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Human Ecological Transitions in Ancient Sicily Analyzed by Bone Stress Markers

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Introduction

Many heterogeneous variables influence humans adaptation to different ecologies and their fitness (Johnson and Earle, 1987; Levine, 1998). Abel and Step (2003) regard the study of human ecology as a very important way to gain further understanding even on our ancient cultural adaptation to different environments, and prehistorical and archaeological contests can provide very important information. The progressive transition from hunting to farming in different geographical areas, played a major role in the cultural evolution of humankind and in the development of human chronic and infectious diseases. For example, several metabolic issues arose with plant and animal domestication, as a consequence of genomic inadequacy of first farmers to effort a new subsistence ecology. Moreover, diet and food resources at the Neolithic transition, with the reduction of protein and carbohydrates has led to increased spread of some diseases like iron deficiency anaemia (Cameron, 1999), and osteoarthritis, presumably favored by agricultural work and anti-hygienic settlement. Different and new diseases developed from animal source once the humans established continuous contacts with the domesticated animals (Larsen, 2006). Furthermore, historical period nearly always signified a progress toward social complexity. This complexity usually meant increasingly sophisticated strategies for the control and the exploitation of the environment. Societies stated to be structured to achieve a greater food production, and the management of technological innovation, with consequent social stratification in urban aggregates (Armelagos, 2009). Roles in society changed with the need for greater specialization, particularly military roles (Dandeker, 1994). With the development of civilization, the birth and survival rates of infant increased for many well-fed civilization with each advancing century (Armelagos and Harper 2010). Anthropology and palaeopathology analysis are elective tools for the palaeoecological reconstruction and for the study of ancient human life history and lifestyles in populations from different periods. Skeletal markers of health have been the subject of research for a long time (Aufderheide and Rodríguez-Martín, 1998). The study of skeletal stress patterns is a means of investigating both the social and environmental factors affecting the economic choices of ancient population (Smith, 2001). Some studies use stress markers in bones (Roberts and Lewis, 2002; Slàdek *et al.*, 2007, Slaus, 2008) and teeth (Vodanović *et al.*, 2005; Temple and Larsen, 2007; Irei *et al.*, 2008) to indicate whether observed changes over time are the result of an improvement or decline in living condition. Such studies are frequently ineffective to discern whether the documented changes in a population are caused by events like mutation, natural selection, demic movements, evolutionary trends, or adaption due to environmental factor, because a specific difficulty, given the complexity of biological systems, related to the variety and multiplicity of factors that compose them.

A number of studies have addressed, with different results, the articulated transitions between different subsistence economies, and the potential effects they had on population biology. Slaus (2011) noted as the general trend of deteriorating health with the transition to the Early Medieval period in Dalmatia was observed when cribra orbitalia, linear enamel hypoplasia, non-specific periostitis and trauma frequencies were analyzed. it would appear that the political, social, economic and religious changes that characterized the Late Antique/Early Medieval transition in Dalmatia resulted in a clear discontinuity, not only from the cultural, but also from the biological point of view with an evident deterioration of oral health during the Early Medieval period.

The comparative analysis of dento-alveolar lesions in the Tyrrhenian region of central Italy from two Roman Imperial samples (1st–3rd centuries AD), to a Lombard Early Medieval sample (7th century AD) showed a significant increase of caries, alveolar abscesses and ante mortem tooth loss in the Lombard sample, suggesting a deterioration of living conditions towards Middle Age (Manzi *et al.*, 1999). A data in partial contrast with another research conducted in Italy (Belcastro *et al.*, 2007), that indicated substantial continuity of dietary habits and no ecological crisis in the analyses of dento-alveolar pathologies, cribra orbitalia and periostitis frequencies, in a similarly distributed sample (a Late Antique, 1st–4th centuries AD, and an Early Medieval, 7th century AD) in Molise region. The importance of skeleton markers and dental diseases must be carefully evaluated in the light of sample representative ness and punctual situations.

In the archaeological landscape of central Mediterranean a very important site for the study of recurring cultural transitions is Sicily island. Due to its geographical position in the Mediterranean basin, its vicinity to African northern coast, and to continental Europe, since the last Würm glaciation, Sicily had a very articulated continental ecology that repeatedly challenged human settlers. Furthermore the island early become the objective of consecutive migrations since the late Epigravettian times (D'Amore *et al.,* 2009).
In this study we started from the initial consideration that ecological changes of ancient populations of Sicily, chronologically subdivided in Prehistoric, Protohistoric, and Historical groups, can supply a lot of information on the biology of ancient populations, their ecology and their palaeodemography. Specifically, the aim of this report is to test the hypothesis that ecological parameters (environmental and cultural) influence the survival rates of individuals and the quality of life in terms of expectancy of survival, impairing diseases and fitness.
The tools for this investigation are the frequencies of arthritis (Weiss and Jurmain, 2007) periostitis (Aufderheide and Rodríguez-Martín, 1998) and cribra orbitalia (Stuart-Macadam, 1991) that are considered important markers of health in skeleton biology, together with traumatic events, that can be interpreted in the light of palaeoecological reconstruction if presumably related to social stress or inter-population competition.

Materials and Methods

The sample has been investigated on the base of demographic and palaeopatological parameters. A total of 207 complete skeletons were examined in this study (Tab. 1).

Group	Site/Necropolis	Dating	Num individuals
Prehistoric	Grotta dell'Uzzo (TP)	Mesolitich (9800-9460 BP)	12
Prehistoric	Grotta D'oriente (TP)	Mesolitich (8740-8390 BP)	3
Prehistoric	Grotta Molara (PA)	Mesolitich (8600±100 BP)	2
Protohistoric	Stretto Partanna (TP)	Early Bronze Age (1600±1400)	40
Protohistoric	Marcita (TP)	Middel Bronze Age (1500±1300)	40
Protohistoric	Polizzello (CL)	Iron Age (900-734 BC)	44
Historic	Caserma Tukory (PA)	Punic period (264-241 BC)	22
Historic	San Giovanni (TP)	Byzantine period (535-827 AD)	22
Historic	Monte Iato (PA)	Arab period (827/902 AD)	22

Tab. 1. *Brief information about investigated population.*

The estimated age was based on the degree of dental wear (Miles, 1963; Lovejoy, 1985), pubic symphyseal surface (Katz & Suchey 1986), the ilium auricular surface (Buckberry and Chamberlain, 2002); the epiphyseal union of long bones (Krogman and Iscan, 1986), dental development (Ubelaker, 1989). In according to (Buikstra and Ubelaker, 1994) we considered seven age classes: fetus (before birth), infant (0-3 years), child (3-12 years), adolescent (12-20 years), young adult (20-35 years), middle adult (35-50 years), old adult (50+ years). Cribra orbitalia were detected macroscopically in individuals with at least one orbital roof preserved. The degree of severity was scored according to the Stuart-Macadam (1982; 1991) scale. Periostitis was scored as absent or present when new superficial bone and fine striae were observable on the femur and tibia. In particular, we only scored the complete bone, although some small fragments and the proximal and distal ends may have been absent. Side and bilateral presence and, for the tibia, medial and/ or lateral position were recorded. Bones with clear signs of fracture associated with periostitis were excluded (Aufderheide and Rodríguez-Martín, 1998). Trauma were recorded following the indications of (Lowell, 1997). A fracture consists of an incomplete or complete break in the continuity of a bone. The most common types of fractures, such as transverse, spiral, oblique, and crush fractures, result from direct or indirect trauma. Each bone in respectively skeleton was carefully examined in according to Weiss and Jurmain (2007) to detect the presence of arthritis.
Palaeodemographic research has been intensely criticized for the past two decades, (Bocquet-Appel and Masset, 1982). Many of these criticisms focused on the inherent problems of a skeletal sample such as sampling bias, errors in estimating age at death, and hidden heterogeneity (Jackes, 1992). Abridged life tables were calculated using modern palaeodemographic methods (Alesan *et al.*, 1999; Abbè, 2008).
The statistical analysis of health indicators in the sample was performed in according to Cox and Mays (2006). Fisher's nonparametric test has been carried out (Madrigal, 1998). The use of this test is requested, in order to verify the presence of statistically significant difference between age classes, in relation to diseases, by the non-homogeneous consistency of the sample.

Results

In the Abridged life tables (Alesan *et al.,* 1999) shows only two parameters Life expectancy (e°x, average number of years lived after exact age x, years) and Death (dx, fraction of population in age class x) (Tab. 2). The life expectancy, at birth, for the Prehistoric group, is of 26.6 years, with a cumulative percentage of mortality, within 12, of the 16.66%. Life expectancy at birth for Protohistoric group is 44, with 40,2% a cumulative percentage of mortality within 12 years. However, after this period in Historic group the life expectancy at birth is 29,4 with a cumulative percentage of mortality, within 12, of age of the 21,9%.

Age interval	Prehistoric (dx)	Protohistoric (dx)	Historic (dx)	Prehistoric (e°x)	Protohistoric (e°x)	Historic (e°x)
infans (0-3)	11,11111111	28,10650888	13,86321627	26,65277778	43,9896327	29,42118792
child (4-12)	5,555555556	12,13017751	8,133086876	9,703703704	33,62032483	21,52268925
adolescent (13 - 20)	4,444444444	4,733727811	7,948243993	9,358974359	21,11857239	11,6638745
young adult (21-35)	3,333322222	11,53846154	57,3012939	6,3895303	13,43643096	8,426290552

Tab. 2. *Abridged life table combined for both sexes Dx, absolute number of individuals dead at age x; e°x, number of years a person can expect to live beyond age x. (Abbè, 2008).*

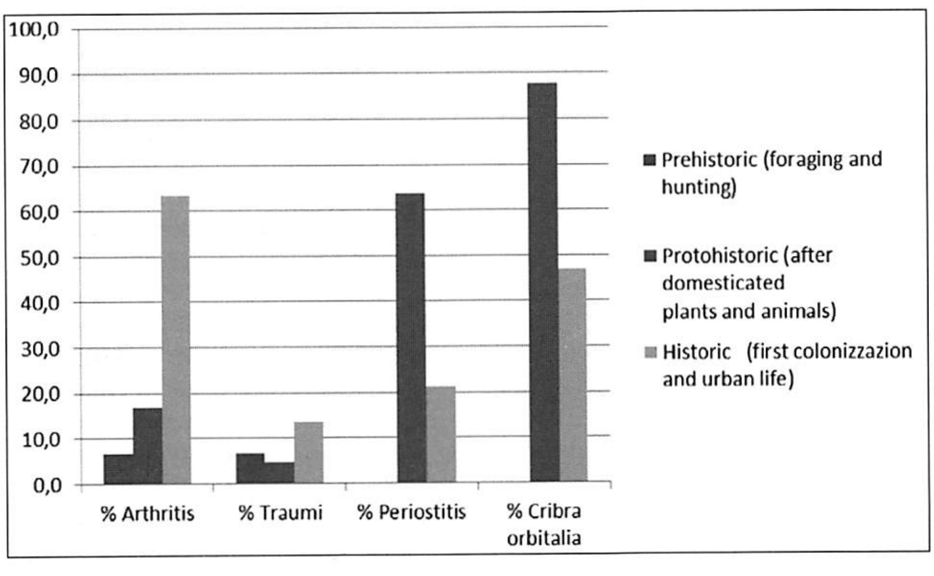
In the recognized frequencies of skeletal markers of health under examination for Protohistoric group, there is a significant difference for trauma (p-value of 0.0004), for arthritis (p-value 0.00003), for periostitis (p-value of 0.0415), and for *cribra orbitalia* (p-value 0.0012). Among classes of age in the Historic group there is a significant difference for trauma (p-value of 0.0011), for arthritis (p-value of 0.0018), for *cribra orbitalia* (p-value 0.0012). No significant differences were observed between Prehistoric subadult and adult (Tab. 3).

Discussion

Paleodemographic and palaeopathological analysis of archeological populations provide direct evidence of life expectancy and mortality (Buikstra and Cook, 1980). Infact, cultural and economic transitions effect human life history in different ways, and life expectancy is deeply modified by ecological parameters like food availability and quality, infective diseases, antagonistic behaviors, and by more culturally mediated causes like wars, slavery, and deportation. The effects of these factors, that can leave a

	Adult			Sub Adult				Adult			Sub Adult				Adult			Sub Adult			
	Prehistoric			Prehistoric			P	Protohistoric			Protohistori			P	Historic			Historic			P
	N	n	%	N	n	%		N	n	%	N	n	%		N	n	%	N	n	%	
Trauma	15	1	6,6	4	0	0	ns	36	6	16,6	88	0	0	0,00	44	3	6,81	22	6	27	0,00
Arthritis	15	1	6,6	4	0	0	ns	36	19	52,7	88	2	2,2	0,00	44	38	86,3	22	4	18	0,00
Periostitis	15	0	0	4	0	0	ns	36	28	77,7	88	51	57,9	0,04	44	10	22,7	22	4	18	ns
Cribra Orbitalia	15	0	0	4	0	0	ns	36	32	88,8	88	77	87,5	0,00	44	20	45,4	22	11	50	0,00

Tab. 3. Result of fisher test for arthritis, periostitis, cribra orbitalia and trauma in the total sample



Graph. 1. Percentage of the skeletal markers of health in the total sample.

significant sign on the skeleton, are suitably tooled for the explanation of healthy status of ancient population.

This study analyzes biological and demographic parameters in the very stimulating horizon of ancient Sicily, taking in consideration two main ecological transitions from Mesolithic period to the historical rise of early colonization (9800 BP - 902 AD), by relating four skeletal markers of health: arthritis, periostitis and *cribra orbitalia* together with (generalized) trauma. In the graph 1 we illustrate the result in percentage of the pathological analysis.

The transition between the Prehistoric and Protohistoric times consists of a progressive transition from hunting and gathering to a more stationary ecology, based on agriculture and domestication. In this crucial transition we observe a considerable increase of life expectancy at birth, approximately of 60,6%, in the Protohistoric group; and mortality within the first twelve years greatly increases until 40,2%. This evidence of dramatic change in the demographic mechanisms, with a inexorable modification in patterns of population evolution (from small numbers of selectively resistant individuals to large numbers directionally selected) is accompanied by a high percentage of *cribra orbitalia* and periostitis (respectively 0-63,7% and 0-87,9%). This stress markers accumulation could be caused both by poor hygienic conditions and by cohabitation with animals, otherwise associated to metabolic disorders caused by dietary changes. Ecological changes increase the potential for disease load as a consequence of the shift to primary food production. Sedentary lifestyle increases parasitic disease infection by increasing contact with human waste (Barnes, 2007). If semi-sedentarism did occur prior to Neolithic period in those areas with abundant resources such as marine products, the shift to agriculture necessitated a strict sedentary living or a seasonality in occupation of a site (Herrscher and Le Bras-Goude, 2010). The switch to the historical period offer to the analysis the decreases of the 45,6% of the mortality in the first 12 years of life, as like the decrease of *cribra orbitalia* and periostitis; but a significant decrease of approximately the 32% of the life expectancy at birth. Such result can be related to other markers that has been pictured in this study: the high rate of traumatic injuries, and arthritis recorded in the Historic groups compared to the Protohistoric group (respectively 13,6-4,8% and 63,6-16,9%). Well documented (Finley, 2009; Roberts and Manchester, 1995; Holloway, 1991) violent population change took place when foreign settlers started their colonization of the island and with roman expansion in the Mediterranean Basin. The Greek-Punic wars (600 to 265 BC), and the first Punic war (B.C. 264-241) (Finley, 2009) have influenced the environmental and sociocultural contexts of indigenous populations increasing human forced delocalization and famine but resulting also in the increase in traumatic evidences. Also, arthritis increased in frequency, indicating increased exposure of populations to debilitating activities.

In according to the demographic data and the indicators examined, the general health status of the population during important transition show a worsening in life-condition (Bogatenkov, 2002). This is probably attributable to a combination of effects due to general environmental degradation, more centralized and isolated settlements, and disintegration of the social and political situation.

Capasso and colleagues (2003) claim that high rates of immigration through the Mediterranean have begun to produce changes in the biological characteristics of the Italian population, especially with respect to demographics and disease. The collected data of Manzi (Manzi *et al.*, 1999) suggest that the political, social and economic changes that characterized the Medieval transition in Central Italy population resulted in a deterioration of health status.

Our study analyzes variation of demographics parameters of the ancient Sicilian population across two transition. The first transition between the prehistory and protohistory, where the ecological factor that has played an important role in cultural innovation is the agriculture and domestication, we found high percentages of *cribra orbitalia* and periostitis. The vast majority of researches agree that *cribra orbitalia* found in archaeological sample is the result of an acquired iron deficiency anaemia (Mensforth *et al.*, 1978; Stuart-MacAdam, 1992). Anaemia is also associated with increased pre and postnatal infant mortality (Orbetova and Thurzo, 2008). Periostitis is a non-specific inflammation of bone (Steinbock, 1976) more commonly seen in settled communities prating agriculture (Resnick, 2002).

In the second transition between the protohistory and history, Sicily has played host to a continuous series of massive migrations and ethnic wars because of its c entral position in the Mediterranean. In the Early history of ancient Sicily (264-241 BC) frequent episodes of interpersonal aggression may be the norm (Finley, 2009). Frequently the most dramatic injuries are to the skull as, certainly in interpersonal/intergroup violence, the head if often the main target for blows (Ardill and Gidado, 2003). Arthritis are the most common degenerative diseases affect skeleton (Weiss and Jurmain, 2007). These alterations are generally related to mechanical stress, and tend to increase with age, with serious social and economic consequences (Rogers *et al.*, 2004).

Conclusion

This study exanimates the palaeodemographic changes between three periods: Prehistoric, Protohistoric and Historic, and their possible interpretation through the frequency of detected skeletal markers of health. The results of our study indicate that there was substantial discontinuity of life conditions between three groups considered, indications that can be added to the previous knowledge of an important phases of socioeconomic and cultural transitions. Among the skeletal series, representative of groups employing different subsistence strategies and responsible of the populating the area of West Sicily, worst biological status was characteristic of the settled populations with agricultural occupation. Periodical nutritional deficit and possible spread of infection in their dense settlement made their living condition more demanding. The process of cultural hybridization resulting from colonial expansion affect the health and well-being of provincial populations.

References

Abel T., Stepp J.R. 2003. A New Ecosystems Ecology for Anthropology. *Editorial Cons Ecol.,* 7: 12.

Alesan A., Malgosa A., Simo C. 1999. Looking into the demography of an Iron Age population in the western MediterraneanMortality. *Am. J. Phys. Anthropol.,* 110: 285-301.

Ardill W, Gidado S. 2003. Penetrating head wound: a remarkable case. *Surg. Neurol.,* 60: 120-123.

Armelagos G.J. 2009. The Paleolithic Disease-scape, the Hygiene Hypothesis, and the Second Epidemiological Transition. In: Rock. G.A., *The Hygiene Hypothesis and Darwinian Medicine,* Ed. Birkhauser Publishing, Basel, Switzerland: 29-43.

Armelagos G.J., Harper K.N. 2010. Emerging Infectious Diseases, Urbanization and Globalization in the Time of Global Warming. In: William C.C., *The New Blackwell Companion to Medical Sociology,* Ed. Hoboken, NJ: Wiley Publishing: 291-311.

Aufderheide A.C., Rodríguez-Martín C. 1998. *The Cambridge Encyclopedia of Human Paleopathology.* Cambridge University Press, Cambridge.

Barnes E. 2007. *Diseases and Human Evolution.* University of New Mexico Press.

Becker M. J. 2000. Skeletal studies of the people of Sicily: an update on research into human remains from archaeological contexts. *Int. J. Anthropol.,* 15: 191-239.

Belcastro G., Rastelli E., Mariotti V., Consiglio C., Facchini F., Bonfiglioli B. 2007. Continuity or Discontinuity of the Life-Style in Central Italy During the Roman Imperial Age-Early Middle Ages Transition: Diet, Health, and Behavior. *Am. J. Phys. Anthropol.,* 132: 381-394.

Bocquet-Appel J.P., Masset C. 1982. Farewell to paleodemography. *J. Hum. Evol.,* 11: 321-333.

Bogatenkov D.V. 2002. Bio-archaeological reconstruction on data of prehistoric populations from South of Eastern Europe, III C. BC-III C. AD. Ecological aspects. *EAA Biennial Books,* 2: 111-128.

Bridges P. S. 1993. The effect of variation in methodology on the outcome of osteoarthritic studies. *Int J. Osteoarchaeol.,* 3: 289-295.

Buckberry J.L., Chamberlain A.T. 2002. Age estimation from the auricular surface of the ilium: a revised method. *Am. J. Phys. Anthropol.,* 119: 321-329.

Buikstra J.E., Cook D.C. 1980. Palaeopathology: an American account. *Annu. Rev. Anthropol.,* 9: 433-470.

Buikstra J.E., Ubelaker D.H. 1994. *Standards for Data Collection from Human Skeletal Remains.* Arkansas Archaeological Survey Research Series, 44, Fayetteville.

Cameron J. S. 1999. Towards the millennium: a history of renal anaemia and the optimal use of epoetin. *Nephrol. Dial. Transplant.,* 14: 10-21.

Capasso L., D'Anastasio R., Pierfelice L., Di Fabrizio A., Gallenga P.E. 2003. Roman conquest, lifespan, and diseases in ancient Italy. *The Lancet,* 362: 9384.

Cox M., Mays S. 2006. *Human Osteology in Archaeology and Forensic Science.* (Eds), Greenwich Medical Media, London: 61-81.

D'amore G., Di Marco S., Tartarelli G., Bigazzi R., Sineo L. 2009. Late Pleistocene human evolution in Sicily: comparative morphometric analysis of Grotta di San Teodoro craniofacial remains. *J. Hum. Evol.,* 56: 537-550.

Dandeker C. 1994. New Times for the Military: Some Sociological Remarks on the Changing Role and Structure of the Armed Forces of the Advanced Societies. *Br. J. Sociol.,* 45: 637-654.

Finley M. I. 2009. *History of Ancient Sicily.* Editore Laterza.

Herrscher E. Le Bras-Goude G. 2010. Southern French Neolithic Populations: Isotopic Evidence for Regional Specificities in Environment and Diet. *Am. J. Phys. Anthropol.,* 141: 259-272.

Holloway R. R. 1991. *The archaeology of ancient Sicily.* Routledge. London

Irei K., Doi N., Fukumine T., Nishime A., Hanihara T., Yoneda M., Ishida H. 2008. Dental diseases of human skeletal remains from the early-modern period of Kumejima Island, Okinawa, Japan. *Anthropol. Sci.,* 116: 149-159.

Jackes M. 1992. Paleodemography: problems and techniques. In: Saunders S.R., Katzenberg M.A. (eds.): *Skeletal Biology of Past Peoples: Research Methods.* New York: Wiley-Liss.

Johnson A.W., Earle T. 1987. *The evolution of human societies: from foraging group to agrarian state.* Stanford University Press, Stanford, California, USA.

Katz D., Suchey J.M. 1986. Age determination of the male os pubis. *Am. J. Phys. Anthropol.,* 19: 237-244.

Krogman W.M, Iscan M.Y. 1986. *The Human Skeleton in Forensic Medicine.* Springfield, IL: Thomas.

L'Abbè E.N., Steyn M., Loots M. 2008. Life expectancy of the 20th century Venda: A compilation of skeletal and cemetery data. *HOMO.,* 59: 189-207.

Larsen C. S. 2006. The agricultural revolution as environmental catastrophe: Implications for health and lifestyle in the Holocene. *Quat. Inter.,* 150: 12-20.

Levin S. 1998. Ecosystems and the biosphere as complex adaptive systems. *Ecosystems* 1: 431-436.

Livi Bacci M. 1999. *Introduzione alla demografia.* Loescher Editore.

Lovejoy C.O. 1985. Dental Wear in the libben population. *Am. J. Phys. Anthropol.,* 68: 47-56.

Lovell N.C. 1997. Trauma analysis in paleopatology. *Yearb. Phys. Anthropol.,* 40: 139-170.

Madrigal L 1998. *Statistics for Anthropology.* Cambridge University Press.

Manzi G., Salvadei L., Vienna A., Passarello P. 1999. Discontinuity of life conditions at the transition from the Roman Imperial Age to Early Middle Ages: example from Central Italy evaluated by pathological dento-alveolar lesions. *Am. J. Hum. Biol.,* 11: 327-341.

Mensforth R., Lovejoy C., Armelagos G.J. 1978. The role of constitutional factors, diet, and infectious disease in the etiology of porotic hyperostosis and periosteal reactions in prehistoric infants and children. *Med. Anthropol.,* 2: 1-59.

Miles A.E.W. 1963. The dentition in assessment of individual age in skeletal material. *Dent. Anthropol.,* 5: 191-209.

Obertova Z., Thurzo M. 2008. Relationship between Cribra Orbitalia and Enamel Hypoplasia in the Early Medieval Slavic Population at Borovce, Slovakia. *Int. J. Osteoarchaeol.,* 18: 280-292.

Resnick D. 2002. *Diagnosis of Bone and Joint Disorders.* Philadelphia: Saunders W.B.

Roberts C.A. Lewis M.E. 2002. Ecology and infectious disease in Britain from prehistory to the present: The case of respiratory infections. In: Bodzsár È.B., Susanne C. *Ecological Aspects of Past Human Settlements in Europe.* Eds EAA Biennial Books: 179-192.

Roberts C., Manchester K., 1995. *The Archaeology of Disease.* 2nd Edition, Cornell University Press, Ithaca.

Rogers J., Shepstone L., Dieppe P. 2004. Is osteoarthritis a systemic disorder of bone? *Arthritis and Rheum.,* 50: 452-457.

Slàdek V., Berner M., Sosna D., Sailer R. 2007. Human manipulative behavior in the central European late Eneolithic and early Bronze Age: humeral bilateral asymmetry. *Am. J. Phys. Anthropol.,* 133: 669-681.

Šlaus M. 2008. Osteological and dental markers of health in the transition from the Late Antique to the Early Medieval period in Croatia. *Am. J. Phys. Anthropol.,* 136: 455-469.

Šlaus M., Bedić Ž., Rajić Šikanjić P., Vodanović M., Kunić A. D. 2011. Dental health at the transition from the Late Antique to the early Medieval period on Croatia's eastern Adriatic coast. *Int. J. Osteoarchaeol.*, 21: 577-590.

Smith B.D. 2001. Documenting plant domestication: the consilience of biological and archaeological approaches. *PNAS.*, 98: 1324-1326.

Steinbock R.T. 1976. *Paleopathological Diagnosis and Interpretation.* Charles C. Thomas, Springfield.

Stuart-Macadam P., Kent S. 1992. *Diet, Demography, and Disease: Changing Perspectives on Anemia Aldine de Gruyter.* New York.

Temple D.H., Larsen C.S. 2007. Dental caries prevalence as evidence for agriculture and subsistence variation during the Yayoi period in prehistoric Japan: Biocultural interpretations of an economy in transition. *Am. J. Phys. Anthropol.*, 134: 501-512.

Ubelaker D.H. 1989. *Human Skeletal Remains: Excavation, Analysis, Interpretation.* Smithsonian Manuals on Archaeology 2 Taraxacum Press: Washington, DC.

Vodanovic M., Brkic H., Slaus M., Demo Z. 2005. The frequency and distribution of caries in the mediaeval population of Bijelo Brdo in Croatia (10the11th century). *Arch. Oral Biol.*, 50: 669-680.

Weiss E., Jurmain R. 2007. Osteoarthritis Revisited: A Contemporary Review of Aetiology. *Int. J. Osteoarchaeol.*, 17: 437-450.