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Address for Manuscripts

Dr. Christopher W. Schmidt
Department of Anthropology, College of Arts and Sciences
University of Indianapolis
1400 East Hanna Ave, Indianapolis, IN 46227 U.S.A.
E-mail address: daaeditor@gmail.com
[Electronic submission is requested]

Address for Book Reviews

Dr. Greg C. Nelson
Department of Anthropology, University of Oregon
Condon Hall, Eugene, Oregon 97403 U.S.A.
E-mail address: gcnelson@oregon.uoregon.edu

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In Memoriam: Julius (Jules) August Kieser (20 December 1950 – 10 June 2014)

Jules Kieser was born in Pretoria, South Africa, in 1950. Jules' parents moved to Johannesburg where he enrolled at the University of the Witwatersrand. He obtained a BSc in Anatomy in 1971, followed by a Bachelor of Dental Sciences in 1975. Jules then practiced dentistry in the outback of South Africa, London and Johannesburg, with his wife Glynny working as his assistant. In 1989, Jules received his PhD from the University of the Witwatersrand, working under Phillip Tobias on the dentition of the Lengua Indians of Paraguay. After holding positions of consultant and honorary lecturer, Jules was appointed as Professor and Reader of Craniofacial Biology at the University of the Witwatersrand in 1991. In 1996, Jules and his family emigrated from South Africa to New Zealand, where he was appointed Chair in Oral Biology and Professor in the Department of Oral Sciences and Orthodontics at the University of Otago. In 2001 he was awarded his DSc from the University of the Witwatersrand.

In Otago, Jules held positions as Chair and Professor at the Department of Oral Sciences and Orthodontics, and Associate Dean for Research in the Division of Health Sciences. He was the inaugural Director of the Sir John Walsh Research Institute and Associate Dean for Research at the Faculty of Dentistry. Since his arrival in New Zealand in 1996, he lectured Oral Biology, Biomedical Sciences and Forensic Biology to many dental surgery, oral health and forensic science students. He was regarded widely as a positive and enthusiastic lecturer, with a relaxed, humorous and engaging style of teaching.

Jules had a prolific research record, having published 196 journal articles and four books. His research interests were broad and spanned across diverse disciplines such as dental anthropology, craniofacial biology and biomechanics, forensic biology and dental education. In particular, Jules' contributions to the fields of human odontometrics, dental asymmetry and development instability, and many other areas of craniofacial biology were valued by dental anthropologists worldwide. Jules studied the dentition of modern human populations, of early archaeological and fossil human remains, and of diverse animals such as crocodiles, primates, tuataras and dolphins.

He was instrumental in the development of forensic biology research in New Zealand and his practical expertise in forensic odontology was fundamental in the identification of the victims of the 2004 Thai Tsunami and 2011 Christchurch Earthquake in New Zealand. He received a New Zealand Special Services Medal for his service during the Thai Tsunami and a New Zealand Commissioner of Police Citation for his work in Christchurch. Other awards included Fellowships of the Galton Institute of London (1994) and Linnean Society of London (1995), an *Ad Hominem* Fellowship in Dental Surgery from the Royal College of Surgeons of Edinburgh (2004), the Alan Docking Award for Distinguished Research in Dentistry (2008), a Fellowship of the Faculty of Maxillofacial Pathology of the Royal College of Pathologists of Australasia (2013), a Fellowship of the Chartered Society of Forensic Sciences (2014), and a Wits Distinguished Scholar and a Wits-Carnegie Alumni Diaspora Fellowship (2014).

Jules was a keen and experienced scuba diver and had diving as one of his main hobbies. He held a 3rd Dan Karate black belt and had been a keen martial artist. Jules was also an eager rugby enthusiast. He enjoyed gardening, taking his dogs for bush walks and observing and attracting native birds to his property, especially New Zealand wood pigeons. Jules had a substantial library, including many diverse subjects outside his work interests. He was particularly interested in world history, war and strategy, and the evolution and development of civilizations. He enjoyed trying different varieties of chocolate and wine from other parts of the world during his multiple travels overseas. Jules and Glynny had four children: Annie, JJ, Daniel and David, who, from very early days, had always been involved in his work and research. As a result, many of his students and colleagues were also friends of his family.

Jules will be remembered as a very supportive and influential mentor and outstanding role model. His warm and positive personality was combined with a sharp mind and generous heart. Jules always fostered collaboration instead of competition; and always saw the development and advancement of the careers of his students and peers as beneficial to his own career development. He was a very humble and humane person, and a skilled master of social interactions. His contributions and his influence on his colleagues went way beyond the scientific and academic environments. We will miss this exceptional friend and colleague greatly and he will be always remembered as an example of someone we should all strive to emulate.

Carolina Loch[1], Grant Townsend[2] and Christopher Dean[3]

[1]Sir John Walsh Research Institute, Faculty of Dentistry, University of Otago, New Zealand
[2]School of Dentistry, University of Adelaide, South Australia
[3]Cell and Developmental Biology, University College London, UK

Determining onset of significant facial pathology using dental wear and microwear texture analysis: a case study from the Middle Archaic (~5,500 BP) of Indiana.

Anna Casserly[1], Rebecca Van Sessen[2], Christopher Schmidt[3]
[1]*Department of Anthropology, University of Kentucky, Lexington, Kentucky 40506*
[2]*Department of Sociology and Anthropology, Indiana University– Northwest, Gary, Indiana 46408*
[3]*Department of Anthropology, University of Indianapolis, Indianapolis, Indiana 46227*

Keywords: treponemal disease, paleopathology, macrowear

ABSTRACT Paleopathologists face complicated presentations of osteological conditions that accrued over a considerable period of ill-health. Determining the relative sequence of symptoms and how long the individual lived with them is critical to understanding disease onset and progression in the body and may help to identify a specific disease. This paper describes an atypical presentation of the dentition associated with a 5,000-year-old case of treponemal disease. This circumstance led to a cessation of macrowear, which allowed for an estimation of the age when the jaw began to profoundly deform. This paper also summarizes molar microwear texture analysis (DMTA) that was employed in order to determine if the diet of the victim prior to death was consistent with other people from the site.

Burial 54 (B. 54) is a young adult female from Meyer site (12Sp1082), a late Middle Archaic mortuary in southern Indiana. She presents considerable evidence of a pathological condition, with the cranio-facial bones being the most impacted (Figure 1). Notably for this study, the anterior maxillary alveolar margin is completely resorbed, resulting in antemortem loss of the anterior dentition from the right lateral incisor to the left first premolar. The mandible indicates major changes to the alveolar region as well; the bone appears to have been weakened to the point of collapsing under the dentition, causing the lower anterior teeth to jut forward at a near 90° angle to their natural position. In addition, the right body of the mandible was the site of a severe lytic lesion measuring at least 39 mm in length. The right lower molars were present at recovery, indicating that they were held within the soft-tissue. Together, these conditions were determined to be the result of a treponemal infection (Casserly 2013). All of the teeth show some level of macrowear; caries are absent. The only teeth shed antemortem are those of the anterior maxilla mentioned already. The teeth are morphologically similar to those of other people in the cemetery and there are no obvious defects in dental hard tissue quantity or quality.

DENTAL MACROWEAR AND MICROWEAR

The objective of the macrowear study was to determine when the bones supporting the dentition started to fail and move the teeth out of their normal anatomical orientations. To accomplish this, the dental macrowear was documented and compared to others from the cemetery in order to determine the approximate age of the individual at the time when the incisors no longer came into contact. The molars were similarly analysed to determine if the point of their disuse corresponded to that of the incisors. The dental microwear texture analysis (DMTA) was undertaken to determine the similarity of B. 54's diet to others from the site in order to determine if she was able to consume typical foods up until the point when she finally succumbed to the disease.

METHODS

We scored dental macrowear by direct observation following guidelines described by Smith (1984) for the anterior teeth and Scott (1979) for the

Correspondence to:
Anna Casserly, Dept. of Anthropology, University of Kentucky, 211 Lafferty Hall, 150 Patterson Dr., Lexington, KY, 40506-0027
Email: acasserly@gmail.com
Telephone:(859) 257-2710

molars. DMTA followed guidelines described by Scott et al. (2006). Molars of seven Meyer individuals, including the lower left M2 from B. 54 were replicated with high resolution polyvinylsiloxane impression material and cast with an epoxy-resin. Areas of Phase II occlusal facets that were approximately 242.38 x 181.18 µm were viewed with a white light confocal profiler (WLCP) at 100X. Analysis of data clouds was conducted via scale sensitive fractal analysis software (Sfrax® and ToothFrax®), which calculates a number of topographic variables including surface complexity (roughnesss) and anisotropy (similarity of feature orientations). In general, hunter-gatherers (like the population from which B.54 originated) tend to have rough surfaces and moderate anisotropy due to their poorly processed and diverse diets.

RESULTS

Burial 54 had anterior tooth wear scores that were in the stage 3 to 4 range. Compared to others in her cemetery, the only people with similar anterior wear were two 12 to 14 year-olds. Her left first molar scored 31 in the Scott's (1979) system and the right first molar scored a 32. Thus, her molars were worn to nearly identical levels on both sides of her mouth. Only left side molars were suitable for DMTA; the right molars had a thin veneer of occlusal calculus that obscured the surface from view. The means texture values for the Meyer site were 1.276 for complexity and 0.002 for anisotropy. The DMTA values for Burial 54 were 0.847 for complexity and 0.002 for anisotropy.

DISCUSSION

The maxillary condition that B. 54 presents is similar to the handful of other individuals from the Middle Archaic to also have been diagnosed with treponematosis. Snow (1948) describes a young adult male from Indian Knoll (B. 490) with maxillary resorption that is much like that of B. 54. But that burial does not have the anterior tilt to the mandibular dentition and there is no discussion of a mandibular lytic lesion. In fact, of the four or five possible to likely cases of treponemal disease at Indian Knoll, none have the mandibular involvement seen in B. 54. It may be that B. 54 has a unique manifestation of treponematosis, or it may be that she actually has more than one condition and that either the lytic lesion, the anterior tilt of the mandibular teeth, or both are related to separate maladies.

Burial 54's macrowear scores indicate that she began to lose normal maxillary and mandibular incisal contact in her adolescence perhaps around the time she entered puberty. Thus, the condition, or conditions, she had were chronic and she endured them for what was probably a decade or more. Her molar macrowear indicates that she maintained a typical diet for most of her life, although the occlusal calculus on the right side molars indicates that those teeth were no longer being used at the end of her life.

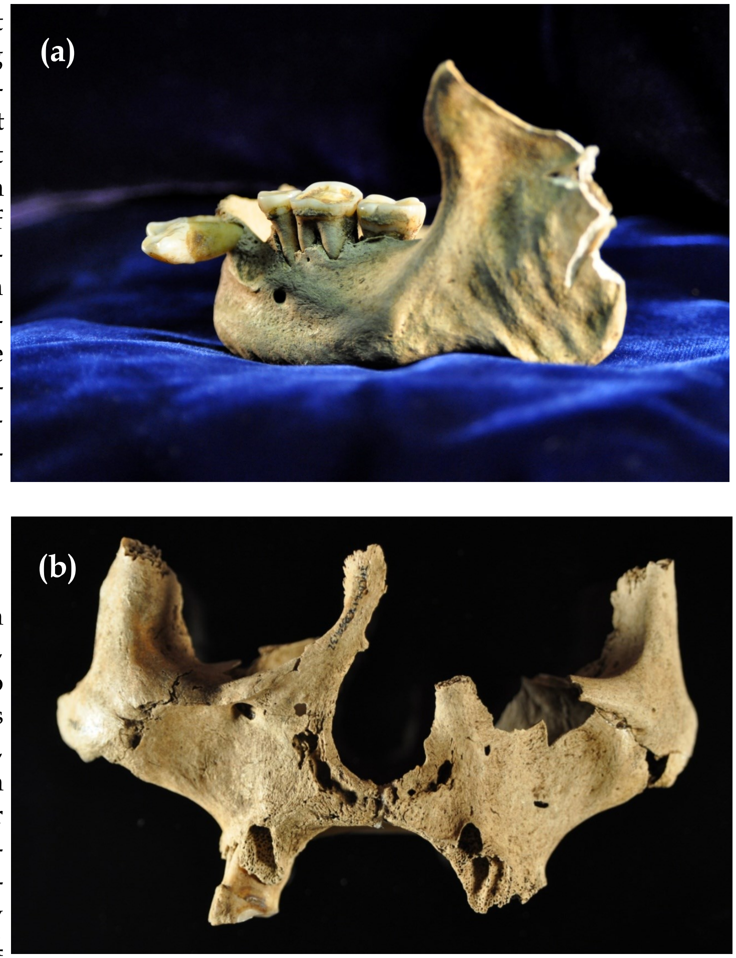

Fig. 1. (a) Left view of mandible showing impact on anterior dentition (b) Facial destruction of Burial 54. Note the maxillary resorption, nasal aperture reduction, and antemortem fracture of left frontal process of maxilla.

TABLE 1. Dental microwear texture analysis scores for Meyer site

Individual	Complexity	Anisotropy
Burial 54	.8477	.0016
Surface Mand. A	1.4071	.0036
Burial 42	.6905	.0007
Burial 46	.9854	.0023
Burial 104	2.4398	.0037
Burial 109	1.14156	.0009
Burial 111	.9912	.0079

In fact the right side molar enamel is pitted microscopically (which is visible in areas that were not covered with calculus). It is possible the pitting is the result of an acidic oral environment, which may be the result of abnormal saliva secretion or pus, which can have a pH around 6 (Nekoofor et al., 2009). Microscopic pitting was not found on the left-side molars.

As a whole, the Meyer site has a DMTA complexity value that is very low for a foraging population indicating that the Meyer diet likely had a high meat component. Burial 54's microwear values are low even for the Meyer Site, but they are not the lowest in the population; that distinction is held by a 12-year-old boy who was killed and decapitated. Dental texture reflects the last few weeks of one's life, so it appears that her diet was comparable to other people in her population even if only her left side dentition was in use. It is possible that softer foods became more dominant toward the end, but in general her microwear does not indicate a wholesale change her diet at any point before she died. Figure 2 shows a bivariate scatterplot of complexity and anisotropy for the Meyer sample.

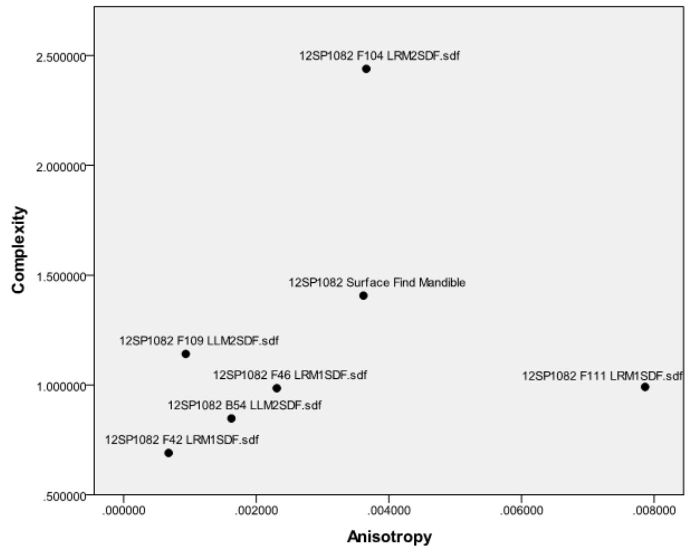

Fig. 2. Bivariate scatterplot of complexity and anisotropy.

CONCLUSION

This study demonstrates the value of dental anthropology in general and macrowear and microwear in particular to help reconstruct the circumstances of a particularly devastating disease condition. The dental data informed us on the age of onset for certain manifestations of the condition as well as the impact the condition had on the victim's diet. Moreover, it aided in the determination of the duration of the condition, which is important for those attempting to better understand the progression of diseases like treponematosis among ancient people. It is hoped that others will consider microwear and macrowear as tools to assist with their diagnoses and analyses in paleopathology.

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2014 Dahlberg Award Winner: The effects of dietary toughness on occlusopalatal variation in savanna baboons

Evan Muzzall[1], Ryan M. Campbell[1], Meadow Campbell[1,2], and Robert S. Corruccini[1]
[1]Department of Anthropology, Southern Illinois University, Carbondale, IL 62901
[2]Department of Anatomy, Southern Illinois University School of Medicine, Carbondale, IL 62901

Keywords: Diet, occlusopalatal variation, savanna baboons

ABSTRACT This study investigates the relationship between dietary toughness and craniofacial variation in two groups of savanna baboons. Standard craniofacial and malocclusion data were collected from a captive, soft-diet experiment group (n=24) and a sample of wild-captured baboons, raised on tougher, natural foods (n=19). We tested the hypothesis that in the absence of normal masticatory stress experienced during the consumption of wild foods, the captive baboons would exhibit higher levels of facial and dental structural irregularities. Principal component analysis indicates separation of the two samples. The soft-diet sample exhibits significantly shorter palates, greater variability in palate position, and higher frequencies of occlusal irregularities that correlate with the shorter palates. Results offer further support that long-term dietary chewing stresses have a measurable effect on adult craniofacial variation.

Malocclusions are the improper growth, positioning, and/or alignment of the teeth and jaws that lead to irregularities in occlusal surface contact and abnormalities of the surrounding bony structures. These deviations are due to multiple factors, but the reduced masticatory demands of modern diets have shown considerable influence (Corruccini, 1984; 1999; Corruccini et al., 1983; Corruccini and Lee, 1984; Varrela, 1990, 1992, 2006; Evensen and Øgaard, 2007). Notably, alterations in the proper growth trajectories of these areas due to decreased chewing forces are not unique to humans. By controlling for diet, laboratory animal studies have contributed to a broader understanding of occlusofacial variability (Beecher and Corruccini, 1981a, b; Corruccini and Beecher, 1982; Larsson et al., 2005; Grünheid et al., 2009; Jašarević et al., 2010; Ravosa et al., 2010; Dias et al., 2011; Makedonska et al., 2012).

This study expanded on the research of Corruccini and Beecher (1984), who found reduced facial growth, decreased structural correlations, narrower faces, and more occlusal irregularities in savanna baboons fed a soft diet. Using the same soft-diet sample as Corruccini and Beecher (1984), but a different research design and a wild comparative sample, the present study contrasted craniofacial and occlusal data between two groups of savanna baboons fed diets that differed in their mechanical properties. This study tested the hypothesis that in the absence of natural food consumption, the soft-diet baboon sample would exhibit higher levels of craniofacial variation due to their reduced chewing demands.

MATERIALS AND METHODS

The soft-diet experiment group consisted of 24 male *Papio cynocephalus* skulls housed at Southern Illinois University Carbondale. As part of a biomedical study in the 1970s, these individuals were fed "a very soft, atherogenic diet consisting of cholesterol, lard, butter, egg yolks, and powdered chow" for the last 27 months of their dental maturation (Corruccini and Beecher, 1984:136). Eighteen male *P. anubis* and one male *P. cynocephalus* individual housed at the Field Museum of Natural History were selected to be the wild-diet control sample because of their wild African origin. Although their exact diet was not known, their natural wild foods consist of grasses, roots, plants, leaves, bark, gums, seeds, fruit, berries, corn, small invertebrates, and even sheep and goats (Post, 1981; Barton, 1993; Wahungu, 1998; Akosim et al., 2010; Johnson et al., 2012). Visually, all individuals were dentally mature and had erupted third molars to suggest ages around 6-8 years (Phillips-Conroy and Jolly, 1988).

Correspondence to:
Evan Muzzall, Dept. of Anthropology, Southern Illinois University, Faner Building, Rm. 3525, 1000 Faner Dr., Carbondale, IL, 62901
Email: muzzall@siu.edu
Telephone: (618) 536-6651

Members of genus *Papio* are possibly populations of a single species and are sometimes referred to as *Papio hamadryas cynocephalus* and *P. hamadryas anubis* to reflect this subspecies distinction. *P. cynocephalus* and *P. anubis* have been known to interbreed (Samuels and Altmann, 1986; Alberts and Altmann, 2001; Charpentier et al., 2008; Tung et al., 2008) despite geographical distinctions in their genetic compositions (Williams-Blangero et al., 1990; Zinner et al., 2013). Further, Frost et al. (2003) noted cranial morphological clinal organization of genus *Papio* in Africa. Northern baboons (like *P. anubis*) exhibit broader, less flexed crania and rostra compared to the southern forms (such as *P. cynocephalus*) that display inferiorly flexed and narrower crania and rostra (Frost et al., 2003:1056, 1069). Because of their clinal organization and similar environments, general shape differences between these two groups observed by Frost et al. (2003) likely reflect genetic differences.

Linear measurements consisted of standard craniofacial measurements (Moore-Jansen et al., 1994) and posterior airway maximum lengths and breadths (Fig. 1, Table 1). These data were recorded using spreading and sliding Mitutoyo calipers calibrated to 0.01mm. Principal component analysis (PCA) was used to identify measurement loadings responsible for driving the observed variation. Pearson's product-moment correlation coefficient was used to analyze the strength of correlation between measures identified by the PCA.

Occlusal data (Table 2) consisted of molar class relationships (Angle, 1899), posterior crossbite, rotations, displacements, and incisor overbite and overjet following the summation in Harris and Corruccini (2008). For the purposes of our study, we reduced occlusal scores to a score of 0 for normal occlusion and 1 for any deviation from normal occlusion in each category. These values were summed to estimate the magnitude of occlusal irregularity for each individual, and significant differences between the samples were calculated using a Mann-Whitney U test.

Spearman's rank correlation coefficient tested for associations between relevant linear measures and occlusal scores. To attempt to account for potential variation in body size, shape ratios were calculated by dividing all linear measurements by foramen magnum breadth (simplified from area calculations found in Radinsky, 1967; Gould, 1975). The raw and scaled datasets produced highly similar results so that the data quality appears to be high, and only the scaled data are reported here. Statistical analysis was conducted by RMC using the R Project for Statistical Computing (R Core Team, 2013) and PAST: Paleontological Statistics software (Hammer, Harper, and Ryan, 2001).

RESULTS

The PCA results indicate that the combined first two principal components account for 81% of variation within the sample (Fig. 2). The first principal component (PC1) indicates a size increase, primarily in the measures with the highest loadings, along that axis (Fig. 3). There was clear separation between the wild-diet (maroon circles) and soft-diet (blue circles) samples primarily along the second principal component (PC 2). The loadings for PC 2 (Fig. 3) suggest that palate length (PAL) and incisivion (most distal point in the incisive foramen) to basion (IFB) distance contributed most to variation along this axis. Importantly, the single wild-diet *P. cynocephalus* (red circle) groups with the wild-diet *P. anubis* sample rather than the soft-diet *P. cynocephalus* sample, which suggests that the variation along

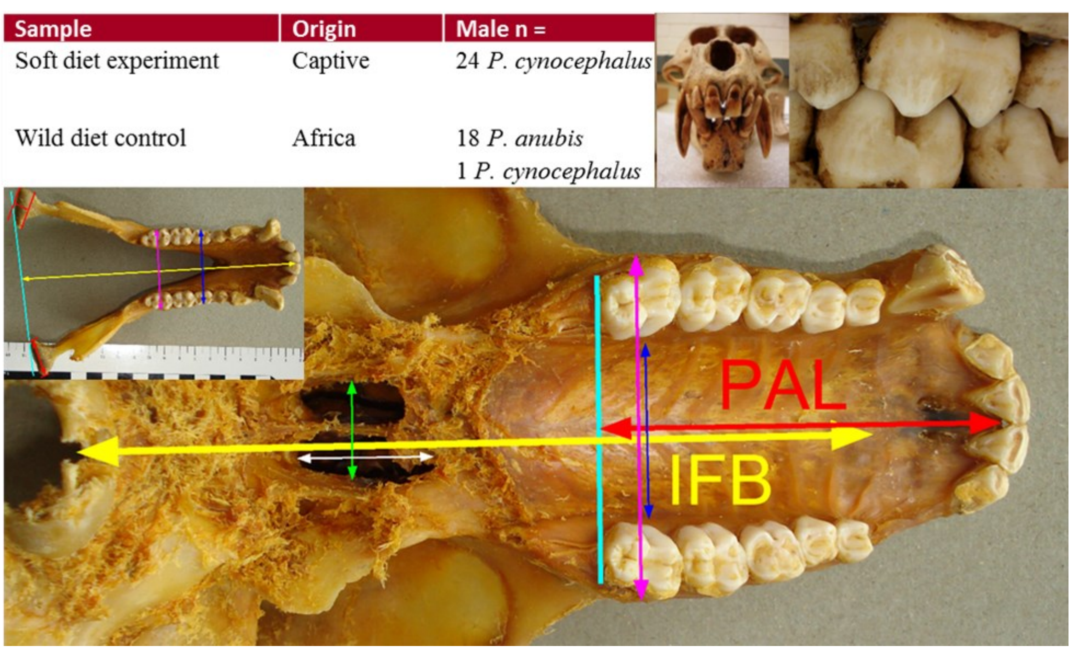

Fig. 1. Illustration of relevant linear measures, palate length (PAL) and incisivion to basion (IFB).

TABLE 1. Metric variables

Measure	Description
MWCond	Mediolateral width of the mandibular condyle taken at the longest ML axis
MLCond	Maximum AP length of the mandibular condyle, perpendicular to MWCond
MDC	Maximum depth of the mandibular corpus from the superior edge of the alveolar
MWCorp	Maximum width of the mandibular corpus from the labial to lingual side of the mandibular corpus at the midpoint of M1
MMdW	Maximum mandibular arch width at M1 taken on alveolar bone with calipers at the midpoint of LM1 and RM1
NMdW	Minimum mandibular arch width at M3 taken on the alveolar bone with calipers at the midpoint of LM3 and RM3
MandL	Mandibular length from the anterior point of projection on the alveolar bone of the mandible to the most posterior projection of the mandibular condyles (infradentale to condylion)
MMW	Maximum maxillary arch width taken at the widest point of the alveolar bone on the maxilla regardless of field or adjacent tooth
NMW	Minimum maxillary arch width at M3 taken on the alveolar bone (lingual surface) at the midpoints of LM3 & RM3
NSB	Minimum snout breadth between L & R maxilla, with calipers in the fossae
PAL	The length of the palate measured from prosthion to the plane of the posterior projection of the maxilla (using a rubber band to delineate the posterior border)
IFB	From the most posterior point on the incisive foramen to basion (incisivion was estimated in poorly mascerated soft-diet individuals)
PAB	The greatest medio-lateral breadth of the posterior airway, taken with the calipers held just posterior to the palate
PAH	The anterio-posterior length of the internal nares, from the posterior margin of the palate to the anterior margin of the opening
BZB	The widest breadth across L & R zygomatic arches (zygion to zygion)
FB	The breadth of the frontal bone across brows
FMW	The medio-lateral breadth of the foramen magnum, measured from within the margins of the occipital with the "inside" arms of the caliper

PC 2 is not the result of genetic differences.

A two-sample t-test demonstrates that mean differences in PAL were significantly smaller (P<0.000), and an F statistic indicates that IFB was significantly more variable (p<0.010) in the soft-diet sample (Fig. 4, Table 3). Again, the bivariate plot of PAL and IFB (Fig. 5) implies that the wild-diet *P. cynocephalus* individual groups with the wild-diet *P. anubis* group, as a this is a reflection of the PCA measures responsible for driving the observed variation. Although a Pearson's correlation coefficient for the soft-diet group (r=0.752) was only slightly lower than the wild-diet sample (r=0.780), results suggest that the soft-diet sample displays significantly shorter palate lengths relative to IFB distances. A Mann-Whitney U test (Table 4) indicates that the soft-diet sample exhibits significantly greater overall occlusal scores than the wild-diet group. Spearman's correlation coefficient (Table 5) demonstrates a relatively weak yet significant (p<0.050) negative correlation between PAL and occlusal scores and suggests that occlusal patterns become more variable as palate length reduces.

DISCUSSION

The hypothesis that the soft-diet baboon sample would exhibit higher levels of craniofacial variation due to decreased masticatory loading during ontogeny is supported. Specifically, the soft-diet group exhibits greater occlusopalatal variation. The single wild-diet *P. cynocephalus* offers support that our results are not the mere reproduction of clinal shape differences of genus *Papio* as noted by Frost et al. (2003). Although genetics undoubtedly play a considerable role (Carlson, 2005; Harris, 2008; Koussoulakou et al., 2009), our study supports the potential for environmental factors to alter developmental trajectories.

Incisivion (Mew, 1974; Frost et al., 2003) should be utilized when investigating basicranial flexion. By using incisivion to construct multivariate ratios, it may be possible to test for the functional and taxonomic significance of the palate's effect on basicranial flexion (Corruccini, 1978; Oxnard, 1983). Through dietary manipulation of living animals, radiographs could be used to investigate the relationships between ontogenetic shape changes, adult cranial form, allometric scaling, heterochrony, and differential

TABLE 2. Occlusal variables

Measure	Description
Anterior Overjet	The maximum distance between the most inferior point on the upper central incisors, and the most superior point on the lower central incisors
Anterior Overbite	The maximum distance between the labial surface of the lower central incisors and the labial surface of the upper central incisors
Posterior Crossbite	The buccolingual interrelationship between upper and lower first molar antagonists
Normal occlusion	The buccal cusp of the upper molars overhang the lower buccal cusps, with the lowers reaching proper centric occlusion
Buccal crossbite	The upper molars are atypically buccally located, such that the lowers do not reach proper centric occlusion
Lingual crossbite	The upper molars are atypically lingual, such that the buccal cusps of the uppers do not overhang the lowers
Buccal Segment Relationship	The interrelationships between the upper and lower first molars in the parasagittal plane
Class 1	The mesiobuccal cusp of the M1 is parasagittal to the buccal groove of M1
Class 2	The mesiobuccal cusp of M1 is mesial to the buccal groove of M1
Class 3	The mesiobuccal cusp of M1 is distal to the buccal groove of M1
Rotation	Refers to a tooth in its normal position in the dental arcade but rotated about its long axis. The sum of rotated teeth are recorded for each side. Recorded for both maxilla and mandible
0	Unrotated
1	Rotated < 45°
2	Rotated > 45°
Displacement	Refers to a tooth that is out of ideal alignment. The summed value is recorded. Recorded for both maxilla and mandible
0	Not displaced
1	Displaced < 2mm
2	Displaced > 2mm

growth (Frost et al., 2003; Leigh, 2006; Trenouth and Joshi, 2006). This could broaden allometric understanding, as Gilbert (2011) reminds us that a large percentage of shape information is lost during allometric correction, and our results suggest that masticatory behavior also confounds shape analyses.

These implications are also important for humans. Many authors have used the hunter-gatherer/agricultural transition to illustrate how changes in dietary selective pressures produced skull morphologies able to cope with new masticatory functional demands (Carlson, 1976a, b; Carlson and Van Gerven, 1977; Hinton and Carlson, 1979; Paschetta et al., 2010). Clinically, Haskell et al. (2009) noted correlations between snoring, sleep apnea, and the structures of the face and mouth. However, this study cannot conclude about the taxonomic significance of airway dimensions in the two samples specifically, nor the relationships between dental variation and airway dimensions in general. There could be multiple reasons why smaller airway dimensions were not found in the soft-diet group. Although the tight confines of the airway's location could have prevented the caliper arms from accurately touching the landmarks, there also exists the possibility that there does not exist significant morphological differences in this area.

Anthropologically, it should be remembered that diet influences our reconstructions of biodistance, phylogeny, and taxonomy whether we account for it or not. Eshed et al. (2006) and Halcrow et al. (2013) rightfully remind us that simple linear relationships between diet and the denti-

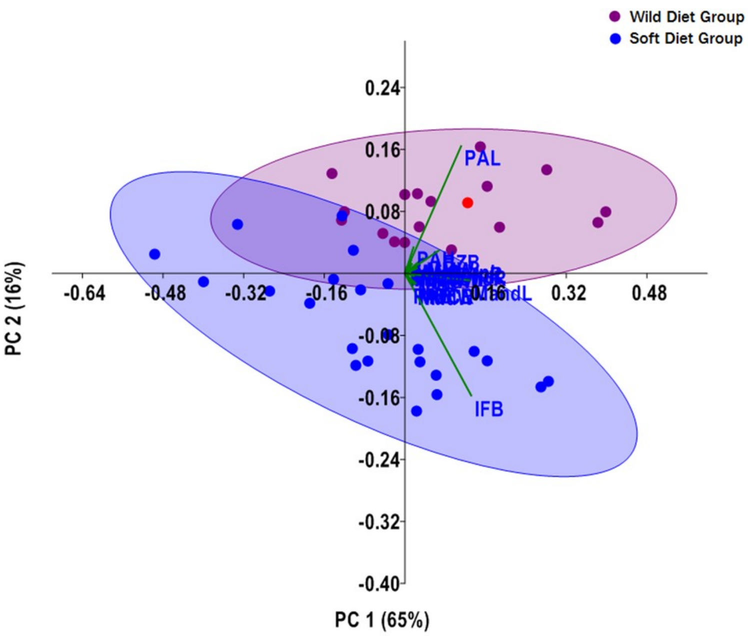

Fig. 2. PCA on scaled data. Maroon circles = wild diet sample; blue circles = soft diet sample; red circle = the single wild-diet *P. cynocephalus.*

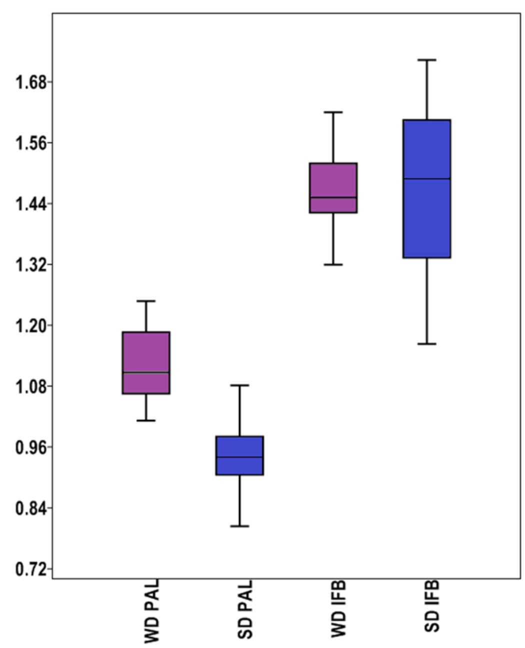

Fig. 4. Boxplot for scaled data. WD = wild-diet sample; SD = soft-diet sample. PAL = palate length; IFB = incisivion to basion.

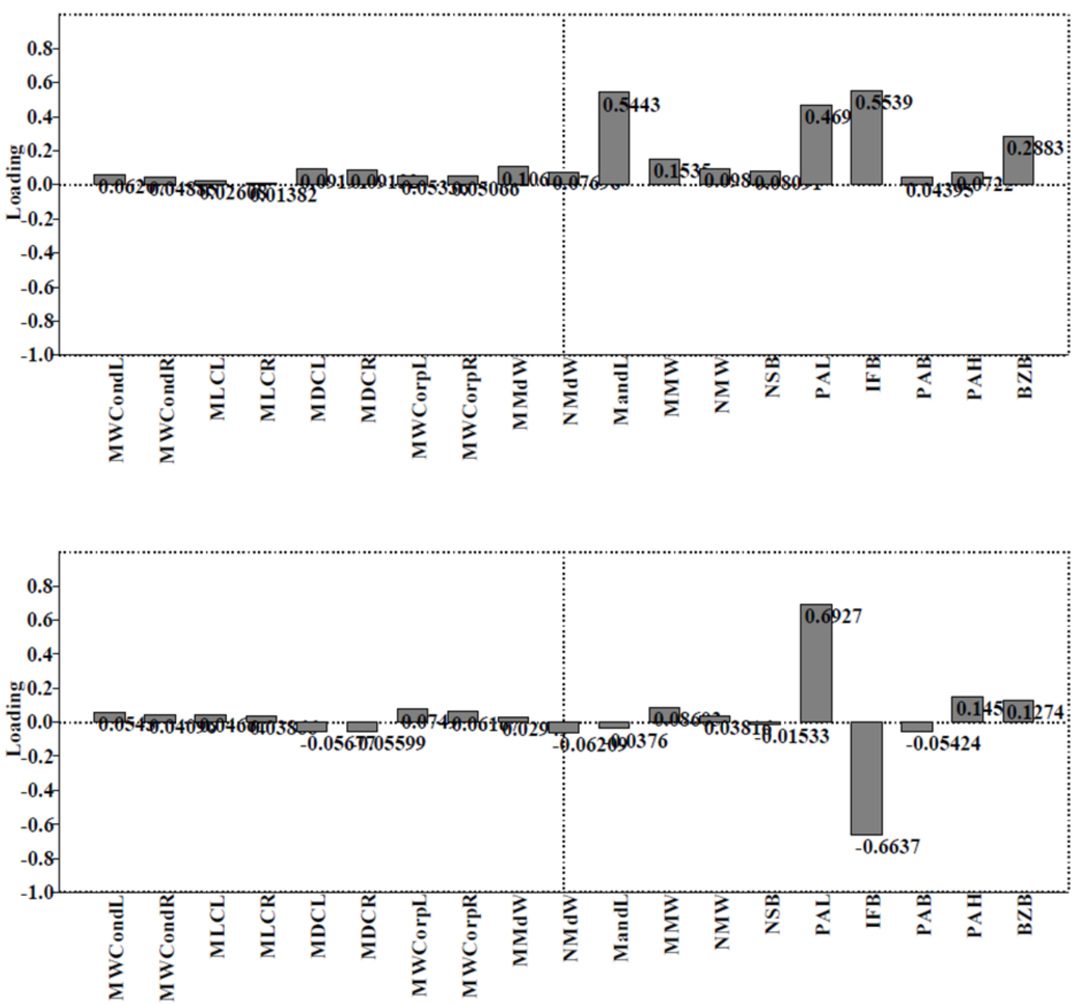

Fig. 3. Loadings for PC1 (top) and PC2 (bottom). Note the inverse relationship between PAL and IFB for PC2.

tion should not be assumed as the ambiguity of genetic, environmental, and cultural influences have the potential to produce a multitude of skeletal adaptations and alterations. By expanding on the research of Corruccini and Beecher (1984), we were able to demonstrate that a variety of research designs can strengthen discussions about the gene-environment interaction and other complex anthropological topics. Luckily, a stronger understanding of genetic influences will better contextualize environmental factors of phenotypic variation. Kuang et al. (2013) have documented the involvement of regulatory genes in mice with long-term, laboratory induced malocclusions. New discoveries such as this continue to enable anthropology to pioneer explanations of observed skeletal variation.

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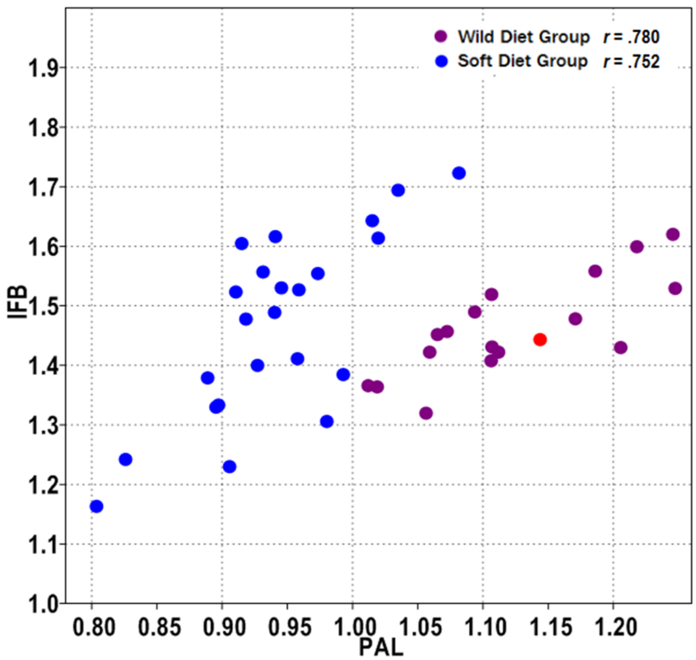

Fig. 5. Biplot showing the relationship between PAL and IFB. Maroon circles = wild-diet sample; blue circles = soft-diet sample; red circle = the single wild-diet *P. cynocephalus.*

TABLE 3. Summary statistics for relevant linear measurements scaled for body size

	n	x̄	SD	F	*p*	t	*p*
PAL WD	18	1.12	0.07	1.35	0.500	8.49	2.16E-10**
PAL SD	23	0.94	0.06				
IFB WD	18	1.46	0.08	3.668	0.008*	-0.13	0.90
IFB SD	23	1.47	0.15				

*significant at P<0.010, **significant at p<0.000; WD = wild-diet sample, SD = soft-diet sample; PAL = palate length, IFB = incisive foramen to basion

TABLE 4. Mann-Whitney U Test for wild-diet and soft-diet occlusal scores

	n	Median	U	*p*
Occlusal WD	19	0	122	0.035*
Occlusal SD	20	1		

*significant at p<0.050

TABLE 5. Spearman correlation for relevant linear measures and occlusal scores

	r's	*p*
PAL + Occlusal	-0.3782	0.017*
IFB + Occlusal	-0.2260	0.172

*significant at p<0.050

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The Biological Implications of the Transition to Agriculture in Ukraine: A Study of Enamel Hypoplasias

Jordan K. Karsten[1*], Sarah E. Heins[1], Gwyn D. Madden[2], Mykhailo P. Sokhatskyi[3]
[1]Department of Religious Studies and Anthropology, University of Wisconsin Oshkosh, Oshkosh, Wisconsin, 54901
[2]Department of Anthropology, Grand Valley State University, Allendale, Michigan, 49401
[3] Borschiv Regional Museum, Ministry of Culture and Arts of Ukraine, Borschiv, Ukraine

Keywords: dental pathology, hunter-fisher-gatherers, Mesolithic, Neolithic

ABSTRACT The Tripolye were the first archaeological culture in Ukraine to cultivate domesticated cereals, practice animal husbandry, and establish large settlements with high population densities. This cultural adaptation was much different than that of mobile hunter-fisher-gatherers of the Ukrainian Mesolithic/Neolithic, and likely resulted in different outcomes for human health. This study compares the rates of enamel hypoplasias in a Tripolye skeletal population with that of Mesolithic/Neolithic hunter-fisher-gatherers. A recently excavated sample of dentitions representing a minimum of 35 individuals from Verteba Cave was examined macroscopically for hypoplasias and was compared statistically to published rates for hunter-fisher-gatherers. The Tripolye from Verteba Cave were found to have at least one enamel hypoplasia on 18.18% of teeth, while the hunter-fisher-gatherers have hypoplastic lesions on 1.88% of teeth. When examined at the individual level, 48.57% of the Tripolye were found to have at least one hypoplasia, as compared to 12.77% of the hunter-fisher-gatherer individuals. The results indicate that the agropastoral Tripolye experienced significantly more systemic stress than the hunter-fisher-gatherers. The higher stress likely relates to dietary and behavioral variables associated with the Tripolye's agropastoral economy, including heavy reliance on cereals as weaning foods and sanitary problems linked to sedentism.

The Tripolye were the first archaeological culture in Ukraine to possess the full Neolithic package of domesticated cultigens, livestock, and pottery (Korvin-Piotrovskiy, 2008). Compared to earlier Ukrainian populations, the Tripolye interacted with their environment in a radically different way through their use of an agropastoral subsistence system and settlement in more sedentary villages with higher population densities. These changes likely had implications for the health of prehistoric humans living in the area of modern Ukraine. The goal of this study is to assess the relative success of the Tripolye cultural adaptation from a biocultural perspective. Specifically, we use enamel hypoplasias to document the level of physiological stress experienced by the Tripolye and compare this to earlier Ukrainian Mesolithic and Neolithic hunter-fisher-gatherer populations.

Enamel hypoplasias are areas of abnormally thin enamel found on the crowns of teeth (Goodman and Rose, 1991). Enamel hypoplasias can take the form of horizontal linear grooves, pits, or large areas of missing enamel (Goodman and Rose, 1990). These lesions form during the years of enamel development, from infancy to late childhood, and result from insufficient enamel production due to the disruption of enamel producing cells called ameloblasts (Hillson, 1996). Ameloblast disruption can be caused by a variety of factors, including malnutrition, infection, localized trauma, and congenital defects (Goodman and Rose, 1991). However, the rates of linear enamel hypoplasias caused by trauma and hereditary conditions are estimated to be extremely low, and therefore most of these lesions are believed to reflect physiological stress resulting from malnutrition, infection, or the synergistic interaction of both (Goodman et al., 1980; Winter and Brook, 1975). This notion has been reinforced by studies of living populations, which have found a positive relationship between the prevalence of enamel hypoplasias and the degree of malnutrition and disease (Cutress and Suckling, 1982; Goodman et al., 1987). As a non-specific indicator of physiological stress, linear enamel hypoplasias are well suited to monitor the general biological well-being of prehistoric populations.

BIOARCHAEOLOGICAL STUDIES OF THE TRANSITION TO AGRICULTURE

Previous bioarchaeological studies have used enamel hypoplasias to examine the impact of the transition to agriculture on the health of ancient human populations. Studies from regions around the globe, including North America's Ohio River Valley, Illinois, India, China, Egypt, the Andes,

Correspondence to:
Jordan K. Karsten, Department of Religious Studies and Anthropology, UW Oshkosh, 800 Algoma Boulevard, Oshkosh, WI 54901
Phone: (920) 424-7307
Fax: (920) 424-0882
Email: karstenj@uwosh.edu

and Mesoamerica, have documented increases in the prevalence of enamel hypoplasias following the adoption of agriculture (Cassidy, 1984; Perzigian et al., 1984; Goodman et al., 1984; Marquez-Morfin and Storey, 2007; Alfonso et al., 2007; Lukacs et al., 2001; Pechenkina et al., 2002). For example, in their study of burials from the multicomponent site of Dickson Mounds, Illinois, Goodman et al. (1984) found the rate of enamel hypoplasias to significantly increase following the transition to agriculture. The cumulative impact of these studies has led many researchers to conclude that the transition to agriculture was detrimental to human health (Larsen, 1995; 2006; Cohen and Armelagos, 1984; Cohen and Crane-Kramer, 2007; Armelagos et al., 1991). However, it is important to point out that some studies have found the rate of enamel hypoplasias to decline or remain unchanged following the agricultural transition (Hodges, 1987; Temple, 2010; Danforth et al., 2007). For instance, Temple (2010) found a decline in the prevalence of enamel hypoplasias following the transition to agriculture in his comparison of Jomon hunter-gatherers and Yayoi agriculturalists from Japan. Other studies have found patterns that are difficult to interpret. Starling and Stock (2007) observed an initial increase in the rate of enamel hypoplasias following the adoption of agriculture in Egypt and Nubia. Interestingly, this transitional stress appeared to be short lived, as the rate of hypoplastic lesions gradually declined through time. The variable results of these studies demonstrate that our understanding of the health consequences of the transition to agriculture remains incomplete.

Compared to the rest of the globe, very few studies have focused on the health consequences of the transition to agriculture in prehistoric Europe (Meiklejohn and Zvelebil, 1991). Papathanasiou (2005; Papathanasiou et al., 2000) documented enamel hypoplasias in Neolithic skeletons from Greece, and concluded the population experienced relatively low levels of systemic stress. Due to a lack of Mesolithic burials in the area, the rates of enamel hypoplasias among agriculturalists could not be compared to hunter-gatherers. Bennike and Alexandersen (2007) studied the biological impacts of the transition to agriculture in Scandinavia, and found the rates of enamel hypoplasias to decline following the adoption of an agricultural economy and then increase over time.

This study aims to address the general scarcity of European data on the health consequences of the transition to agriculture by analyzing relevant skeletal populations from Ukraine. Based on the results of previous bioarchaeological studies, we seek to test the hypothesis that the transition to agriculture was detrimental to the health of prehistoric populations living in Ukraine.

BIOCULTURAL CONTEXT

Ukrainian Mesolithic and Neolithic Populations

In Ukrainian archaeological terminology "Neolithic" is used to mark the appearance of pottery rather than the transition to agriculture as it is elsewhere in Europe (Jacobs, 1993). In fact, at many Ukrainian Neolithic sites, the presence of pottery may be limited to a few sherds, while at others pottery is not present (Lillie, 1996). The Ukrainian Neolithic sites show continuity with earlier Mesolithic sites in material culture, burial practices, and subsistence systems, and therefore, the Mesolithic and Neolithic sites will be discussed together here.

Much of what is known about the Mesolithic/Neolithic period in Ukraine comes from the mariupol-type cemeteries excavated in the Dnieper Rapids region (Zvelebil and Lillie, 2000; Lillie, 1996; Jacobs, 1993). Stable isotope studies on the skeletal remains suggest that these populations consumed diets rich in fish and terrestrial animals (Lillie and Richards, 2000; Lillie and Jacobs, 2006; Lillie et al., 2011; Lillie and Budd, 2011). The consumption of a diet rich in protein and low in carbohydrates is further supported by analysis of dental pathology in these skeletal samples, which have been found to be universally free of dental caries (Lillie, 1996). The ephemeral nature of the Mesolithic/Neolithic settlements in the area, a lack of domesticated cultigens in the archaeological record, and the appearance of only a limited number of domesticated fauna at the end of the Neolithic have led researchers to conclude that these populations were fairly mobile hunter-fisher-gatherers (Lillie, 1996; Zvelebil and Lillie, 2000).

In his examination of dental pathology in the Mesolithic/Neolithic populations from the Dnieper Rapids region, Lillie (1996) documents and interprets the occurrence of enamel hypoplasias. He found enamel hypoplasias throughout the sample, although at a relatively low prevalence. Specifically, Lillie observed at least one enamel hypoplasia on 16.66% of Mesolithic individuals and 11.42% of Neolithic individuals for a pooled rate of 12.77%. When examined by teeth, Lillie found 1.22% of Mesolithic teeth and 2.25% of Neolithic teeth to have one or more hypoplasias. According to Lillie, the rates of enamel hypoplasias indicate suboptimal levels of subadult health during the Mesolithic/Neolithic period, but the low frequencies do not indicate severe systemic stress, suggesting a generally healthy existence for the Mesolithic/Neolithic Ukrainian hunter-fisher-gatherers.

Tripolye

The Tripolye were an Eneolithic people that existed between 4800-2900 cal BC on territory that now corresponds to the modern nations of Ukraine, Moldova, and Romania (Zbenovich, 1996; Rassamakin, 2012). In Ukraine, the Czech Republic, and Slovakia, the Eneolithic is defined as beginning with the appearance of copper artifacts and the onset of copper metallurgy and ends with the start of the Bronze Age (Milisauskas, 2011). The Tripolye culture occupied an area stretching from the Carpathian piedmont in the west, to the Dnieper River in the east, and extended as far south as the Black Sea and as far north as Kiev (Videiko, 2004). The term Tripolye is derived from the name of the Ukrainian village near the first discovery of Tripolye material culture in 1896 by V. Khvoika (Nikitin et al., 2010). Tripolye cultural remains were independently discovered in Romania, and are known there as Cucuteni (Lillie, 2008). Consequently, publications referring to the Tripolye culture also use the terms Tripolye-Cucuteni or Cucuteni-Tripolye to recognize their unity (e.g. Zvelebil and Dolukhanov, 1991).

Detailed relative and absolute chronologies have been developed that divide the existence of the Tripolye into a number of different phases, including the Tripolye A (4900-4300 calBC), Tripolye BI (4300-4100 calBC), Tripolye BII (4100-3600 calBC), Tripolye CI (3600-3200 calBC,) and Tripolye CII (3400-2750 calBC) (Nikitin et al., 2010; Videiko, 2004). These different phases are associated changes in pottery manufacture and decoration (Ryzhov, 2012).

Paleobotanical evidence indicates that the Tripolye cultivated a wide variety of domesticated crops including the hulled wheat types of emmer, einkorn, and spelt, hulled and non-hulled barley, peas, bitter vetch, and lentils (Pashkevych, 2008). The frequent recovery of hulled wheat plants from Tripolye sites supports the notion that these crops were important components of the Tripolye diet (Zbenovich, 1996). These cereals may have been consumed as porridges, as indicated by crushed hulled wheat grains found inside a pot at the site of Maydanetske (Pashkevych, 2008).

Zooarchaeological evidence indicates that Tripolye populations also practiced animal husbandry. Tripolye livestock herds included cattle, pigs, sheep, and goats (Markova, 2008; Zhuralev, 2008). Although the relative importance of each domesticated animal species varies between sites, cattle are often dominant (Korvin-Piotrovskiy, 2012). At the sites of Traian -Doalul Viei and Tirpesti I cattle make up over 45% of the faunal osteological material (Ellis, 1984; Marinescu-Balcu, 1981). However, at the site of Mayaki, sheep and goats make up 64% of the faunal assemblage, while at Luka-Vrublevetska, pigs are the most common species (Ellis, 1984).

In addition to agropastoral activites, Tripolye populations engaged in hunting and gathering a wide range of wild species (Lillie, 2008). Gathered foods like wild grapes, cornelian cherries, plums, and pears have been identified at Tripolye sites (Pashkevych, 2004), and identification of animal species such as roe deer, red deer, wild pigs, aurochs, and catfish demonstrate that hunting and fishing were also practiced (Korvin-Piotrovskiy, 2012). For some Tripolye populations it is likely that hunting greatly contributed to the diet, as wild animals comprise over half the zooarchaeological material at the CI period site of Kolomyishchina (Lillie, 2008).

Tripolye settlements vary in size, ranging from small seasonal sites to large permanent settlements (Chapman, 2010). Villages are located near permanent sources of water and are usually on the edge of the first river terrace or on promontories of steep river banks (Zbenovich, 1996). Some settlements dated to the middle period (B Period) of the Tripolye culture are found to be fortified with ramparts or surrounded by ditches (Passek, 1961; Markevich, 1981). Early (A Period) Tripolye hamlets and villages are relatively small and vary in aerial extent from 0.5-6 hectares, usually containing fewer than 15 residential structures (Zbenovich, 1996). In the later periods (B-C Periods), many villages reached 20-40 hectares in size and were composed of an average of 200 dwellings (Zbenovich, 1996). Some later settlements were extremely large, such as Talyanki, which was 450 hectares in area (Kruts, 1989). These “megasites” were the largest in Europe at the time (Kruts, 2012) and were occupied year-round for a period up to 50 years, representing relatively sedentary settlement practices (Korvin-Piotrovskiy et al., 2012).

The Tripolye were a densely settled group, with the population density of the Dniester area estimated at 12 individuals per square kilometer, making it one of the most densely settled areas in Europe (Korvin-Piotrovskiy, 2012). Likewise, the site of Talyanki has been estimated to contain over 2,000 residential structures and have a population of 14,000 individuals (Kruts, 2012), rivaling major prehistoric urban centers.

Fig. 1. Location of Verteba Cave.

MATERIALS AND METHODS

The dental sample used to test our hypothesis include all known dentitions and loose teeth excavated from Verteba Cave, a mortuary site located outside the modern village of Bilche Zolote, Ternopil Oblast, Ukraine (Figure 1). The human remains found in the cave have been attributed to the Eneolithic Tripolye culture based on associated pottery, lithics, and ceramic figurines. Radiocarbon dating of the human bone, faunal remains, charcoal, and pottery from Verteba Cave place the site's use between 3800-2600 calBC (Nikitin et al., 2010). Analysis of pottery places the use of the cave during the BII, CI, and CII periods of the Tripolye relative chronology. Very few human remains attributable to the Tripolye are known prior to the CII period, making the skeletons from Verteba Cave extremely valuable in terms of studying the biology and mortuary customs of this population.

The sample was collected over the course of two periods of excavation. The most recent excavations took place over the field seasons of 2008 and 2012, and were conducted by the authors. These excavations yielded a minimum number of 36 individuals recovered as comingled secondary burials, mixed with pottery, ceramic figurines, stone and bone tools, and faunal remains. This material is housed on site by the Borschiv Regional Museum. In addition to the specimens collected during the two recent field seasons, the remains of a minimum of 24 individuals were examined that were excavated from Verteba Cave during the late 19th century by Polish archaeologists. These human remains are curated at the Museum of Archaeology in Krakow, Poland. Only crania and mandibles are present in the Krakow museum collection. Although detailed field notes are not available regarding the excavation of the material from the 19th century, their association with diagnostic Tripolye pottery supports the pooling of this sample with the more recently excavated material.

A pooled sample of 231 permanent teeth from a minimum of 35 individuals was examined for enamel hypoplasias (Table 1). A total of 121 permanent teeth representing a minimum of nineteen individuals were collected during the two most recent field seasons. Of the 121 teeth, thirteen are not associated with a maxilla or mandible. A total of 110 permanent teeth representing a minimum of 16 individuals were available for study in the Krakow collection. Twenty-one of the teeth in the Krakow collection were not associated with a mandible or maxilla.

Due to the comingled nature of the burials, sex and age were assigned to individual crania and mandibles. Ages-at-death were determined using dental development, dental attrition, and cranial suture closure (Buikstra and Ubelaker, 1994; Lovejoy, 1985; Meindl and Lovejoy, 1985). Due to the fact that more accurate aging methods could not be employed since no associated os coxae were available, individuals were segregated into age categories of "subadult" and "adult". Sex was determined for adults using the standard morphological characteristics (Buikstra and Ubelaker, 1994; Walker, 2008).

All of the teeth were examined for the presence or absence of enamel hypoplasias. The lesions were recorded following the method described by Lukacs (1989; 1992) and Temple (2010), with teeth examined macroscopically under diffuse lighting with a second light source positioned at an oblique angle to the specimen. A handheld 10x magnifier was used in some cases to help identify defects. This technique allows for optimal perikymata detection. To avoid confusing enamel hypoplasias with normal perikymata, the spacing of adjacent perikymata were compared to potential defects (Skinner et al., 1995). Each tooth examined was scored as either having an enamel hypoplasia present or absent. For teeth with hypoplastic lesions, the number of enamel hypoplasias present was recorded. The number of individuals displaying at least one enamel hypoplasia was also recorded. In Verteba Cave, some maxillae and mandibles representing single individuals are associated with one another, while others are isolated. When associated, upper and lower jaws are counted as single individuals. In cases where isolated mandibles and maxillae were not definitively associated with their occluding jaw, the isolated element is treated as an individual. This potentially overestimates

TABLE 1. Composition of sample by tooth type

Tooth Type	Teeth	Tooth Type	Teeth
Maxillary		**Mandibular**	
Incisors	17	Incisors	2
Canines	19	Canines	5
Premolars	43	Premolars	18
Molars	92	Molars	35
Total Maxillary	171	Total Mandibular	60

TABLE 2. Enamel hypoplasia frequencies

Sample	Ratio of Teeth With At Least 1 Hypoplasia To Total Teeth Observed	Ratio of Individuals With At Least 1 Hypoplasia To Total Individuals Observed
Verteba Cave Tripolye Agriculturalists	42/231	17/35
Mesolithic/Neolithic Hunter– Fisher– Gatherers (Lillie, 1996)	43/2284	18/141

the number of individuals present in the sample, however, we believe it provides the most appropriate way to organize the available dental material. Loose teeth were not included in the individual count. Wear in the Verteba Cave sample was not severe and no tooth crowns had lost over one-third of their height to macrowear. Therefore, wear did not bias the identification of enamel hypoplasias in the sample.

The data on enamel hypoplasias among the Tripolye from Verteba Cave will be presented in two ways following Lillie (1996) to allow for statistical comparison with Ukrainian hunter-fisher-gatherer populations. The first is the tooth count method, where the number of teeth with at least one enamel hypoplasia is presented as a ratio to the total number of observable teeth. This method has the advantage of using a large sample size, which increases the power of statistical analysis (Lukacs, 1992). One drawback to the tooth count method is that it may overestimate stress. Single stress events are recorded on all teeth developing at the time of a physiological insult. Therefore, the tooth count method can overestimate the stress experienced by a population by treating all of the defects resulting from one stress episode as representing independent stress events. The second way enamel hypoplasia data will be presented is using the individual count method, where each dentition representing a single individual is scored as either having one or more enamel hypoplasias or as lacking hypoplasias altogether. The individual count method has the advantage of focusing on the individual, the primary unity upon which selection acts (Lukacs, 1992). One disadvantage of using the individual count method with prehistoric skeletal samples is that it often results in small sample sizes and reduces the power of statistical analysis (Lukacs, 1992). The relative frequencies of enamel hypoplasias for agriculturalists and hunter-fisher-gatherers are compared using $\chi 2$-tests (α=0.05).

A recent study by Hassett (2012) has demonstrated that, as compared to microscopic methods, examination of teeth with the naked-eye provides a minimum estimate of the number of hypoplastic defects. As microscopic analysis was not possible with the sample from Verteba Cave, the current data will be regarded as a conservative approach to quantifying systemic stress among prehistoric populations from Ukraine.

RESULTS

The Eneolithic Tripolye agriculturalists from Verteba Cave have significantly more enamel hypoplasias than the Mesolithic/Neolithic hunter-fisher-gatherers when examined using both the tooth count ($\chi 2$=168.993, $p<0.001$) and individual count methods ($\chi 2$=20.58, $p<0.001$)(Table 2). The Tripolye have at least one enamel hypoplasia on 18.18% of the teeth examined. In comparison, the hunter-fisher-gatherers have enamel hypoplasias on 1.88% of teeth. Among the Tripolye, 48.57% of observable individuals had at least one enamel hypoplasia, as compared to 12.77% of individuals in the hunter-fisher-gatherer sample.

The rate of enamel hypoplasias in Tripolye subadult (2/4 individuals) and adult dentitions (15/31 individuals) was similar. Hypoplasias occurred at the highest prevalence on canines (45.83%), followed by incisors (33.33%), premolars (19.67%), and molars (10.24%). This pattern of prevalence by tooth type is not unexpected based on the known differences in susceptibility (Goodman and Rose, 1990).

DISCUSSION

Analysis of enamel hypoplasias indicates that the agropastoral Tripolye experienced significantly more systemic physiological stress than earlier hunter-fisher-gatherers. This suggests that the introduction of agriculture and its associated sedentary lifestyle had negative consequences for human health in prehistoric Ukraine. The results lead us to accept our hypothesis that the transition to agriculture was detrimental to health in our study area. However, due to the small sample size of dentitions from Verteba Cave, the results must remain preliminary. Excavations are ongoing at the site with the aim of expanding the sample size.

Enamel hypoplasias form during the period of enamel development and leave an indelible record of systemic stress that occurred during infancy and childhood (Larsen, 1997). Weanling stress, diarrheal diseases, malnutrition, and infection are all commonly implicated as causative agents in the formation of enamel hypoplasias (Goodman and Rose, 1990). Nutritional stress engendered by an agricultural diet may be a contributing factor to the higher rates of systemic stress observed among the Tripolye. Cereals were a major component of the Tripolye diet (Zbenovich, 1996), and may have been a primary weaning food in the form of porridges (Pashkevych, 2008). However, cereals lack essential amino acids, such as lysine, are a generally poor source of protein, and are deficient in vital minerals such as iron (Baynes and Bothwell, 1990; Abdel-aal and Hacl, 2002). High reliance on cereals, especially as weaning foods, and reduced dietary variability as a consequence of an agricultural economy could have resulted in malnutrition and contributed to the relatively high systemic stress observed in the Tripolye skeletal sample.

The practice of animal husbandry by the Tripolye makes it likely that they were consuming at least some protein- and nutrient-rich animal products and meat. However, Mesolithic/Neolithic groups from Ukraine had diets highly focused on the meat of terrestrial animals and fish, with a lesser focus on vegetation (Lillie, 1996; Lillie and Richards, 2000). Such a diet would be nutritionally superior to one focused on domesticated cereals, and likely contributed to the lower incidence of systemic stress observed among Mesolithic/Neolithic peoples in this study.

In addition to dietary factors, changes in population density and behavior associated with the adoption of agriculture likely altered the disease ecology of the Tripolye farmers as compared to the Mesolithic/Neolithic hunter-fisher-gatherers. Both the farmers and the hunter-fisher-gatherers would have been affected by infections of enteric bacteria such as Salmonella, E. coli, and Staphylococcus (Cockburn, 1971). Likewise, both groups would have experienced some zoonotic diseases transmitted through insect bites and the consumption of contaminated meat (Armelagos, 1990). However, as compared to the mobile Mesolithic/Neolithic hunter-fisher-gatherers who lived in small bands, the settlement of the Tripolye in sedentary villages with high population densities would have resulted in a significantly different disease ecology. The densely settled Dniester region and megasites such as Talyanki would have easily met the threshold for the maintenance of contagious crowd diseases such as measles, influenza, smallpox, and mumps (Armelagos, 1990). Additionally, densely settled sedentary populations, such as the Tripolye, would have quickly contaminated their environments with their own waste, leading to sanitary health hazards (Larsen, 1995). This environmental contamination can lead to diarrheal diseases and parasitic infections, which can result in malnutrition through a reduction in the efficiency of nutrient absorption and the loss of nutrients to parasitic activity (Walker, 1986). Diarrheal disease can have especially harmful effects on subadults (Walker et al., 2009), and were likely a contributing factor to the elevated systemic stress documented in the Tripolye agriculturalists. By contrast, the low population density of Mesolithic/Neolithic hunter-fisher-gatherers would have precluded the existence of contagious crowd diseases, and their mobile lifestyle would have prevented infections resulting from environmental contamination (Armelagos, 1990).

The Tripolye would have also experienced close contact with domesticated animals via the practice of pastoralism, which would have significantly altered their disease ecology as compared to earlier hunter-fisher-gatherers. Close contact with domesticated animals would have exposed the Tripolye to novel zoonotic diseases and infections including tapeworm parasites, viruses, rabies, and tuberculosis (Armelagos, 1990). One specific cultural practice may have made the risk of zoonotic diseases especially severe for the Tripolye. Although the reconstruction of houses has been controversial in Tripolye archaeology, it seems that they constructed two-story structures where the ground floor served as a stable for animals and the top floor was used for human habitation (Korvin-Piotrovskiy et al., 2012). The ground floor of these structures was constructed using timber to build a log cabin-like frame that would have provided a sturdy structure to contain animals, unlike wattle-and-daub walls, which are easily destroyed by pigs (Korvin-Piotrovskiy et al., 2012). By keeping farm animals in their homes, the Tripolye greatly increased the likelihood of contracting zoonotic diseases and probably resulted in a substantial parasite burden for the population.

The level of systemic stress documented among the Tripolye from Verteba Cave is higher than that of a Late/Final Neolithic agricultural population from Greece. Papathanasiou (2005) analyzed 436 teeth from Alepotrypa Cave and found 8.3% of teeth to have at least one enamel hypoplasia. Perhaps the Tripolye experienced more systemic stress than Greek agriculturalists due to their higher population density. It is interesting to note that the level of systemic stress documented in the Greek agriculturalist sample is higher than that of the Ukrainian hunter-fisher-gatherers.

The results of our study are in accordance with results obtained by Wittwer-Backofen and Tomo (2008) who found central European agriculturalists to have more enamel hypoplasias than earlier hunter-gatherers. However, the results of our study differ from those obtained by Bennike and Alexandersen (2007) who found the rates of enamel hypoplasias to immediately decline and then increase following the transition to agriculture in Scandinavia. This suggests that the biological implications of the adoption of agriculture were variable across Europe, and further study is necessary to fully understand the impact of this transition on prehistoric health.

CONCLUSION

The transition to agriculture was one of the most pivotal events in the biological and cultural evolution of our species. Despite this importance, relatively little is known regarding how the adoption of agriculture affected the health of prehistoric European populations. This study addressed this weakness in the literature by using enamel hypoplasias to document the systemic physiological stress experienced by Tripolye agriculturalists from Ukraine. Comparison of the Tripolye with hunter-fisher-gatherers indicates that the transition to agriculture resulted in increased biological stress in this region. Contextualizing the results archaeologically suggests that the higher prevalence of enamel hypoplasias may have been caused by malnutrition due to reduced dietary breadth and infection resulting from increases in population density, sedentism, and contact with domesticated animals.

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BOOK REVIEW

Legacy of a Longitudinal Growth Study in Central Australia. By Tasman Brown, Grant C Townsend, Sandra K Pinkerton, James R Rogers. Published in Adelaide by University of Adelaide Press, 2011. pp. 327. ISBN: 978-0-9807230 -9-0, price A$35.00, paperback. 978-0-9870730-0-6, Free, e-book PDF.

This is terrific book, detailing the important longitudinal dental and growth study in Yuendumu (1951-1971), how it came about, the logistics, the principle investigators and what knowledge has been gained. This is a readable book, with a fascinating historical account of the background to the study, the complexity and difficulty collecting longitudinal data in a remote, inhospitable region. All four authors write from direct experience, particularly Tasman Brown and Grant Townsend. The book has nine chapters and three appendices and is richly illustrated with photographs, tables and diagrams. The chapters fall into three sections and a bibliography. The first part chronicles early expeditions to the Northern Territory and the logistics of the field trips of the longitudinal study. The middle section summarises the research findings of the occlusal development and function of teeth and facial growth patterns of the Warlpiri people. The third section is about the people involved and an account of more recent outcomes and collaborations using this valuable resource of curated records. The documented list of the hundreds of publications, theses and films is a valuable reference. In addition, a useful appendix of 24 summary tables of growth variables from 5-20 years in half year intervals is provided. The book is supported by an open access electronic version.

The major strength of this book is the way it brings together the historical context, the logistic organisation of the field trips and challenges of data collection during this period. It also describes the extensive impact of this research in the understanding of dental anthropology and cranio-facial growth. These two chapters build on what must be one of the founding studies of dental anthropology in the modern era i.e. Campbell's thesis on the dentition and palate of the Australian Aboriginal (1925). The legacy of knowledge from this longitudinal study in Yuendumu touches most aspects relating to the dentition and developing cranio-facial complex. The teeth of Australian Aboriginals are characterized by larger crown diameters than most other living groups and ample dental arch dimensions. Dental crown features form a characteristic Australian dental complex that includes Carabelli trait and metaconules (cusp 5) on maxillary molars, cusps 6 and 7 on mandibular molars and shovel shaped incisors. Tooth use as tools and extensive occlusal and interproximal tooth wear are also features. Mid-facial prognathism is common, with relative protrusion of the mid-facial region particularly prominent in the alveolar bone, allowing wide excursions of the mandible during mastication. Less malocclusion and tooth crowding occurs than in other populations. The longitudinal study has documented the age of eruption and exfoliation of deciduous and permanent teeth as well as facial growth. Lip and tongue pressure in relation to occlusion, occlusal wear, function in the worn dentition and the function of cusps have also been investigated. More recent studies document the oral health and general health in Yuendumu Aboriginals at the present time and the increasing dental caries experience as food habits changed. Human longitudinal growth studies in general and their future are discussed. These two chapters are supported by an excellent biography of publications and theses. The appendices and online access of an ebook also make this an important resource that will be valuable to anyone with an interest in dental anthropology, dental morphology or cranio-facial growth.

The only limitation of this book is that the two chapters on occlusal development and function and facial growth in the Warlpiri are too short as, in my view, they could be a volume in their own right. The only related book is about the Fells longitudinal study of human growth, maturation and body composition (Roche 1992). The Yuendumu legacy is written in a more narrative style and because of the unique timing collecting data on previous hunter-gatherers and the focus on the dentition, this book will be of particular interest to readers of Dental Anthropology Journal.

It is a privilege to have worked on this material and dental anthropologists the world over, owe a debt of gratitude to Campbell and Barrett as well as the authors, for collecting, documenting and curating the records that make up the physical legacy that continue to contribute to the understanding of the complexities of the developing dentition and cranio-facial region.

HELEN LIVERSIDGE
INSTITUTE OF DENTISTRY
Turner Street, London, United Kingdom E1 2AD
Email: h.m.liversidge@qmul.ac.uk

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Campbell TD. 1925. Dentition and Palate of the Australian Aboriginal. Adelaide: Univ. Adelaide.

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CORRECTION

The author would like to apologise for an error in calculating standard deviation using logistic regression in the publication of Liversidge HM. 2010. Demirjian stage tooth formation results from a large group of children. *Dental Anthropology* 23:16-24.

The standard logistic distribution has a variance of $\pi^2 \div 3$ and standard deviation of $\pi^2 \surd 3$ (Greene and Hensher 2010). This means that standard deviation values in Tables I and II are incorrect and require a correction factor. The standard deviation should be corrected by multiplying with 1.814 year.

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RESEARCH COMPETITION in DENTAL ANTHROPOLOGY

THE ALBERT A. DAHLBERG PRIZE

The Albert A. Dahlberg Prize is awarded annually to the best student paper submitted to the *Dental Anthropology Association* (*DAA*). Dr. Dahlberg was a professor at the University of Chicago, one of the founders of the International Dental Morphology Symposia, and among the first modern researchers to describe variations in dental morphology and to write cogently about these variations, their origins, and importance. The prize is endowed from the Albert A. Dahlberg Fund established through generous gifts by Mrs. Thelma Dahlberg and other members of the Association.

Papers may be on any subject related to dental anthropology. The recipient of the Albert A. Dahlberg Student prize will receive a cash award of $200.00, a one-year membership in the Dental Anthropology Association, and an invitation to publish the paper in *Dental Anthropology*, the journal of the association.

The student should submit a printed copy (or, preferably, an electronic PDF) of his or her paper in English to the President of the *DAA*. Manuscripts must be received by March 20th to be considered for for the 2015 Albert A. Dahlberg Prize. The format must follow that of *Dental Anthropology*, which is the same as the style of the *American Journal of Physical Anthropology*. The Style Guide to Authors is available at the web site for the *AJPA* (http://physanth.org/).

The manuscript should be accompanied by a letter from the student's supervisor indicating that the individual is the primary author of the research and of the paper. Multiple authorship is acceptable, but the majority of the research and writing must be the obvious work of the student applying for the prize. Send enquiries and submissions to the President of the *DAA*:

Dr. Scott E. Burnett
Department of Anthropology
Eckerd College
4200 54th Avenue South
St Petersburg, Florida 33711 USA
E-mail: burnetse@eckerd.edu

The *DAA* reserves the right to select more than one paper, in which case the prize money will be shared equally among the winners. The selection committee also reserves the right to not select a winner in a particular year.

The winner of the Albert A. Dahlberg Student Prize will be announced at the Annual Meeting of the *DAA*, which is held in conjunction with the annual meeting of the American Association of Physical Anthropologists. In 2015, the meeting will be held in St. Louis, Missouri March 25 - 28.

Dental Anthropology Association
3rd Annual Turner CUPs Poster Competition
AAPA annual meetings: St. Louis, MO 2015



Requirements:

1.Poster must revolve around teeth as research medium

2.Student must be first author (if there are multiple authors)

3.To be eligible, you must contact G. Richard Scott (grscott@unr.edu) no later than March 20th, providing name, poster title, and session number

4.Competition will be judged by senior members of DAA

5. Cambridge Press will award $150.00 in value of books to the top 3 winners

6.Poster award(s) will be announced via email and published in the Journal

Dental Anthropology

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