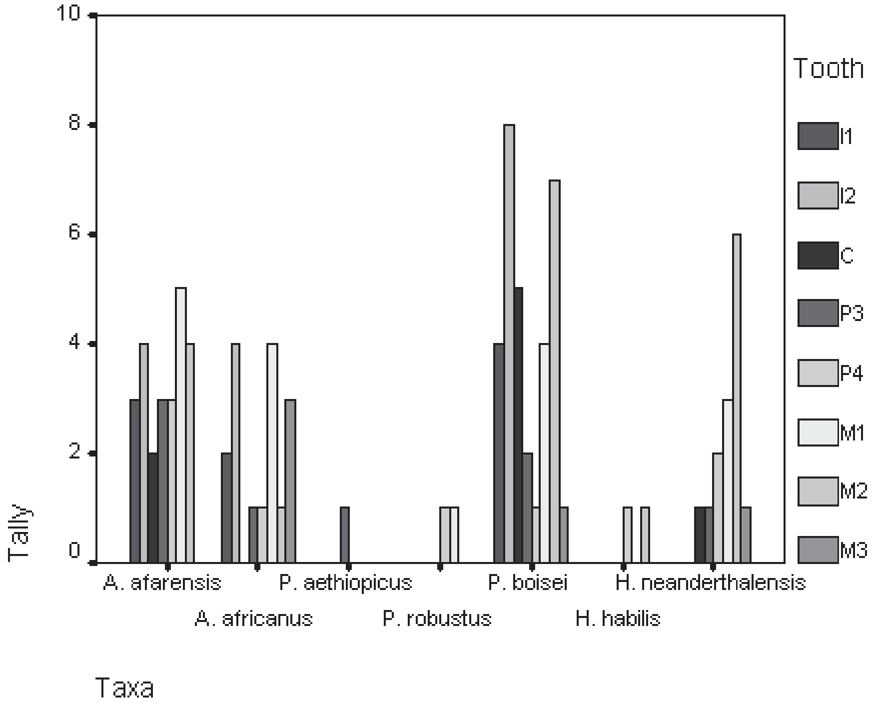
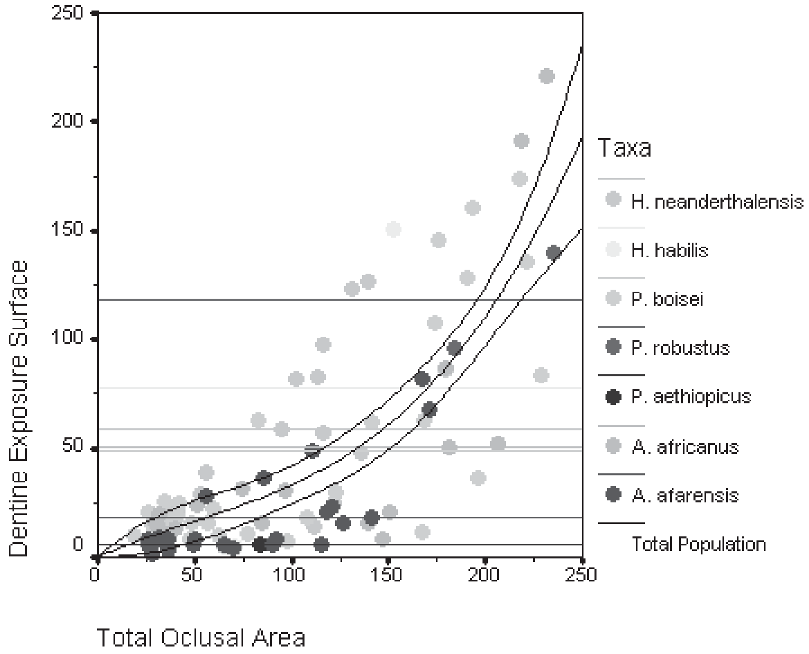


FIGURE 3. Regression between total occlusal area and total dentine exposure surface.



higher abrasion of the occlusal surfaces than the smaller teeth (*Figure 4*). A distinct pattern of dentine exposure seems to arise depending on tooth size. Generally, for all the taxa analyzed, molar teeth are larger (total occlusal area) than the anterior teeth. If the posterior dentition were more frequently involved in grinding food stuffs, it would most probably be affected to a larger extent by occlusal abrasion, eventually resulting in higher dentine exposure. In the sample studied, only the Neanderthals seem to have larger values of dentine exposure on smaller teeth than the other taxa studied (*Figure 4*), since this may be related to cultural activities (Ungar 1990, 1992, 1994a,b). The smaller teeth of the *Paranthropus* show low levels of dentine exposure compared to the larger sized teeth. The distinct pattern of dentine exposure seen between small and large teeth seems not to be dependent on age, since the smaller, anterior dentition erupts earlier in life than the larger, posterior dentition. The pattern observed is consistent for the whole sample considered as well as within each taxa, despite the reduced sample sizes. Enamel thickness seems to compensate masticatory forces, so the pattern of dentine exposure of the large tooth sized taxa does not substantially

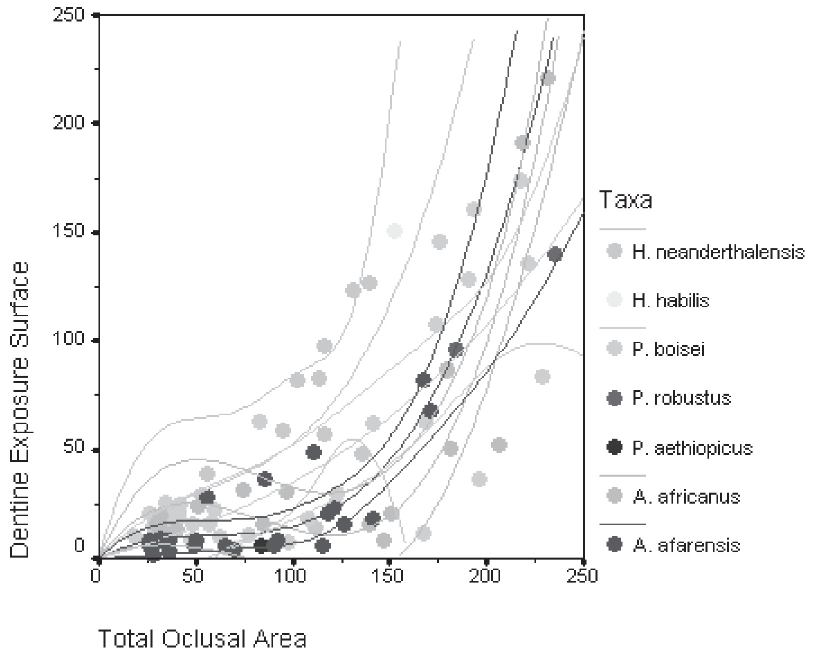


FIGURE 4. Confidence intervals of TOA vs. DES regression by taxa.

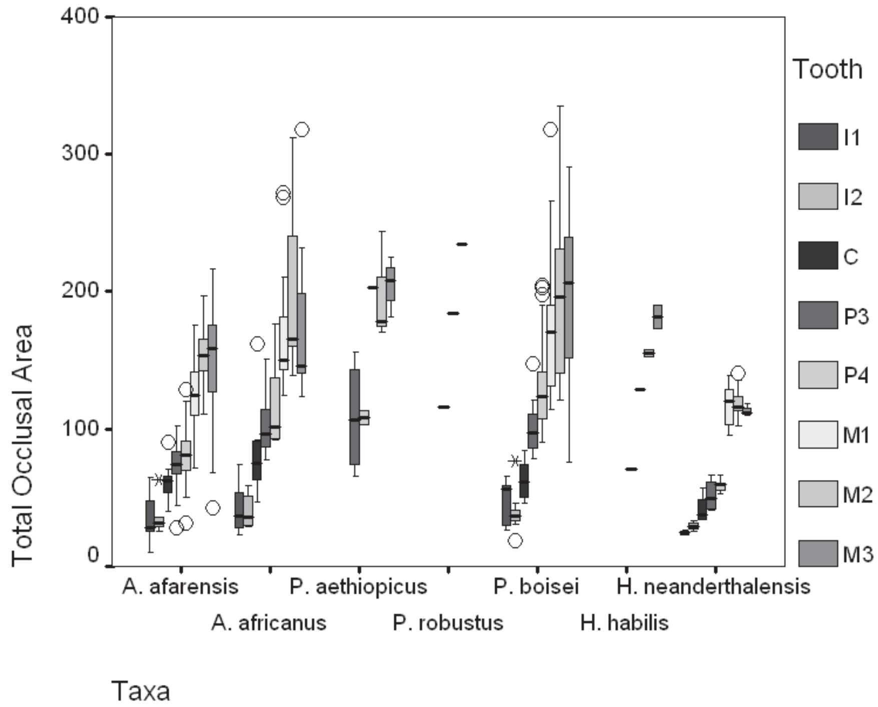
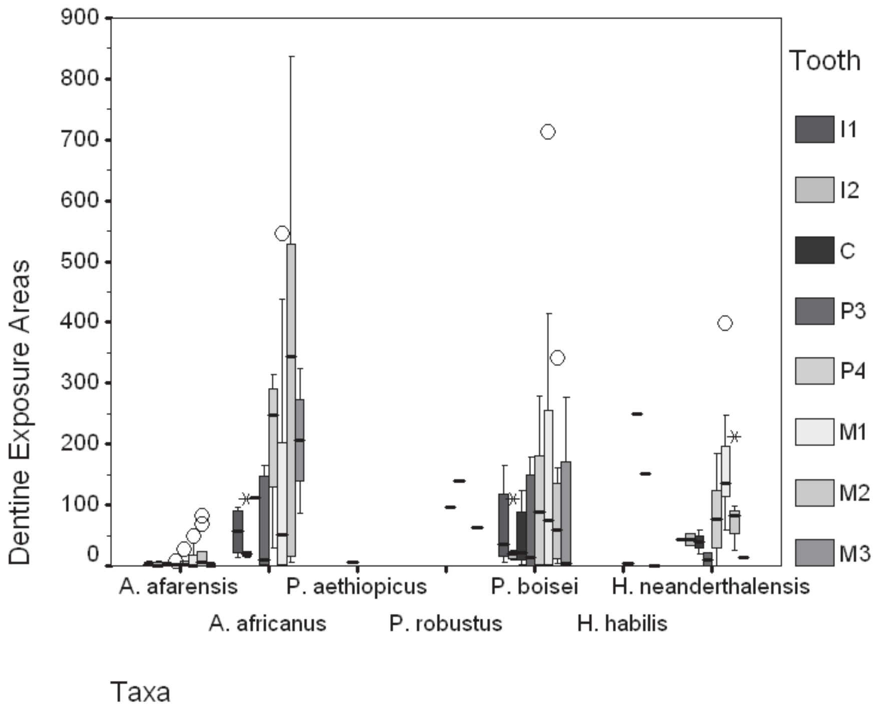


FIGURE 5. Total occlusal area by tooth and taxa.

differ from that of the small sized ones. Greater differences would be expected in *Figure 4* if enamel thickness had no effect on dentine exposure.

The most significant result obtained with the analysed sample is that different processes resulting in dentine exposure seem to be affecting the anterior and posterior teeth (*Figures 5* and *6*). Tooth size seems to be more dependent on the occlusal function of teeth rather than on the repetitive chewing of edible foods. If this is the case, buccal microwear might not be necessarily correlated with occlusal dentine exposure and, consistently, with occlusal microwear. We have long postulated that occlusal microwear and buccal microwear might be indicators of significantly distinct chewing processes. We will not have a reliable clue to demonstrate this point until a direct correlation is computed. However, we need to have a clearer understanding of the interaction between tooth size and crown use to be able to accept any given hypothesis. Large teeth might be necessary for occlusal biting, but this function might not be significantly related to food chewing. Future research on these relationships with the complete sample available will serve to test hypotheses on hominid adaptation and dietary related behaviour.

FIGURE 6. Total dentine exposure surfaces by tooth and taxa.



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