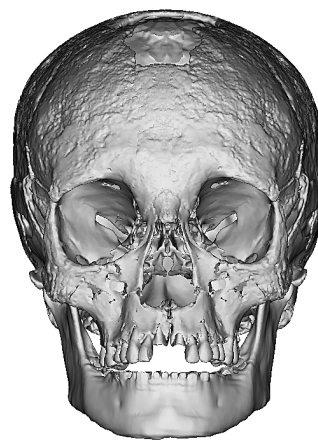


Bulletin der Schweizerischen Gesellschaft für Anthropologie

Jahrgang
Volume 16

Heft
Fascicule 1–2



2010

Bulletin de la Société Suisse d'Anthropologie

Bulletin der Schweizerischen Gesellschaft für Anthropologie

Herausgegeben von der Schweizerischen Gesellschaft für Anthropologie (SGA). Publiziert seit 1995.
Unterstützt von der Akademie der Naturwissenschaften Schweiz (SCNAT).

Bulletin de la Société Suisse d'Anthropologie

Edité par la Société Suisse d'Anthropologie (SSA). Publié depuis 1995.
Supporté par l'académie suisse des sciences naturelles (SCNAT).

Redaktion/Rédaction

Christine Cooper, Bern (Chefredaktorin)

Christina Papageorgopoulou, Mainz

Scientific Board

Kurt W. Alt, Mainz
Jesper Boldsen, Odense
Thomas Böni, Zürich
David Bulbeck, Canberra
Joachim Burger, Mainz
Rethy Chhem, London, Ontario
Alfred Czarnetzki, Tübingen
Georges Descœudres, Zürich
Alexander Fabig, Rostock
Paolo Francalacci, Sassari
Birgit Großkopf, Göttingen
Gisela Grupe, München
Miriam Noël Haidle, Tübingen
Winfried Henke, Mainz
Estelle Herrscher, Marseille

Israel HersHKovitz, Tel Aviv
Ariane Kemkes, Scottsdale
Christiane Kramar, Genève
Christian Lanz, Zürich
François Mariéthoz, Sion
Wolfgang Müller, London
Geneviève Perréard Lopreno, Genève
Iris Ritzmann, Zürich
Brigitte Röder, Basel
Hartmut Rothe, Göttingen
Bruce M. Rothschild, Youngstown
Carel van Schaik, Zürich
Elisabeth Stephan, Konstanz
Susi Ulrich-Bochsler, Bern
Ursula Wittwer-Backofen, Freiburg i. Br.

Erscheinungsweise/Fréquence de parution:

Das Bulletin der Schweizerischen Gesellschaft für Anthropologie erscheint in der Regel zweimal pro Jahr (Frühjahr, Herbst). Beide Hefte bilden zusammen einen Band.

Le Bulletin de la Société Suisse d'Anthropologie paraît deux fois par an (printemps et automne). Deux cahiers constituent un volume.

Bezugsort/Abonnement:

Kassier SGA/Comptable SSA: Martin Häusler, Zürich. E-mail: mfh@aim.unizh.ch

Preis dieser Nummer/Prix de ce numéro: 25.00.- CHF

Jahresabonnement/Abonnement annuel: 50.00.- CHF

Für Mitglieder der SGA ist das Bulletin im Jahresbeitrag inbegriffen.

Les membres de la SSA reçoivent gratuitement le bulletin.

Umschlag/Couverture:

Fotografie von/Photographie de: Fotografie von S. Schlager, P. Pieper, U. Wittwer-Backofen. (S. 63–70)
Gesichtsrekonstruktion des Langenfeld-Schädels.

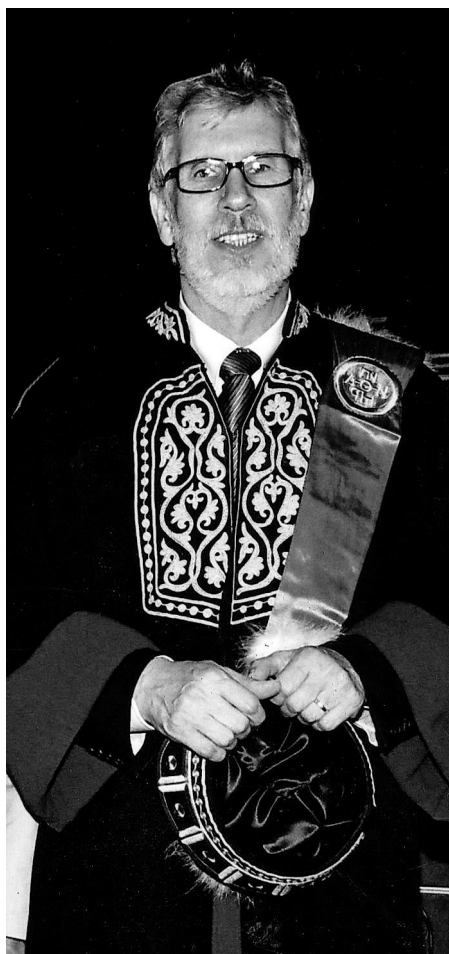
Herstellung/Impression:

Books4you, Brno, CZ

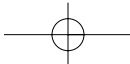
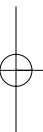
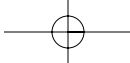
Jahrgang/Volume 16, Heft/Fascicule 1–2, 2010

Erscheinungsdatum/Parution: April/Avril 2011

ISSN 1420-4835



FESTSCHRIFT FÜR WINFRIED HENKE
Prof. Dr. rer. nat., Dr. h. c.



Inhaltsverzeichnis / Table of contents

DIE REDAKTION

Vorwort/Foreword	7
-------------------------------	---

SUSI ULRICH-BOCHSLER

Winfried Henke zum 65. Geburtstag	9
--	---

THEODOROS PITSIOS

Ancient Sparta – Research Program of Keadas Cavern	13
---	----

GISELA GRUPE, STEFANIE DOPPLER, MARINA VOHBERGER, JORIS PETERS

Fishing with the Vikings: Vertebrate food webs and isotopic mixing models in a brackish water ecosystem at Viking Haithabu and medieval Schleswig	23
--	----

HARDY MÜLLER

Kann ein modernes Gesundheitsmanagement von der physischen Anthropologie profitieren? Das anthropologische Konzept der Variabilität zur Hermeneutik von Über-, Unter- und Fehlversorgungen in der gesundheitlichen Versorgung [Can modern health managment benefit from physical anthropology? The anthropological concept of variability with regard to the hermeneutics of too much, too little or wrong treatment in health care]	35
--	----

ARIANE KEMKES

The ties that bind – the impact of godparents on baptisand survival	47
--	----

MARTIN FRIESS

Parietal expansion during later hominin evolution, and the validity of <i>H. heidelbergensis</i> – A quantitative approach	55
---	----

STEFAN SCHLAGER, PETER PIEPER, URSULA WITTWER-BACKOFEN

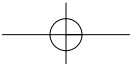
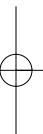
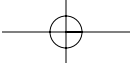
Execution and determent – Giving a face to the Langenfeld skull	63
--	----

JOACHIM BURGER, RUTH BOLLONGINO

Richtlinien zur Bergung, Entnahme und Archivierung von Skelettproben für palaeogenetische Analysen [Guidelines for the recovery, acquisition and storage of skeletal samples for palaeogenetical analyses]	71
--	----

KALLY SIMITOPOULOU, NIKOLAOS I. XIROTIRIS

The revival of creationism in contemporary societies: a short survey	79
---	----



Vorwort

Als Winfried Henke im Jahr 2010 seinen 65. Geburtstag feierte, kam die Frage nach einer Ehrung in der Schweiz auf. Daher fügen wir zwei Ausgaben des Bulletins zu einem Sonderband zusammen und widmen diesen Jahrgang – ohne den Anspruch, hiermit eine klassische Festschrift vorzulegen – Winfried Henke zum 65. Geburtstag. Beigetragen haben Kollegen und Freunde, die mit Winfried Henke und der Schweizer Anthropologie in unterschiedlicher Weise verbunden sind. Die Redaktion musste nicht lange um Beiträge bitten, im Gegenteil: selbst den Umfang der eingereichten Beiträge mussten wir leider begrenzen, um die Möglichkeiten des Bulletins nicht zu sprengen. Auf eine gewiss sehr lange *Tabula Gratulatoria* haben wir deshalb zugunsten der wissenschaftlichen Beiträge verzichtet.

Obwohl nie hier lebend oder lehrend, hat Winfried Henke eine langwährende Beziehung zur anthropologischen Forschung in der Schweiz. Stets hat er die hiesigen Publikationen mit grossem Interesse verfolgt, die Jahrestagungen unserer Gesellschaft regelmässig besucht und oft hier vorgetragen. Das Grusswort von S. Ulrich-Bochsler in diesem Band beleuchtet seine tiefen wissenschaftlichen Bande zur Schweiz genauer. Angesichts der vielfältigen Interessen und des breiten Wirkens von Winfried Henke hat die Redaktion kein übergreifendes Thema festgelegt. Vielmehr sollen die ihm von Kollegen, Freunden und Schülern gewidmeten Beiträge zumindest in einigen Facetten die Vielfalt seines Schaffens widerspiegeln.

Der Zufall macht uns – Christine Cooper und Christina Papageorgopoulou – zu Redaktorinnen dieses Bands. Wir freuen uns sehr darüber, denn wir sind Winfried Henke tief verbunden und verdanken seinem Zuspruch, seiner stets weiterführenden Kritik und seiner Förderung viel.

Foreword

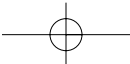
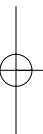
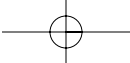
When Winfried Henke celebrated his 65th birthday in 2010, the wish to honor his work arose in Switzerland. Therefore both issues of this year's Bulletin were merged to one volume and are dedicated – without claiming to replace a classical Festschrift – to Winfried Henke's 65 birthday. Friends and colleagues of Winfried Henke who are connected to him and Switzerland in various ways have contributed to this volume. As editors, we had no problem acquiring manuscripts, on the contrary we had to restrict the number of contributions to stay within the capacity of the Bulletin. For this reason we have not added a *Tabula Gratulatoria* in favor of more space for the scientific publications.

Although Winfried Henke never lived or worked in Switzerland he has had a long-lasting and strong bond with this country. He was always interested in the local publications, he regularly participated in the meetings of our Association, and he often presented his work here. The *Laudatio* of Susi Ulrich-Bochsler in this volume enlightens this relation to Switzerland in detail. Taking into consideration his broad scientific interests the editorial team decided not to define a specific theme for this volume. Instead, the manuscripts from his friends, colleagues and students underline the diversity of his interests and academic work.

Just by coincidence we – Christine Cooper and Christina Papageorgopoulou – are the editors of this volume. Since we are both academically connected to him this is a great pleasure for us, and we want to thank Winfried Henke for his advice, his constructive criticism, and his encouragement with this volume.

ad multos annos!

Christina Papageorgopoulou & Christine Cooper



Winfried Henke zum 65. Geburtstag

Winfried Henke, Prof. Dr. rer. nat., Dr. h. c., feierte am 26. Dezember 2009 seinen 65. Geburtstag. Für die Schweizerische Gesellschaft für Anthropologie und die Redaktion des Bulletins der Schweizerischen Gesellschaft für Anthropologie ist dies ein willkommener Anlass, Winfried Henke eine Festschrift mit Arbeiten einiger seiner wissenschaftlich eng mit ihm verbundenen Freunde und Kollegen aus verschiedenen Bereichen der Anthropologie zu widmen. Den Autoren sei an dieser Stelle für ihre spontanen Zusagen herzlich gedankt. Der Verfasserin des Vorwortes fiel dabei die auf den ersten Blick einfache Aufgabe zu, eine Würdigung von Winfried Henke zu schreiben. Mag es für Festschriften auch allgemein üblich sein, Werdegang, Tätigkeitsbereiche, Verdienste und Ehrungen aufzuzählen, so sei hier aus verschiedenen Gründen von diesem Vorgehen abgewichen. Mit den heutigen Recherchiemöglichkeiten wäre es zwar keine grosse Sache, alle Informationen zur wissenschaftlichen Laufbahn einer Persönlichkeit in kurzer Zeit zusammenzustellen, aber ob der Mensch und vor allem der Kollege Henke damit unseren Vorstellungen gemäss erfasst würde, ist fraglich. Deshalb sei hier ein anderer Weg eingeschlagen, indem der Schwerpunkt des Vorwortes ganz spezifisch auf die langjährige Beziehung und die Nähe von Winfried Henke zur Schweizer Anthropologie, sprich zu den historisch ausgerichteten Anthropologen in der Schweiz, gelegt wird.

Meine persönlichen Erinnerungen reichen bis ins Jahr 1974 zurück. Damals war Winfried Henke bereits Akademischer Rat am Anthropologischen Institut der Universität Mainz unter der Direktion von Frau Prof. Ilse Schwidetzky, nachdem er sein Studium der Biologie, Geowissenschaften, Anthropologie sowie ferner der Pädagogik und Philosophie in Kiel und Braunschweig abgeschlossen und 1971 an der Universität Kiel promoviert hatte mit der Inaugural-Dissertation in Anthropologie *„Methodisches zur Geschlechtsbestimmung und zum morphometrischen Vergleich von menschlichen Skelettserien – dargestellt am mittelalterlichen Skelettmaterial des Kieler Gertrudenfriedhofs im Vergleich mit anderen nord-europäischen Skelettserien“*. Als auslösender Anlass des bis heute andauernden Interesses an der Schweizer Anthropologie kann zweifellos der Workshop der Europäischen Anthropologen in Zusammenarbeit mit dem ungarischen Demographic Research Institute anfangs September 1974 in Budapest und Debrecen gelten. An diesem Workshop *„Methodological Questions on the Determination of Sex and Age from*

Human Skeletons“ unter der Leitung von János Nemeskéri kam die kombinierte Methode von Acsádi / Nemeskéri zur Sprache beziehungsweise wurde diese intensiv an alters- und geschlechtsbekannten Skeletten geübt. Zu den Teilnehmern gehörten neben Bernd Herrmann, Torstein Sjøvold, Gerfried Ziegelmayr, Herbert Ullrich, Milan Stloukal, Friedrich W. Rösing und anderen auch Winfried Henke und als einzige Vertretung aus der Schweiz ich als Anfängerin. Diese denkwürdige Veranstaltung im weitab gelegenen Debrecen, wo sich an den Abenden keinerlei kulturelle Ablenkung bot und das „Fachsimpeln“ in der kleinen Runde die sinnvollste Unterhaltungsmöglichkeit schien, legte den Grundstein einer langjährigen Zusammenarbeit zwischen Winfried Henke und der Schweiz (die allerdings einseitig gestaltet war, da Winfried Henke vor allem der Befragte und Gefragte war und er schon damals durch seine Eloquenz und sein fast sprichwörtlich „lexikalisches Wissen“, aber auch durch die unglaublich gute Schilderung skurriler Ereignisse hervorstach). Ein zweiter ähnlich spartanisch, aber fachlich reich gestalteter Anlass folgte 1978 mit der „Conference on Palaeodemography“ im ungarischen Sárospatak wiederum unter der Ägide von János Nemeskéri. Im Extrawagen des Zemplén-Express sassen neben Winfried Henke auch die meisten Teilnehmer von Debrecen, zusätzlich aber auch George J. Armelagos, Jean N. Biraben, Jean P. Bocquet, Denise Ferembach, Claude Masset, Theya Molleson, Douglas H. Ubelaker, Alfred Czarnetzki und Ilse Schwidetzky. Diesmal nahmen aus der Schweiz drei weitere Kollegen teil: Wolfgang Scheffrahn, Roland Menk und Christian Simon, die in der Folge ihrerseits einen fachlichen Dialog mit Winfried Henke suchten. Diese beiden Anlässe in Ungarn, über deren detaillierte Beschreibung und Namensnennung man sich wundern mag, spielten meines Erachtens eine wichtige Rolle: Einerseits bildeten sie den Anfang der freundschaftlichen Beziehungen zwischen der Schweizer Anthropologie und Winfried Henke, andererseits hatten sie aber auch eine Kickoff-Bedeutung für die sich nun stark und engagiert entwickelnde historische Anthropologie, denn sie führten zum Auf- oder Ausbau eines Netzwerkes dieser später etablierten Anthropologen. In Bezug auf die Schweiz waren es vor allem die im Aufbau begriffene elektronische Datenbank von Genf und die damit zusammenhängenden Arbeiten von Roland Menk, für die sich Winfried Henke interessierte. Der erst rudimentär, aber hoffnungsvoll angelaufenen Zusammenarbeit setzte dann der frühe Tod von Roland Menk ein Ende. Roland Menk gründete 1982 die bis heute weiterbestehende AGHAS (Arbeitsgruppe für Historische Anthropologie der Schweiz), während

Winfried Henke im gleichen Jahr Gründungssprecher bei der mit der AGHAS vergleichbaren APPA (Arbeitsgemeinschaft für Paläoanthropologie und Prähistorische Anthropologie) war. Die AGHAS durfte auf das Mitwirken von Winfried Henke ebenfalls verschiedentlich zählen, so beispielsweise 1995 am zweitägigen Kurs zu morphometrischen Verfahren (zusammen mit Uschi Wittwer-Backofen und Ariane Kemkes-Grottenthaler: „Ist Morphometrie noch zeitgemäss?“) oder 1997 an der AGHAS-Tagung mit dem Beitrag „Die Neandertalerin – Botschafterin der Vorzeit (phylogenetische Aspekte der Geschlechterrolldifferenzierung)“. In diesem Kontext sind die massgebliche Beteiligung von Winfried Henke an der Planung des neuen Neandertal-Museums in Mettmann und die langjährige wissenschaftliche Beratertätigkeit zu erwähnen (Eröffnung 1996) und sein zusammen mit Nina Kieser und Wolfgang Schnaubelt verfasste Buch „Die Neandertalerin. Botschafterin der Vorzeit“ (1996, Edition Archaea). An den Aktivitäten der Schweizerischen Gesellschaft für Anthropologie beteiligte sich Winfried Henke immer wieder mit Vorträgen, sei es als Gastreferent, sei es als ordentliches Mitglied. Gerne denken wir an seinen letztjährigen Beitrag zum Darwinjahr zurück, als er in Solothurn an der Tagung der SGA als Gastreferent die Frage erörterte „Wurde Darwin verstanden? – Eine anthropologische Bilanz zum Darwinjahr“. Diese verschiedenen Inhalte von Winfried Henkes Vorträgen in der Schweiz, vereinzelt auch publiziert im Bulletin der SGA, umreissen, wenn auch nur in äusserst rudimentärer Form, seine vielseitigen anthropologischen Interessen und Kompetenzen.

Neben diesen offiziellen Anlässen wurde Winfried Henke – und dies wird sich nach seiner Emeritierung wohl kaum ändern – gerne von Kolleginnen und Kollegen aus der Schweiz um Stellungnahmen in Fachfragen kontaktiert. Die Betreuung von Diplomarbeiten und die Leitung von Doktorarbeiten hat er verdankenswerterweise in einigen Fällen übernommen, denn – so unverständlich dies auch erscheinen mag – naturwissenschaftliche Universitätsabschlüsse für Arbeiten mit historisch-anthropologischen Inhalten waren in der deutschsprachigen Schweiz in den letzten Jahrzehnten nur erschwert möglich. Zu erwähnen sind die zahlreichen Gutachter- und Beraterfunktionen, die Winfried Henke übernommen hat, unter anderem auch in der Schweiz als externer Evaluator beim Aufbau des Zertifikats „Archäoanthropologie“ am Seminar für Ur- und Frühgeschichte der Universität Basel. Weshalb die Beziehungen der Schweizer Anthropologinnen und Anthropologen historischer Arbeitsrichtung über Jahre hinweg gut und fruchtbar waren und weshalb der Jubilar

(nicht nur) hierzulande eine hohe Wertschätzung geniesst, liegt eigentlich auf der Hand und müsste nicht unbedingt explizit erwähnt werden. Winfried Henkes umfassendes, breites und fundiertes Wissen nicht nur zur Paläoanthropologie, Primatologie, Evolutionsbiologie, phylogenetischen Systematik und Taxonomie und den weiteren Arbeitsrichtungen der Anthropologie, sondern auch zur Humanethologie, Wissenschaftsgeschichte der Anthropologie, Bioethik und zur Soziobiologie sucht seinesgleichen und überzeugt, ohne dass er sein Fachwissen laut demonstriert. Gerade diese Eigenschaft mag hier bei uns grosse Sympathien hervorrufen und sie mag mit ein Grund dafür sein, dass sich auch junge Kolleginnen und Kollegen an Winfried Henke wenden. Hinzu kommt die kollegiale und unkomplizierte Hilfsbereitschaft, die manche von uns immer wieder erfahren haben und die es leicht machte, Winfried Henke um Rat, Beurteilung oder Kooperation zu bitten. Genauso geschätzt wird seine kritische Sicht auf das, was unter Anthropologie zu verstehen ist. Ich höre seine Bemerkungen, dass es doch eigentlich um Evolution und Menschheitsgeschichte gehe, dass (historische) Anthropologie bei weitem nicht nur Kasuistik, Narration beinhalte und Deskription lange nicht alles sei und Medienpräsenz als wissenschaftliche Bedeutung missverstanden würde. Wie die Geschichte zeigt, waren hinterfragende, aufrüttelnde, aber auch selbstkritische Stimmen stets von immensem Wert für die Gesellschaft im Allgemeinen und für die Wissenschaft im Besonderen – für unsere rasant vorbeiziehende Zeit sollte dies speziell gültig sein.

Über Winfried Henkes Wirken in der Lehre müssten eigentlich seine Schüler und Institutskollegen das Wort bekommen, denn wir können hier nur die publizierten Angaben wieder-, aber keine Wertung abgeben. Jedenfalls deckte Winfried Henke – ab 1990 als Habilitierter (FB Biologie der Universität Mainz), ab 1993 Akademischer Direktor am Institut für Anthropologie der Johannes Gutenberg-Universität Mainz und 1996 als ausserplanmässiger Professor – mit Vorlesungen, Seminaren, Kursen und Praktika die Primatologie, Paläoanthropologie, prähistorische und ethnische Anthropologie, Paläo- und Rezentdemographie, Forensische Anthropologie, Osteologie und Somatologie, Industrieanthropologie sowie Ethik der Anthropologie ab, alles mit unterschiedlichen Schwerpunkten im Laufe der Zeit. Hinzu kamen Einsätze an der Universität von Kreta und der Demokritos-Universität von Komotini (GR) im Rahmen von Erasmus / Sokrates-Dozenturen (seit 1990 als Erasmus-Koordinator). Im Hinblick auf seine weiteren Funktionen als Rezensent von mehreren Hundert Büchern oder als Berater und Gutachter sei auf die Website der Anthropologie der

Universität Mainz verwiesen (www.uni-mainz.de/FB/Biologie/Anthropologie/winfried_henke.php).

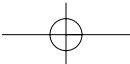
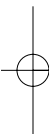
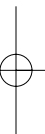
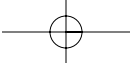
Eine reiche wissenschaftliche Laufbahn liegt hinter Winfried Henke und wurde bereits adäquat ausgezeichnet mit dem *Doctor honoris causa* der National- und Kapodistrian Universität von Athen (2006) und der Aufnahme als Mitglied der Deutschen Akademie der Naturforscher Leopoldina (2007). Seine zusammen mit Hartmut Rothe verfassten Werke „*Der Ursprung des Menschen*“ (Fischer 1980), „*Stammesgeschichte des Menschen*“ (Springer 1999) und „*Menschwerdung*“ (Fischer 2003) sowie das mit Ian Tattersall herausgegebene „*Handbook of Palaeoanthropology*“ (Springer 2007) sind weitere markante Meilensteine seiner wissenschaftlichen Laufbahn. Die lange Liste von Publikationen zu verschiedenen anthropologischen und sozialwissenschaftlichen Themen spricht für sich und veranschaulicht das enorme Spektrum seines Wirkens.

Für mich als jahrzehntelange Kollegin bleibt die Frage offen, welchen Weg Winfried Henke nun einschlagen wird nach seiner Emeritierung und dem zumindest teilweisen Rückzug aus dem Institut. Der Zeitpunkt ist eine Schnittstelle im Leben und kann Neuorientierung durch erweiterte Lebensinhalte bedeuten. Er kann aber auch das Verwirklichen lange geplanter Projekte und Visionen wie etwa das weitere Ausloten der Grenzen der von Winfried Henke so professionell vertretenen Wissenschaft ermöglichen. Wie und wozu auch immer Du Dich entscheiden wirst, ich wünsche Dir zusammen mit meinen Schweizer Kolleginnen und Kollegen und den Autorinnen und Autoren dieses Widmungsbandes von Herzen noch viele befriedigende, harmonische und glückliche Jahre im Kreis Deiner Familie.

Susi Ulrich-Bochsler

Dr. phil. nat.

Leiterin Historische Anthropologie Bern, i.R.



Ancient Sparta – Research Program of Keadas Cavern

THEODOROS K. PITSIOS

University of Athens, Athens, Greece

Summary

The historical question of ancient Keadas is associated with ancient Sparta's myth and its heritage to the history of Greece. Ancient Keadas constitutes a complex puzzle inevitably linked with important historical facts of Greek antiquity as well as life principles and philosophical reflections underlying the essence of human existence and the fundamental relation of man to life and death. Human life span constitutes a quantitative biological trait and as such it is genetically defined while at the same time it is strongly influenced by environmental parameters relative to nutrition, disease and the unexpected intricacies of human behaviour. It is well-known that biological traits developing over extended time-periods (i.e., maximum stature may be reached up to the 25th year of life) have increased probability for environmental factors to be associated in their determination. At the individual level, human life span as a biological feature can be definitely determined only after death – and any prediction about when the fatal event will happen could be proved wrong.

Keywords: Ancient Sparta, Greece, human execution

Zusammenfassung

Die Höhle von Kaiadas befindet sich 10 km nordwestlich von Sparta an der Grenze zur malerischen Siedlung Trypi, auf 750 m Höhe und in der Nähe der Strasse von Sparta nach Kalamata, welche das Taygetos-Gebirge durchquert. Von der offenbar ausgewählten Lage des alten Höhleneingangs auf der Hügelkuppe hat man einen weiten Ausblick auf das lakonische Flachland und das Tal von Evrotas. Alle geologischen und anthropologischen Daten sowie antike und historische Aussagen belegen, dass der Abgrund von Trypi dem Kaiadas der Antike entspricht, der möglicherweise von den Spartiaten auch während der messinischen Kriege (8.–5. Jahrhundert v. Chr.) benutzt wurde. Nach den Ergebnissen der anthropologischen Forschung gehört die grosse Mehrheit der menschlichen Skelettfunde, die im Bereich der Höhle gefunden wurden, zu Männern im biologischen Alter zwischen 18 und 35 Jahren. Im gesamten oberflächlichen menschlichen Skelettmaterial, das bis heute im Bereich der Höhle von Kaiadas eingesammelt wurde, wurde die Existenz einer kleinen Zahl von 46 Individuen bestätigt. Überreste von Neugeborenen, Säuglingen oder allgemein Kinderknochen, die das umstrittenste und fragwürdigste Element der Geschichtsschreibung im Hinblick auf die Höhle von Kaiadas und das antike Sparta ausmachen, wurden nicht festgestellt.

Schlüsselwörter: Sparta, Griechenland, Exekution

Keadas cavern

The picturesque village of Tripi – where the cavern of Keadas is located – lies 10 km northwest of Sparta at an altitude of 750 m near the main road leading from Sparta to Kalamata through the deep valley of Lagada, which crosses over the mountain chain of Taygetos. The ancient entrance of the cavern at the top of a verdant conical hill looks down upon the Laconian plains and the Evrotas river valley from a height making it a continual wonder and pleasure for one to stand and behold them.

The cavern is situated inside the hill, extending approximately 50 m in length, 1,5 m to 3,5 m in width

and 18 m to 25 m in height. Primarily formed due to a vertical tectonic chasm in the bedrock with NE-SW direction, the cavern was secondarily shaped by carstic water flowing towards lower limestone layers. The greater vertical development of the cave – obviously constituting its oldest compartment – at the top of which lies the ancient entrance, demonstrates the heaviest deposition of calcite in its walls and the greater concentration of human skeletal remains at its bottom.

Human bones in assemblies representing entire skeletons found in natural crevices or cavities of the cavern's vertical walls – several meters above the bottom surface – indicate the existence of an old entrance on the rooftop from which the cavern was

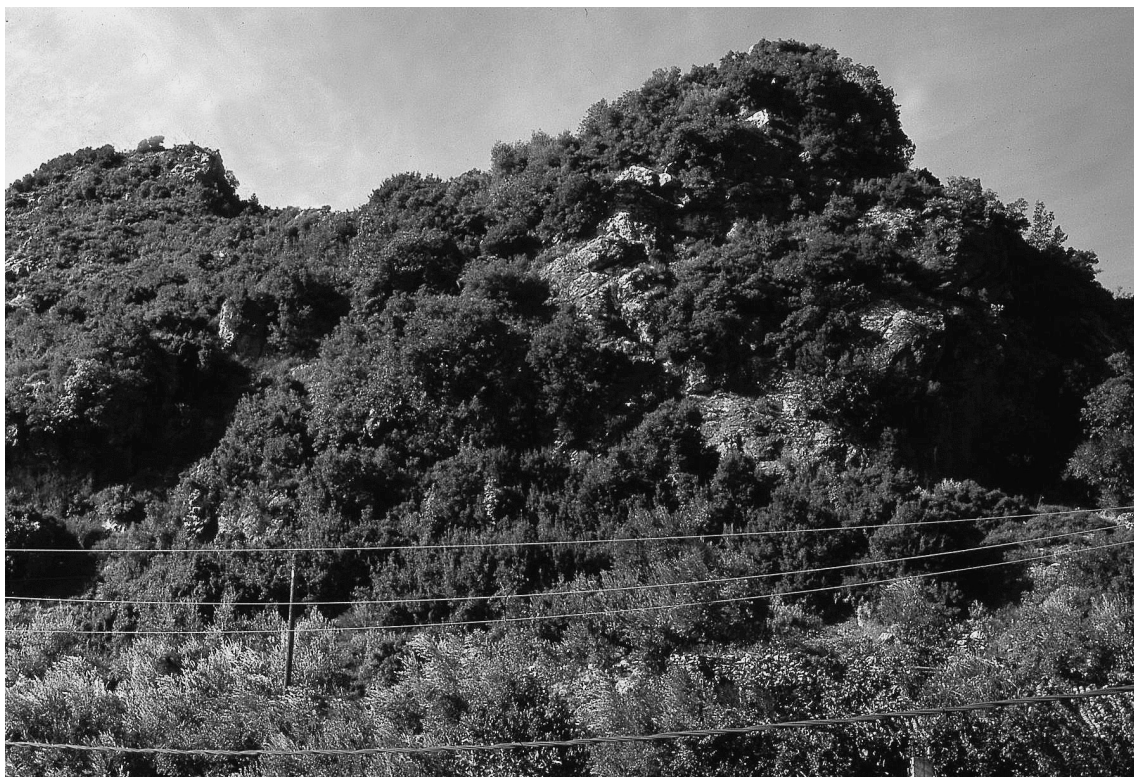


Fig. 1. The hill of Keadas.

supplied. That is, skeletal remains in these cavities may belong to those held during their fall through the cavern or to those who climbed upwards trying to reach the ancient exit.

At 35 m below the present entrance of the cavern in a 2,5 m × 1,5 m cavity there is a natural cross section of sediments revealing human bones and stone blocks covered by calcite 1 cm in thickness. Here is the only compartment of the cave presenting an active dripping, revealing bones compressed by the superincumbent stone blocks covered by a 1 cm thick layer of calcite.

In 1983 archaeologist P. Themelis, head of the Speleology and Palaeoanthropology Ephorate under the auspices of the Ministry of Culture embarked on a research expedition to the cavern. The operation and scientific exploration of the cavern was completed with the cope of the geologist E. Kampouroglou, speleologist I. Ioannou and the physical anthropologist Th. Pitsios. On-site observations revealed dense skeletal material scattered over the floor surface in the last – and deepest – compartment of the cavern. Human skeletal remains were observed in cavities of the cave as well as in the natural section of an underground 2 m × 3 m chamber

forming the sink for karstic waters which drain through underground limestone (Themelis 1984, 1985, Pitsios 1984, 1985).

Site recognition

Regarding the agreement of the known cavern of Tripi with ancient Keadas in Laconia, archaeologist P. Themelis states: “On-site reports lead us to the conclusion that this pothole rich in human skeletal material, in the country of ancient Sparta, is in absolute accordance both with ancient testimonies and the popular tradition, regarding the form and purpose of Keadas. All evidence, both geological and anthropological in origin, convince us that the Tripi pothole is the Keadas of antiquity used by the Spartans mostly during the Messenian wars i.e. 8th–5th century B.C. (Themelis 1984, 1985).

The concordance of ancient Keadas with the Tripi cavern is also noted in an English edition of Pausanias’ works (Pausanias, 115–180 AD). An explanatory passage to the text points out the view that ancient

Keadas was associated with the execution of those convicted for serious crimes and had adequate depth to allow for the slow and complete decomposition of a body.

In a German travel brochure (Baedeker 1908) an older description is found; according to this earlier account, near the verdant village of Tripi there is a big cavern which identifies with ancient Keadas – the site where Spartans used to thrust criminals convicted to death.

However, the first description of the Tripi cavern and its identification with Keadas belongs to the Frenchman O. Rayet who visited Tripi in 1879 and published his observations both in A. Couat's *La poesie alexandrine sous les trois premiers Ptolemées* Paris 1882 and in Daniel Ogden's *Aristomenes of Messene: Legends of Sparta's Nemesis*.

Rayet's description, observations and conclusions do not differ from those of geologist Vaggelis Kampouroglou and physical anthropologist Theodoros Pitsios, both of whom conducted research at the site in 1983.

Hitzig H. and Bluemner H. accepted Rayet's identification (*Pausaniae Craeciae Descriptio*, 1901) as did known American historian Kendrick Pritchett in 1985 without referring to the research conducted at the site during year 1983. Following investigations in year 1983, all previous attempts to place Keadas in the area of Mystra or Parori were abandoned.

According to historical records, Keadas was the site of execution where Spartans would thrust the enemies of Sparta, traitors and those convicted of serious crimes. In addition, an unlikely, unconfirmed fiction – widespread nevertheless in contemporary times as well – holds that disabled or cachectic infants were thrown by Lacaidemonians at Keadas. Anthropological research in the Tripi cavern has failed to establish the presence of infant or child bones. The interior of the cavern yielded ample numbers of skeletal findings belonging mainly to men aged 18–35 years. Therefore, according to P. Themelis, the Tripi cave must have been used by the Spartans during the Messenian wars. Radiocarbon dating conducted in the Institute of Nuclear Physics Demokritos (Athens, Greece) for two separate skeletal samples suggests the period between 8th–5th century BC as the most probable chronology of the bone samples (Maniatis *et al.* 2007).

The traveler of 2nd century AD, Pausanias, describes the mythical escape of Messenian hero and rebel Aristomenes from Keadas where he, along with fifty Messenian captives were thrown –alive– by the Lacaidemonians. Pausanias speaks of “a bold and deep cavern” which correlates to the Tripi cavern. Aristomenes' activities are placed by Pausanias in the second Messenian war which he dates between 685–668

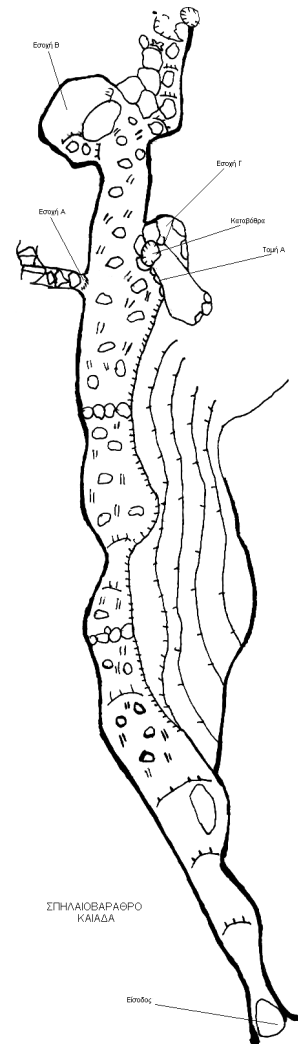


Fig. 2. Ground Keadas (draft I. Ioannou).

BC. Also, king of Sparta Pausanias (467 BC) convicted to death as a traitor of Sparta, was eventually buried outside the cave, while later his bones were buried in Sparta (Themelis 1985).

The collapse of rocks observed inside the cavern may be associated with the great historically confirmed earthquake of 464 BC. The earthquake which destroyed Sparta and allowed for the revolutionary revolt of the helots known as the third Messenian war (464–460 BC), produced fresh Messenian refugees who settled in Nafpaktos assisted by Athenians. According to Plutarch, the 464 BC earthquake was of tremendous strength: “deep clefts in the ground were opened and rocks were cut from the top of Taygetos”.

Anthropological research

Interdisciplinary research regarding populations of Greek antiquity lies upon the exhaustive historical, social and biological analyses and focuses on their continuous evolutionary processes. Ancient cemeteries constitute the standard source of ancient skeletal material. The historical, cultural and social context of these sites constitutes the essential framework for anthropological investigation and has a determinative effect upon anthropological conclusions.

In 2003 the Ministry of Culture approved a three-year instruction and research program conducted by the Anthropology Museum of Athens University aiming at

the more extensive study of the Keadas cavern. The Ephorate of Speleology and Palaeoanthropology under the Ministry of Culture and the Ephorate of Classical and Prehistoric Antiquities of Sparta participated.

The particular objectives set by the Anthropological Museum and the students enrolled in physical anthropology courses included the following:

- a) Examination of the deposition conditions regarding the human skeletal material in the interior of the cavern
- b) Collection and recognition of the skeletal findings
- c) Anthropological analysis and characterization of the skeletal material.

KEADAS – MINIMUM NUMBER OF INDIVIDUALS

		Human bones excavated during (1983 – 2005)	Min. number of individuals
CLAVICLE		10	5
SCAPULA	CORACOID	13	7
	ACROMION	18	9
	BODY	26	13
INNOMINATE	INNOMINATE	1	1
	PUBIC	–	–
	ISCHIUM	–	–
HUMERUS	UPPER EPIPHYSIS	16	8
	DIAPHYSIS	51	26
	LOWER EPIPHYSIS	49	25
ULNA	UPPER EPIPHYSIS	42	21
	DIAPHYSIS	22	11
	LOWER EPIPHYSIS	9	5
RADIUS	UPPER EPIPHYSIS	17	9
	DIAPHYSIS	24	12
	LOWER EPIPHYSIS	12	6
FEMUR	UPPER EPIPHYSIS	39	20
	DIAPHYSIS	92	46
	LOWER EPIPHYSIS	18	9
TIBIA	UPPER EPIPHYSIS	13	7
	DIAPHYSIS	46	23
	LOWER EPIPHYSIS	22	11
FIBULA	UPPER EPIPHYSIS	6	3
	DIAPHYSIS	16	8
	LOWER EPIPHYSIS	15	8

Tab. 1: Minimum no of individuals found in Keadas is estimated to 46 individuals.

Research at the site gave the first record regarding:

- 1) conditions in the cavern
 - 2) dispersal and preservation states of palaeo-anthropological findings in the cavern
 - 3) problems to be faced by further research at the site.
- Particular emphasis was given to the identification of the initial conditions in which human skeletal material was deposited; that is, prior to topographical changes that occurred in the area during the past 20 years – including the more recent interventions in its interior.

Preliminary research yielded the following results and conclusions:

- Human bones were scattered virtually over the entire cavern; secondary concentrations of skeletal remains were observed on the cavern surface and in a few cases paleoanthropological finds were uncovered *in situ*; these results indicate different phases and periods during which skeletal remains were deposited; alternatively a change in the initial conditions of deposition of human skeletal finds in the cavern may be suggested.
- A total of at least 46 individuals is inferred by the collection of human skeletal from the cavern floor up to now (Tab. 1); this result is in accordance with the historical account of the capture and execution of Aristomenes and his companions at the Keadas cavern. The material collected is principally comprised of male skeletons with biological age between 18–35 years; a restricted number of individuals with estimated age at death above 40 years is recorded and 2 or 3 subadult skeletons aged 12–17 years old.
- On-site research as well as laboratory analysis of the sample collected, failed to reveal infant or child bones among the skeletal findings.
- The presence of adult skeletons at a height up to 20 m from the cavern's present floor surface was confirmed; this result is suggestive of survivors in the cavern who tried to escape from the deep cavern.

The human skeleton constitutes a valuable means for studying human populations of previous historical periods; a single biological element which maintains genetic information, bearing as well acquired testimonies relevant to origin, daily life, demographic composition, health and major events experienced by such populations in their historical course.

In a preliminary phase, anthropological analysis of a skeleton or of a skeletal population focuses on determining the basic parameters of sex and biological age at death for the respective material. Results approach with a greater or a lesser validity the facts

regarding the individual age of death or the average life span of a population. Thus, a series of biological features are used in anthropological analysis as indicators of social or environmental stress with an immediate effect on population health. Among these, indicators of population fatality and population morbidity are considered most significant; in addition, aberrations in the development of the long bones and stature and the statistical depiction of dental pathology and the incidence of dental enamel hypoplasia.

Biological age

The determination of biological age in subadult skeletons (small children and adolescents) lies in the process of skeletal ossification, bone development and the degree of sutures synostosis (Krogman 1962; Bass 1987; McKern and Stewart 1957), as well as the stage of formation and time of eruption for deciduous and permanent human dentition (Stevensen 1924; Garn *et al.* 1959; Miles 1963; Brothwell 1972; Ubelaker 1978).

In adult skeletons, the major indicators of age at death are the morphological changes in the pubic symphysis (McKern and Stewart 1957), dental abrasion (Miles 1963), the progressive synostosis of the cranial sutures (Olivier 1960), the progressive osteoporosis of long bone epiphyses (Acsadi and Nemeskeri 1970) and the morphological changes of thoracic ribs (Krogman and Işcan 1986) and the clavicle.

Dental histological methods such as TCA and lamentin help to define biological age with accuracy, principally in adult individuals. That is especially the case where serious erosion of the skeletal remains limits further analysis while preservation of dental tissues due to their natural resistance allows for the above-mentioned methods to be applied.

The biological age of a skeleton is defined by the processes of growth, maturation and ageing of its bones. In Keadas, however, most of the skeletal findings were found scattered and disarticulated from their initial skeletons. That is a consequence of the verticality of the cavern, the slope of its floor and the activities of a vast number of uncontrolled visitors to the cave during the last twenty years. Consequently, age related morphometric observations were obtained from independent bones which were evaluated as a total sample with regard to the frequencies of different age-related observations. In any case, the presence of skeletal findings of newborns or infants was not established in the cave. These constitute the most ambiguous and questionable element of the relevant historiography associated with Keadas and ancient Sparta.

KEADAS – SEX TRAITS					
	Female (-2)	Female (-1)	Undefined (0)	Male (+1)	Male (+2)
Skull volume	1	1	1	5	3
Muscular relief of skull	0	0	0	3	2
Size of long bones	4	5	9	28	11
Muscular relief of long bones	0	0	1	18	11
Observations	5	6	11	54	27
Total sum	11 (10,7%)		11 (10,7%)	81 (78,6%)	

Tab. 2: Sex observations on the skeletal remains of Keadas.

On the contrary, the majority of human findings in the cave belong to male skeletons of biological age between 18 and 35 years. Only two adult skulls exhibit indications of biological age above 50 years, whereas few skeletal findings from two subadult skeletons indicate biological age between 14 and 17 years.

Finally, parts of the frontal bone which must belong to another young person aged approximately 12 years was found. But this case could not be considered proof for the killing of infants in Keadas, since the involvement of older children and adolescents in violent confrontations and warfare is a fact accounted for in modern historical periods as well.

Therefore, the improbable scenario of infant killing in Keadas as an application of eugenics seems to be

unsubstantiated. Since the genetic ground underlying most of the diseases or physical dysplasias of man are largely unknown up until today, the application of eugenics should be rejected as an ineffective and unreasonable brutality against humanity. Even more so since such a practice directly opposes human sense as well as the innate self-sacrifice instinct that parents exhibit through caring and protecting their offspring.

Estimation of sex

In diagnosis of skeletal sex, the morphometrical features of the pelvis bones are considered of particular importance (Martin and Saller 1956; Stewart 1954, 1968; Bass 1987), the morphology of cranial bones (Krogman 1962; Keen 1950; Bass 1987), the bulk of the long bones and the size of their articular surfaces (Krogman 1962) are also evaluated.

As in the case of biological age, determination of sex is based on the development and morphometric characteristics of the bones of a skeleton. However, this classical method of analysis could not be applied to the sample of scattered bones collected from Keadas cavern. Consequently, the method had to be modified accordingly so as to ensure the most probable and valid methodological approach and relevant conclusions.

Intragroup overlapping in the frequency distributions of sex-related biological traits is known for all human populations; an equal percentage of the relevant diagnostic criteria would be expected to appear (e.g. 50% of male and 50% of female indicators) in a skeletal sample with normal demographic composition. According to our research hypothesis and the historical data concerning ancient Keadas, the proportions of male/female indicators are expected to indicate explicit numerical predominance of males in the present sample. This is shown in Table 2 which summarizes the most frequent observations made while determining sex in the skeletal remains collected from the Keadas cavern.

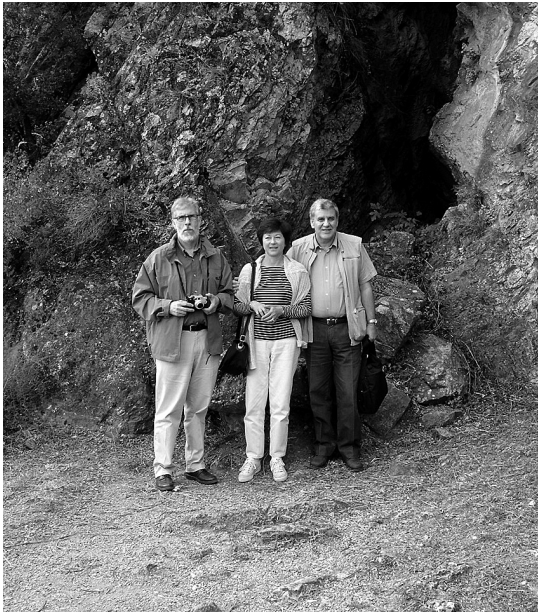


Fig. 3. Recent entrance of Keadas.



Fig 4. Human bones at the lower level of the cavern.

After counter-checking for all probable female sex indicators in skeletal remains found in the cavern, the single strong indication of a female in the skeletal sample of Keadas remained an intact sacral bone, collected in 1983 during the first exploration of the cave.

Where a random mixture of skeletal findings is under anthropological analysis – as is the case with the Keadas material – an important parameter to be estimated is that of the minimum number of individuals represented in the sample. Where conditions of preservation are favorable, the calculation of the minimum number of people can in theory significantly approach the actual number of people in the population. On the other hand, in cases where the skeletal material has suffered extensive losses due to natural factors or human intervention, the estimated parameter for the skeletal sample and the actual parameter for the respective population sample can diverge.

In our sample – that is the total of human skeletal findings collected from the Keadas until today –

a minimum number of 46 individuals have been estimated. This result bears an indirect relation to the historical account on the execution of Aristomenes and his companions in the Keadas cavern (Pitsios *et al.* 2008a, 2008b, 2009a, 2009b, 2009c).

This collection of skeletal material offered very few examples of skeletal elements being recognizable as belonging to the same individual. Skeletal elements identified in this way were: a) discerned in their initial position e.g. a couple of ankles found attached in the west wall of the cave; b) distinguished on the basis of age indicators e.g. a few ossicles from an adolescent skeleton lied among the findings of the cavern sink; c) matched by their unique metric dimensions. Such was the case of “the giant” – a male adult skeleton named by the excavation crew – found in cavity B in an assembly of large bones bearing strong muscular relief, pressed by stone blocks.

The anthropological composition regarding the population in the wider Greek region is considered to

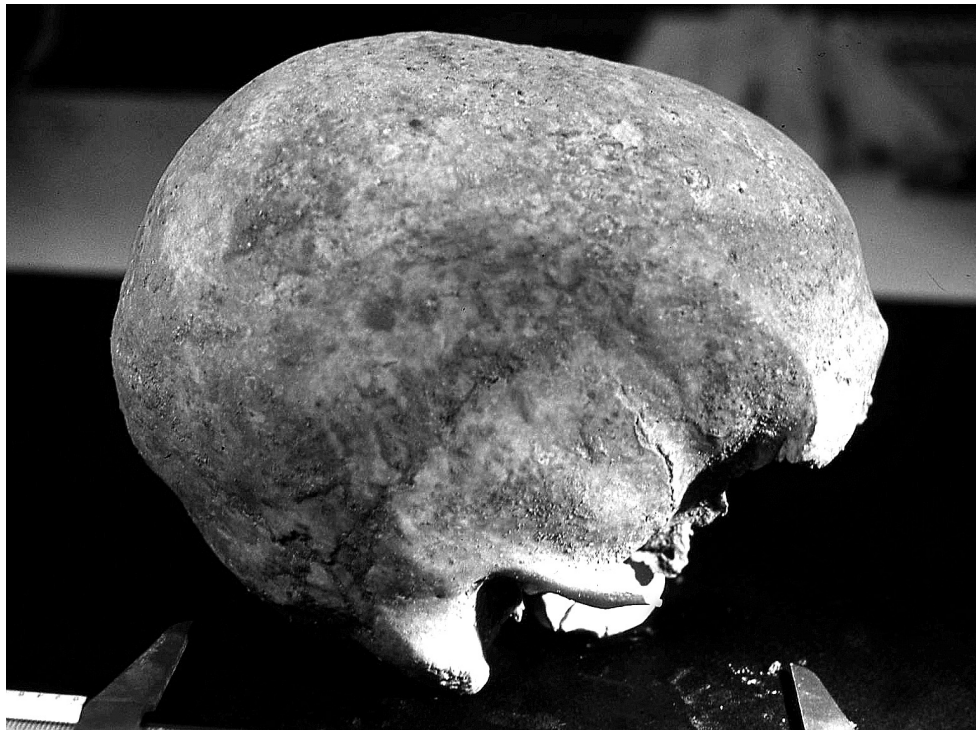


Fig. 5. Keadas, adult male skull.

have been complete within the Neolithic period, constituted by specific anthropological types i.e. the mediterranean, the alpine and the dinaric type. Angel (1971) established the anthropological continuum and genetic relevance between the population of classical Greece and its Neolithic demographic basis.

Epilogue

According to available data, death in Keadas was a ritual execution imposed by a cruel, inevitable sentence following the laws and principles of Sparta. The Homeric epos introduces capital punishment in the heroic era; throughout the heroic epos human life is highly esteemed, emphatically in verse displaying overwhelming wonder and dread over the early loss of it. From the top of the hill of Keadas those condemned for treason were looking down over the beloved fatherland while those jealous of Sparta's glory were looking upon the avenger country, glorious and alluring; in these final moments laid before them in all its glory what was to be lost while they were nearing Keadas; light and life were left behind, ahead were darkness and probable death.

Tripi cavern is a natural sink collecting waters from the surrounding land and yielding the underground waters of Taygetos which flow towards the neighboring ravine of Lagada and the Evrotas valley. Death and the descent to Hades were associated with surface water disappearing underground – as in the traditions of the Aherousia lake and the Hades cave in Taenaron.

Avengeance such as that encountered in Keadas – where convicts were not killed but abandoned in the hands of god – is associated to a widespread perception of antiquity as it happened with the rescue of the Messenian hero Aristomenes and his fictional escape from Keadas.

However, it is the geographical position of the site that is most distinctive among the elements in Keadas' historical character. It stands at the unaltered – from antiquity to contemporary times – boundary of the Laconian land, a quasi sleepless guard and defensive warning for those who conspired against or threatened Sparta's integrity.

Given the great significance the perception of death carried in Sparta and the unequalled self-sacrifice of Spartan citizens, Keadas seems to be an imposing symbol over Sparta, a supreme ideological element,



Fig. 6. Professor W. Henke, *Doctor honoris causa* – University of Athens (2006).

directional in Spartans' lives. Without the aforementioned, Greek and world history would not have received the notion of Thermopylae.

References

- Acsadi G, Nemeskéri J 1970. *History of human life span and mortality*. Akadémiai Kiadó. Budapest.
- Angel JL 1971. *Lerna, a preclassical site in the Argolid. Volume II – The People*. Smithsonian Institute. Washington.
- Baedeker K 1908. *Griechenland, Handbuch für Reisende*. Leipzig, 370.
- Bass WM 1987. *Human Osteology*. Missouri Archaeological Society. Columbia, Missouri.
- Brothwell DT 1972. *Digging up bones*. Cornell University Press. London.
- Couat A 1931. *La poesie alexandrine sous les trois premiers Ptolémées*. Paris 1882 (English translation, London 1931).
- Keen JA 1950. *A study of the difference between male and female skulls*. American Journal of Physical Anthropology 8: 65–79.
- Krogman WM 1961. *The human skeleton in forensic medicine*. Thomas. Springfield.
- Krogman WM, Iscan MY 1986. *The human skeleton in legal medicine*. Thomas. Springfield.
- Martin R, Saller K 1956. *Lehrbuch der Anthropologie*. Fischer. Stuttgart.
- Ogden D 2004. *Aristomenes of Messene: Legends of Sparta's Nemesis*. David Brown Book Co. Wales, 78–80.
- Olivier G 1960. *Pratique Anthropologique*. Vigot Frères. Paris.
- Maniatis Y, Dotsika E, Maniati M, Pitsios T, Coltrain J, Cerling T, Ehleringer J 2006. *Radiocarbon Dating and Stable Isotope Analysis of Human Bones Found in Notorious Kaiadas Gulch near Sparta: A Preliminary Report*. 36th International Symposium on Archaeometry, Quebec, Canada, 2-6 May 2006.
- McKern TW, Stewart TD, 1957. *Skeletal age changes in young American males*. Headquarters, Quartermaster Research and Development Command. U.S. Army, Environmental Protection Research Division.
- Miles AEW 1963. *Dentition in the assessment of individual age in skeletal material*. In: Brothwell DR (ed.). *Dental Anthropology*. Pergamon Press, Oxford, 191–209.
- Pausanias 1901. *Pausaniae Craeciae Descriptio 1901*. Leipzig, 141–2.
- Pausanias 1971. *Guide to Greece – southern Greece*. London. Penguin edition, pp. 145–146.
- Pitsios T 1984. *Kaiadas, anthropological report*. Archeologika Analekta Athinon XΩ: 87–194.
- Pitsios T 1985. *Kaiadas, anthropological report*. Archeology 15: 58.
- Pitsios T, Tsioli S, Krikoni B, Kapralos P 2008a. *Δημογραφική συνθεση και ανθρωπολογικές παρατηρήσεις στο επιφανειακό σκελετικό υλικό των Καιάδα*. Proceedings of scientific symposium in Sparta, 69–87.
- Pitsios T, Themelis P, Kreatsas G 2008b. *Γονιμότητα, παιδική θνησιμότητα και βρεφοκτονία σε προ-βιομηχανικές ανθρωπινές κοινωνίες*. Proceedings of scientific symposium in Sparta, 20–22.5.2005, 99–110.
- Pitsios T 2009a. *Anthropological Research in the Ancient Keadas*. Proceedings 1st International Congress of Anthropology, 21–23.11.2003. 135–138.
- Pitsios T 2009b. *Σπηλαιοβαράθρο Καιάδα. Ερευνητικό και Εκπαιδευτικό Προγραμμα*. Proceedings 2nd International Congress of Anthropology, Athens 5–10.6.2006, 39–158.

- Pitsios T 2009c. *Research program of Kaiadas Cavern, by Sparta*. Proceedings of the 2nd International Congress of Anthropology, Athens-Areopolis-Sparta 5–10.6.2006, 167–178.
- Pritchett K 1985. *Studies in Ancient Greek Topography* 5. Berkeley. Los Angeles, 58–60.
- Stewart TD 1954. *Evaluation of Evidence from the Skeleton*. In: Gradwohl RBH (ed.). *Legal Medicine*. Mosby. St. Louis.
- Stewart TD 1968. *Identification by the skeletal structures*. In: Camps FE (Ed.), *Gradwohl's Legal Medicine*, 2nd Ed. Wright. Bristol, UK, 123–154.
- Themelis P 1984. *Kaiadas*. *Archeologika Analekta Athinon*, XΩ: 87–194.
- Themelis P 1985. *Kaiadas*. *Archeology* 15: 55–60.
- Ubelaker DH 1978. *Human skeletal remains. Excavation, analysis, interpretation*. Aldine Publishing Co. Inc. Chicago.

Address:

Theodoros Pitsios
Medical School – University of Athens
Mikras Asias 75
11527 Athens
Greece

Tel.: +30 210 746 235 860
Fax: +30 210 746 2359
E-mail: tpitsios@med.uoa.gr

Fishing with the Vikings: Vertebrate food webs and isotopic mixing models in a brackish water ecosystem at Viking Haithabu and medieval Schleswig

GISELA GRUPE^{1*}, STEFANIE DOPPLER¹, MARINA VOHBERGER¹, JORIS PETERS²

¹Dept. I, Fakultät für Biologie der LMU, Biozentrum, Martinsried, Germany

²Institute of Palaeontology and the History of Veterinary Medicine, Munich, Germany

*Corresponding author

Summary

More than 400 individual vertebrate bone remains from the archaeofaunal assemblages recovered at Viking Haithabu and medieval Schleswig (Schild site) were analysed in terms of stable carbon, nitrogen, and oxygen isotopic ratios in bone collagen and structural carbonate. This extensive investigation of animal bone remains served as a basis for defining ecological compartments at the sites (terrestrial, fresh water, brackish water, and marine), establishing trophic webs, and reconstructing prey/predator relationships by means of linear mixing models. It was possible to delineate vertebrate habitat preferences in terms of salinity by a combination of stable carbon isotopes from collagen and carbonate, and to quantify the origin of the food of several omnivorous and carnivorous species with regard to the different ecological niches. While this study was meant as a prerequisite for the ultimate goal of our project, that is the reconstruction of the rise and fall of a Viking and medieval trade center with a focus on human population development and economy, it could be shown that the application of stable isotope analysis to archaeofaunal assemblages may result in valuable information for biodiversity research and wildlife conservation policies.

Key words: palaeofood web, stable isotopes, Haithabu, Schleswig, Baltic Sea

Zusammenfassung

Mehr als 400 individuelle Skelettreste aus dem archäozoologischen Fundgut des wikingerzeitlichen Haithabu und mittelalterlichen Schleswig (Grabung Schleswig Schild) wurden bezüglich stabiler Kohlenstoff-, Stickstoff- und Sauerstoffisotope aus dem Knochenkollagen bzw. der strukturellen Karbonatfraktion des Apatits untersucht. Diese umfangreiche Studie stellt die Basisdaten für die Definition ökologischer Kompartimente in der Fundregion bereit (terrestrisch, Süßgewässer, Brackwasser, marin), aufgrund derer sowohl Nahrungsnetze als auch Räuber/Beuteketten durch die Applikation linearer Mischungsmodelle rekonstruiert werden können. Durch eine Kombination stabiler Kohlenstoffisotopenverhältnisse aus Knochenkollagen und strukturellem Karbonat gelang es, die Habitatpräferenzen der Wirbeltierarten in Bezug auf die Salinität zu bestimmen. Ferner konnten die Nahrungsquellen von omnivoren und carnivoren Arten im Hinblick auf deren Herkunft aus unterschiedlichen ökologischen Nischen quantifiziert werden. Zwar diente diese Studie primär der Gewinnung der notwendigen ökologischen Daten für das eigentliche Ziel unseres Forschungsprojektes – der Rekonstruktion von Aufstieg und Fall eines wikingerzeitlichen Handelszentrums mit Schwerpunkt auf der Entwicklung der menschlichen Bevölkerung und deren Ökonomie – jedoch konnte gezeigt werden, dass die Analyse stabiler Isotope von archäozoologischem Fundgut auch wertvolle Erkenntnisse zur Biodiversitätsforschung und zu Artenschutzprogrammen beitragen kann.

Key words: Paläonahrungsnetz, stabile Isotope, Haithabu, Schleswig, Ostsee

Introduction

In the frame of an ongoing project, the rise and fall of historical trade centers at the Schlei fjord in Northern Germany, namely Viking Haithabu and its successor, the medieval town of Schleswig, is investigated in terms of

changing economy and subsistence strategy. Skeletal finds of humans and animals are analyzed in terms of stable isotopes of the light elements carbon, nitrogen, oxygen and sulfur from bone collagen and structural carbonate, and the heavy element strontium in the bone apatite. The reconstruction of human dietary preferences

serves as a vehicle for an assessment of economical strategies and provision. Before considering human diet, however, baseline isotopic values of the various compartments of the palaeoecosystem at the site and the respective vertebrate food webs have to be established. Since only few traces related to agriculture near Haithabu were evidenced archaeologically, people may have lived mainly from trade. However, it is expected that life close to the coast with a year round access to the open waters necessarily led to the exploitation of both the Baltic and the North Sea beside the Schlei fjord.

Therefore, the first focus of this project was the reconstruction of vertebrate isotopic webs, which are fundamental for an understanding of the general environmental conditions, since among all ecosystems on earth, estuaries belong to the more complex ones due to overall low but variable salinity and oxygen availability. For many species, life in brackish water means a life at their tolerance limit, and such sensitive systems are prone to interferences and disturbances (Rheinheimer 1996). Therefore, our study not only aims at the reconstruction of the living conditions of a historical human society, but likewise bears implications for palaeobiodiversity research (Doppler *et al.* in press). In this paper, we will outline the possibilities and limitations for the reconstruction of historical food webs based on bioarchaeological finds and the implications for temporal changes of biodiversity in a given environment.

The sites

The Viking trade center of Haithabu was located at a strategic position on the southern border of the Schlei fjord and was thus capable of controlling both the important east-west trading route via the Eider-Treene-Schlei waterway across the Jutland peninsula, and an oxen route oriented in a north-south direction. Haithabu had expanded considerably since the middle of the 9th century AD and was at its height in the 10th century. It was a busy place for trade and commerce with contacts into almost every part of the then known world (Jankuhn 1986). After the destruction of the town by Western Slavs in 1066 AD (Simek 2002), the settlement was relocated to the north shore of the Schlei fjord and became an important trade center again, now named Schleswig, the inhabitation of which was confirmed archaeologically from the 11th century AD onwards (Vogel 1983). However, a detectable decline in trading activities was evidenced only 100 years after Schleswig's initial rise. A primary reason for this was the construction of new ship types possessing larger

draughts that prevented their navigation in the rivers Treene and Eider. Consequently this once important trade route lost its commercial attractiveness. The Schlei fjord is a meltwater inlet and exhibits decreasing levels of salinity from its mouth to the inland locations. Consequently, marine and fresh water fish live in the different compartments of the Schlei concomitant to the different salinity levels. A brackish water body is also characteristic of the Baltic Sea itself. Today, the salinity of the Baltic Sea varies from only 1‰ in the north to 6–8‰ in the central Baltic, where 15–20‰ prevail in the deep waters of the latter (Björck 1995). Average salinity of open oceans is considerably higher (35‰; Craig *et al.* 2006).

The environmental facets of the Schlei fjord with its brackish water constitute favourable, yet very complex ecological conditions that the inhabitants were forced to adapt to. Although past subsistence strategies have frequently and successfully been assessed by stable isotope analysis of human and animal archaeological bone finds, investigations concentrating on vertebrates from brackish water systems are apparently rare (Schoeninger *et al.* 1984, Ambrose *et al.* 1997). Therefore, our attempts to reconstruct the ancient vertebrate food webs may be considered a pioneering work with several imponderabilities, since many vertebrates may have fed from several or all of the ecological niches offered by the habitat (terrestrial, freshwater, estuarine, marine). In this paper, we will outline the research potential but also the limitations of the application of stable isotope analysis in the course of evaluating prey/predator relationships based on bioarchaeological remains.

The stable isotopic ratios

Stable carbon and nitrogen isotope ratios in bone collagen ($\delta^{13}\text{C}_{\text{coll}}$, $\delta^{15}\text{N}$)

Stable isotopic ratios in bone collagen are related to the protein part of the diet, as a result all essential amino acids contain carbon from dietary protein. Based on fractionation processes taking place during amino acid synthesis, the $\delta^{13}\text{C}$ value in a consumer's bone collagen is approximately 5‰ more positive than the dietary source (for a comprehensive review see Ambrose 1993). In terrestrial environments, major fractionations occur during plant photosynthesis, for example, in C3-plants that discriminate significantly more against the heavy isotope ^{13}C than C4-plants. The fact that C4-plants do not grow in the area of Haithabu and Schleswig means that a C4-plant signature can only be expected in bones belonging to a possible late "immigrant" (human or

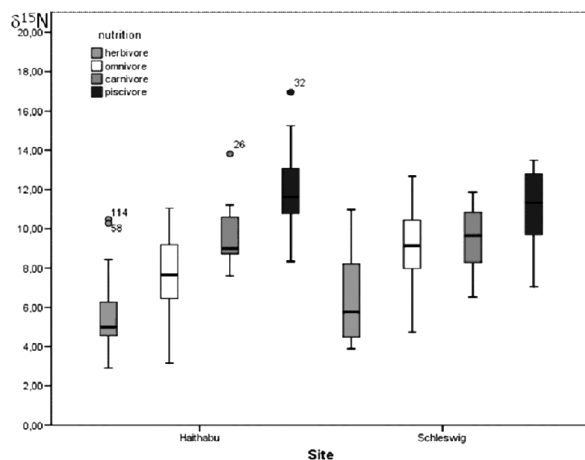


Fig. 1: Trophic level effect of $\delta^{15}\text{N}$ in the collagen of the faunal remains analysed in this paper.

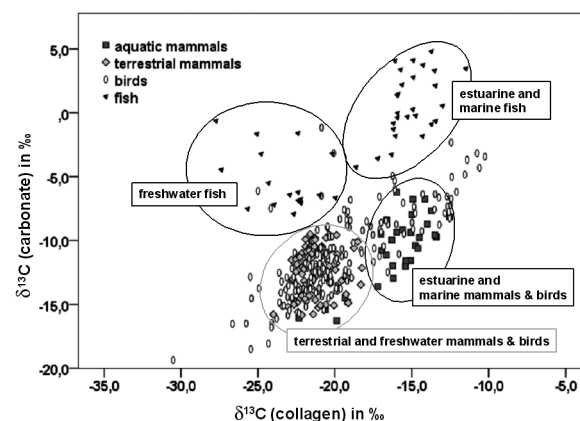


Fig. 2: Clustering of taxa according to their habitat preferences based on $\delta^{13}\text{C}$ values in bone collagen and bone structural carbonate.

animal) to the site. There is ample evidence for trade contacts into regions where C_4 -plants were abundant. The special complexity of the Haithabu/Schleswig environment, however, is due to the brackish water of the Schlei fjord which allowed for the exploitation of both marine and limnic resources by the inhabitants living in the surrounding areas. In such environments, several carbon sources such as solubilized CO_2 , bicarbonate, dissolved inorganic and organic carbon are available. Also, more primary producers are abundant compared to terrestrial environments. Since both the carbon sources and the primary producers are related to the different water depths, a systematic variability in $\delta^{13}\text{C}$ values from benthic to pelagic to profundal areas in a given body of water is evident, with significantly more negative $\delta^{13}\text{C}$ values in water plants growing in the deeper areas as opposed to shallower waters (Vander Zanden and Rasmussen 1999). In marine environments, bicarbonate is the major source of carbon, which is approximately 7‰ more positive than atmospheric CO_2 , resulting in enriched $\delta^{13}\text{C}$ values. Just as in limnic environments, differences are encountered between benthic, pelagic and profundal areas with more positive values in benthic (coastal) food webs (Hobson 1999).

Nitrogen in bone collagen is also exclusively related to dietary protein, resulting in the well known trophic level effect evidenced by the consumer's $\delta^{15}\text{N}$ values (Ambrose 1993, Ambrose *et al.* 1997). Consumers on higher trophic levels have more positive collagen $\delta^{15}\text{N}$ values, and although the enrichment in ^{15}N varies according to species specific metabolic pathways, it averages 3‰ (Minagawa and Wada 1984). In general,

food chains of aquatic ecosystems are longer than those that are terrestrial based, therefore, $\delta^{15}\text{N}$ values in bones of aquatic animals can actually exceed those of terrestrial animals. $\delta^{15}\text{N}$ values in marine ecosystems are usually much higher than in terrestrial ones, since the primary producers (phytoplankton) already exhibit base values up to 8‰ (Coltrain *et al.* 2004a), equal to the upper margin of terrestrial herbivores.

Stable carbon and oxygen isotopes in bone structural carbonate ($\delta^{13}\text{C}_{\text{carb}}$, $\delta^{18}\text{O}$)

$\delta^{13}\text{C}_{\text{carb}}$ of a consumer's bone is also related to its diet, but here the carbon is derived from blood bicarbonate, which stems from all dietary components including lipids and carbohydrates. Fractionation factors from diet to bone carbonate have been investigated by Lee-Thorp *et al.* (1989) and average 12‰, but with pronounced species specificity. Since the spacings between $\delta^{13}\text{C}$ in carbonate and $\delta^{13}\text{C}$ in collagen are significantly smaller in carnivores compared to herbivores, the $\Delta\delta^{13}\text{C}_{\text{carb-coll}}$ is a very useful figure to assess the trophic position of individuals in the food chain based upon skeletal remains.

Although $\delta^{13}\text{C}_{\text{carb}}$ is also sensitive to salinity conditions of the environment in cold blooded animals, the relationship of $\delta^{18}\text{O}$ in carbonate to both salinity and temperature is much more pronounced. The more saline a body of water is the higher $\delta^{18}\text{O}$ values should be expected (Kennett 1996). In an early study of shell carbonate from marine, fresh water and brackish environments, Mook (1971) was able to demonstrate

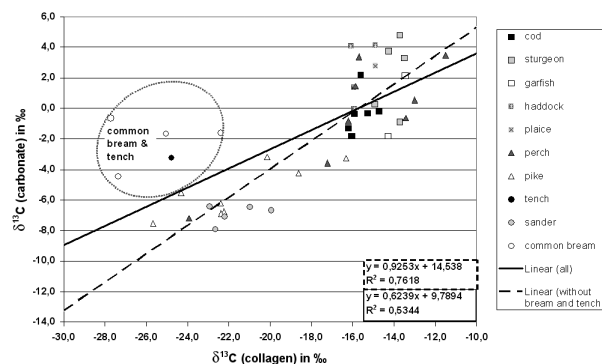


Fig. 3: Linear relationship between $\delta^{13}\text{C}_{\text{collagen}}$ and $\delta^{13}\text{C}_{\text{carbonate}}$ in fish taxa according to their habitat preferences in the Schlei fjord. Common bream and tench have most probably been caught from still waters (cf. Doppler *et al.*, in press).

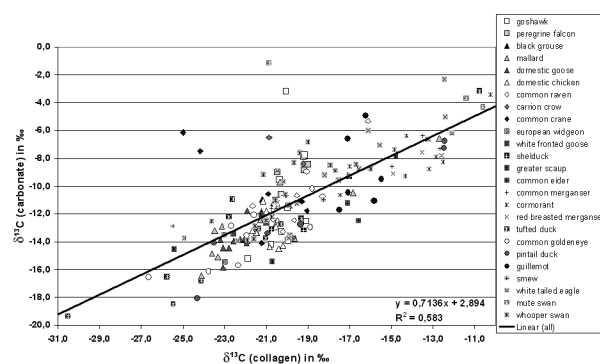


Fig. 4: Linear relationship between $\delta^{13}\text{C}_{\text{collagen}}$ and $\delta^{13}\text{C}_{\text{carbonate}}$ in bird taxa according to their habitat and feeding preferences in the Schlei fjord.

that carbonate which precipitated in pure fresh water would be depleted in ^{18}O by 9‰ relative to the sea water carbonate (given constant temperatures). Therefore, the carbonate analyses are most crucial for this project and constitute an innovative approach to palaeoecology. Meteoric water $\delta^{18}\text{O}$ varies with temperature, latitude, altitude and distance from the coast. An estimation of the modern variability of $\delta^{18}\text{O}$ in precipitation of the Atlantic and Baltic region by use of the Online Isotopes in Precipitation Calculator (www.waterisotopes.org) reveals that $\delta^{18}\text{O}$ varies with latitude and longitude from -9 to -16‰. With regard to the long distance trade evidenced for both Haithabu and Schleswig, the isotopic range encountered in the bioarchaeological finds may be even larger. $\delta^{18}\text{O}$ in the bone structural carbonate can potentially be related to $\delta^{18}\text{O}$ in meteoric water (Bryant *et al.* 1996; Iacumin *et al.* 1996; cf. also review by Kohn and Cerling 2002), but is highly influenced by species specific metabolic peculiarities, and also by humidity which can hardly be assessed for palaeoenvironments (Kohn and Cerling 2002).

Material and methods

In total, 432 individual animal bones (62 terrestrial wild mammals, 37 aquatic mammals, 52 domesticated mammals, 54 fish, and 227 birds) were investigated in terms of $\delta^{13}\text{C}_{\text{coll}}$, $\delta^{13}\text{C}_{\text{carb}}$, $\delta^{15}\text{N}_{\text{coll}}$ and $\delta^{18}\text{O}_{\text{carb}}$, whereby the results of 141 vertebrates (mainly fish and sea mammals) have already been published previously (Grupe *et al.* 2009). Whenever possible, five individuals

of each species were selected for analysis (see Clementz and Koch 2001). To avoid duplicate analysis of bone fragments from one individual, the same skeletal part was systematically selected. Extraction of collagen and structural carbonate, and the mass spectrometry were performed according to well established protocols as published elsewhere (e.g. Grupe *et al.* 2009). While the state of preservation of the extracted gelatine was assessed by amino acid profiles and quality control criteria agreed upon by the vast majority of researchers (Ambrose 1993; Harbeck and Grupe 2009), the extracted carbonate was not subjected to mineralogical identification methods because the $\Delta\delta^{13}\text{C}_{\text{carb-coll}}$ spacing could be controlled for (Jacobson *et al.* 1972; Winkler and Schmidt 1980; Lee-Thorp *et al.* 1989).

Linear mixing models were calculated by use of the IsoSource software (Phillips and Gregg 2003; <http://www.epa.gov/wed/pages/models.htm>), which permits the determination of more than $n+1$ dietary sources from n isotopic indicators. While no unique solutions are provided by this software, all feasible solutions are computed. Therefore, also in this paper, only such feasible solutions (1. – 99. Percentile) are reported. Dietary isotopic signals were calculated by subtracting the fractionation factors from diet into collagen ($\delta^{13}\text{C}$: +5‰, $\delta^{15}\text{N}$: +3‰, as best approximations agreed upon) from the measured isotopic ratios in the animal bones (Newsome *et al.*, 2004). When necessary, baseline plant protein $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values were assessed by the respective isotopic ratios in bones of the exclusively herbivorous and residential deer.

Results

State of preservation of the bone finds

From the majority of animal bones, gelatine was successfully retrieved. In a few instances only, the size of the sampled bone was too small to permit for both collagen and carbonate analysis. From 34 specimens only, no collagen could be retrieved, and it is noteworthy that all these specimens belonged to small bird species, the small and fragile bones of which might have been more prone to diagenesis. In the course of an experimental decomposition of modern mammalian bone, Harbeck and Grupe (2009) were unable to detect any statistically significant relationship between collagen content and collagen quality. Results from the same study showed that stable carbon and nitrogen isotopic ratios in the remaining collagen were unaffected by diagenesis until a C/Nmolar ratio of 4.2 was reached. While fresh collagen has a molar such ratio of 3.2 (Ambrose 1993), a conservatively accepted range for archaeological bone was suggested between 2.9 and 3.6 (DeNiro 1985), which had, however, never been tested experimentally and systematically. Accordingly, collagen from archaeological bone exhibiting C/Nmolar ratios up to 4.0 have since been accepted for interpretation (e.g. Coltrain *et al.* 2004b). The establishment of amino acid profiles in the course of our study, the ultimate proof for the state of preservation of collagen in terms of its correct amino acid composition, justified the inclusion of specimens into the data set the collagen of which exhibited elevated C/Nmolar ratios up to 4.2 (see above).

The bone structural carbonate fraction could be retrieved from > 98% of the specimens. While a test for the integrity of structural carbonate would require mineralogical methods such as Fourier-Transform Infrared spectroscopy (Grupe *et al.*, in press), this would have constituted an enormous effort with regard to the mere number of specimens investigated in the course of our study. Since it is generally accepted that just as the bone mineral does preserve the bone collagen, so does collagen preserve the mineral, and since the validity of the stable isotopic ratios could be controlled for by the diet dependent $\Delta\delta^{13}\text{C}_{\text{carb-coll}}$ spacing (see Lee-Thorp *et al.* 1989; Grupe *et al.* 2009), $\delta^{13}\text{C}_{\text{carb}}$ values were readily included into the interpretation. While it has been shown several times that carbonate $\delta^{13}\text{C}$ is much less prone to diagenesis than $\delta^{18}\text{O}$ (Krueger 1991; Wang and Cerling 1994), especially after an appropriate sample processing protocol (Koch *et al.* 1996), the potential stability of the former has since been shown in the course of apatite radiocarbon dating (e.g. Lanting *et al.* 2001; Olsen *et al.* 2008). Also, due the overall

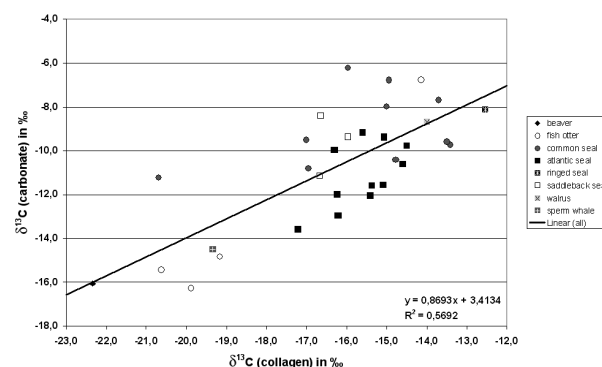


Fig. 5: Linear relationship between $\delta^{13}\text{C}_{\text{collagen}}$ and $\delta^{13}\text{C}_{\text{carbonate}}$ of aquatic mammals according to the salinity of their environment. The sperm whale exhibits a fresh water signature because of its habitat in the high arctic, where very low water temperatures permit a better CO_2 solubility (cf. Doppler *et al.*, in press).

excellent preservation of the finds due to very favourable burial conditions, and the fact that species specific temperature preferences were maintained by $\delta^{18}\text{O}$ at least in heterothermic species (Grupe *et al.* 2009), we presently suppose that also carbonate $\delta^{18}\text{O}$ values represent the original, biological isotopic signals. Nevertheless, data should be viewed with caution until at least a selection of specimens are analysed mineralogically, which will be achieved in the course of our ongoing studies focusing on stable isotopes preserved in the bone mineral fraction, such as $^{87}\text{Sr}/^{86}\text{Sr}$.

Mean, minimum and maximum stable isotopic ratios per species are listed in Table 1. All individual raw data are available by Doppler *et al.* (in press).

Vertebrate isotopic food webs

In terms of $\delta^{13}\text{C}_{\text{coll}}$, mean values (all species included) did not differ significantly between the finds from Haithabu (-20.2‰) and Schleswig (-20.4‰; Table 2). Therefore, these vertebrates most probably shared the same habitat, or, in case of imported animals, imports also came from C3-plant dominated areas. This was largely expected, since both sites are located a very small distance from each other and are separated by only a small period of time. The higher $\delta^{15}\text{N}$ -values for the animals from Schleswig (Table 2) are explained by the higher percentage of bird bones in the assemblage, and the lack of large herbivores. As soon as the bird bones are excluded, differences are no longer detectable. In terms of $\delta^{15}\text{N}$, the trophic level separating herbivores,

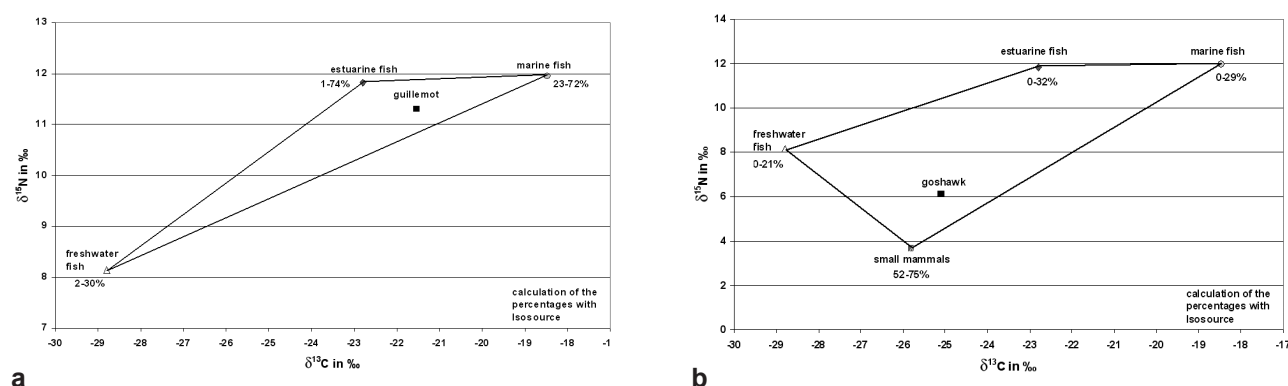


Fig. 6: Linear mixing models for guillemots (a) and goshawks (b) and estimation of their feeding preferences.

omnivores, carnivores and piscivores is perfectly maintained at both sites, with no significant differences between them (Figure 1). Therefore, all vertebrates recovered at the Schleswig and Haithabu sites which have been investigated isotopically are lumped together to permit for a better statistically supported database aiming at the reconstruction of palaeofood webs. It should be noted, however, that the site specific ecology and probably the opportunity for some carrion eating species such as dogs and crows to feed from the ample leftovers available at the harbours, were most probably responsible for measured $\delta^{15}\text{N}$ values up to 10‰ and above at least in some individuals, labeling these vertebrates more piscivorous than carnivorous. The omnivorous pigs were nearly exclusively herbivorous according to their $\delta^{15}\text{N}$ values, indicative of being most probably fed by their owners with food less esteemed by the humans (Table 1).

It had been demonstrated for the fish species that a firm assessment of species specific habitat preferences in terms of salinity was possible by a combination of $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{13}\text{C}_{\text{carb}}$ (Grupe *et al.* 2009). Since aquatic resources form the basis for many omnivorous and carnivorous species, it was therefore expected that – based on this larger data set which is now available – not only a clear separation of terrestrial and aquatic mammals, but also of freshwater and marine birds was possible (Figure 2). For the fish, birds, and aquatic mammals, a significant linear relationship between $\delta^{13}\text{C}_{\text{coll}}$ and $\delta^{13}\text{C}_{\text{carb}}$ was detectable ($R^2 = 0.76, 0.58$, and 0.57 , respectively; Figures 3–5, Doppler *et al.*, in press). No such relationship was detectable in terrestrial animals, most probably due to interferences with trophic level effects. While herbivores still exhibited a linear

correlation between both stable carbon isotopic values by an R^2 of 0.41, this value was down to an insignificant 0.19 in carnivores.

Species specific linear mixing models

As pointed out in the methods' section, linear mixing models do not provide exact clues to vertebrate food webs, but instead serve as a tool for assessing the most likely ones. Certainly, modeling vertebrate food webs will be much more precise for species in which rather clear prey/predator relationships exist and they may even fail when applied to very generalistic feeders. Also, they rely several very important assumptions: overall carbon and nitrogen contents must not differ too greatly in the dietary sources, otherwise, concentration differences may obscure the resulting model (Phillips and Koch 2002). Second, and for more or less the same reason, it must be assumed that all dietary components are metabolized with equal efficiency (Del Rio and Wolf 2005). We are aware that it will hardly ever be possible to take all species specific dietary preferences and metabolic peculiarities into account. However, since the majority of animal bone finds in the archaeofaunal assemblage investigated in this study is made up of omnivores and carnivores, which consume a considerable amount of animal food, grossly similar amounts of carbon and nitrogen, and largely similar digestibility of the food is assumed.

Prerequisite for the calculation of a food web is the definition of the isotopic ratios of its end members. These were assessed by 1) lumping together the isotopic ratios of several species sharing the same habitat, e.g. fresh water fish or small terrestrial mammals, and 2) by

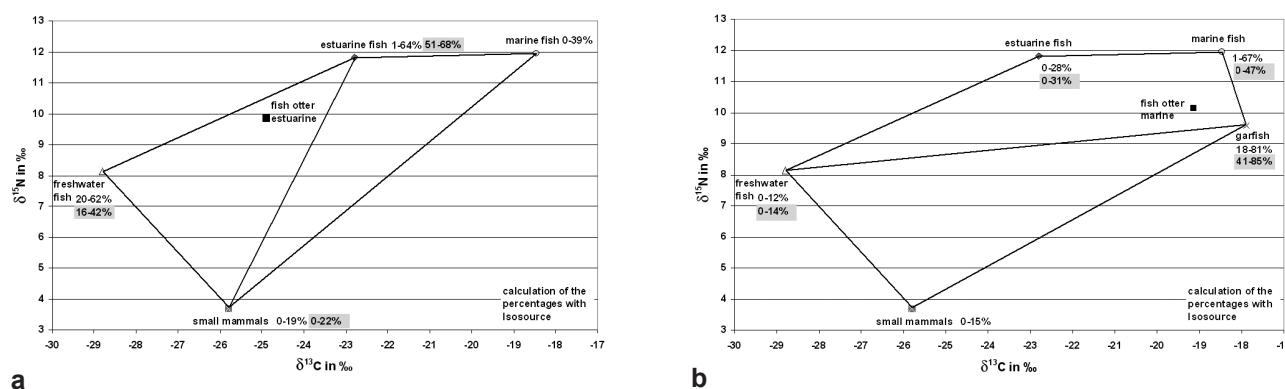


Fig. 7: Linear mixing models permit the ecological allocation of individual fish otter based on their position in the food web. a) estuarine and b) “marine” fish otter.

estimating the isotopic signatures of the edible tissues of prey from the collagen isotopic ratios by application of the known fractionation factors.

For several species, the reconstruction of palaeofoodwebs worked quite well. The guillemot, for example, is a piscivorous bird, and more than 70% of the diet of Viking and medieval period guillemots from the sites consisted of fish from marine and estuarine environments. However, these birds did not totally abstain from eating freshwater fish (Figure 6a). Guillemots largely live on marine fish like herring (Holmström and Berger 2008), but also on pipefish (abundant on the coasts in the temperate climates) and gobies, which frequent brackish waters (Sonntag and Hüppop 2005). The average diet of the terrestrial goshawk most likely consisted of up to 75% small terrestrial mammals, the rest of the diet was made up from fish stemming from all aquatic compartments (Figure 6b). Goshawks usually hunt rabbits, hare, and other bird species (e.g. Rutz 2003), aquatic vertebrates such as amphibians and fish are rarely consumed. While the mixing model suggests that fish should have also contributed to the goshawks’ diet, this aquatic isotopic signature may well be due to predation of waterfowl. Occasionally, a goshawk may successfully hunt waterfowl the size of a goose (e.g. Sellin 1983).

Mixing models are particularly helpful in estimating the ecological allocation of food webs of ecologically flexible carnivores such as the fish otter, which feed both on terrestrial and aquatic mammals, whereby the latter are captured from both fresh and brackish water environments. Fish otter bones analyzed in this study exhibit a considerable variability in terms of stable carbon isotopic ratios (Table 1), indicating that the

individual animal’s home range included ecological niches characterized by different salinity levels. In general, fish otters prefer fresh water habitats, but also occur in salt and brackish water. Today, “coastal” European fish otters are mainly restricted to Scandinavia and Scotland. It can be depicted from figures 7a and b that “estuarine” and more “marine” fish otters obviously subsisted on rather different diets, where small terrestrial mammals contributed to approximately a fifth of the diet of the “estuarine” fish otter, but are negligible in the diet of the more “marine” otter. While fish otters are mainly piscivorous, their diet is supplemented by frogs, birds, small mammals and also invertebrates, whereby seasonal differences in these prey categories may be apparent (Taaström and Jacobsen 1999).

The more generalistic the feeding behaviour of a taxon is, the less meaningful mixing models that result are: Domesticated dogs and cats most likely were fed by their owners to a certain degree, but certainly foraged on their own to a larger extent. The mixing models for these two species (Figures 8a, b) reveal that – as could have been expected due to the location of the sites and ample leftovers accessible at the harbours – the ratio of small terrestrial mammals to fish is estimated to about 3:1, but individual dietary preferences cannot be depicted. In general, the mixing models do resemble the one calculated for the goshawk (Figure 6a). Finally, the wolf shall be considered as an example (among other generalists such as the red fox) where the opportunistic feeding behaviour of the taxon as such, and obviously very different individual dietary preferences or opportunities, lead to an average isotopic signature of the taxon which could have been made up by almost any mixture of the consumed end-members (Figure 9).

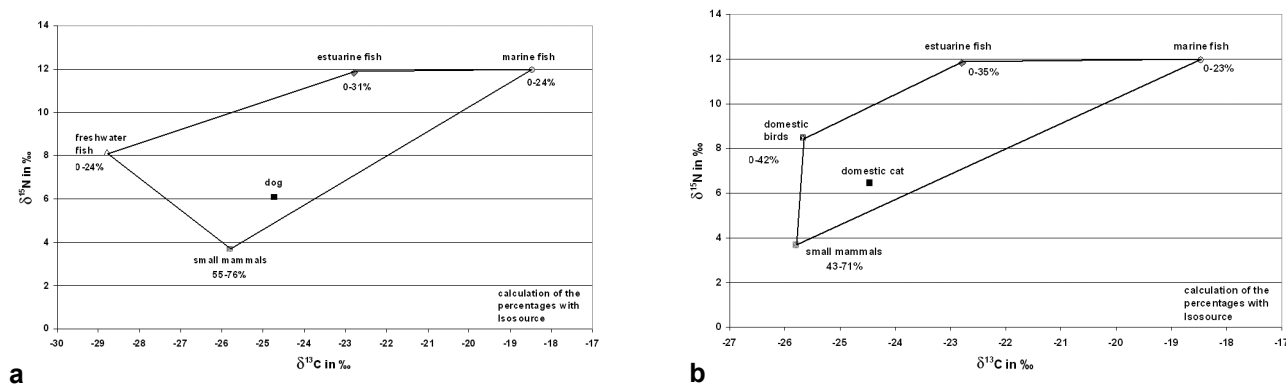


Fig. 8: Less clear assessment of dietary preferences of more generalistic domesticated animals. a) dog, b) cat.

Although wolves are carnivores, they also feed on berries and fruits, and do not shun carrion in times of food shortages. Therefore, average isotopic signatures of all individuals investigated per taxon are still useful for an allocation to a trophic level, but individual dietary preferences are likely to prevent feasible solutions after the application of linear mixing models.

Conclusion

It could be demonstrated that a combination of stable isotopic ratios, especially $\delta^{13}\text{C}_{\text{carb}}$ and $\delta^{13}\text{C}_{\text{coll}}$, permits for a rather firm allocation of vertebrate species to the diverse ecological niches available in the brackish water ecosystem. Linear mixing models are helpful for an assessment of the gross percentages of food derived from these ecological niches. To our knowledge, this study is one of the largest ever carried out on faunal assemblages in terms of the number of analyzed individuals. Not only the definition of trophic levels of the species and their allocation to different ecological departments was achieved, but the amount of differences in individual dietary preferences of nutritionally flexible taxa also became apparent. The application of linear mixing models to archaeofaunal remains proved to be helpful in terms of a more detailed specification of the palaeofood web. At present, this study is augmented by the analysis of $\delta^{34}\text{S}$ from bone collagen for a further refinement of the results obtained so far.

Scientifically, the year 2010 is dedicated to biodiversity research. The example of the ecological distribution and feeding preferences of the fish otter may serve as an example for how archaeobiology may contribute to biodiversity research by tracing the abundance and ecological allocation of vertebrate species at sites which were less prone to human interferences than today. Stable isotope research is indispensable in modern ecology. Applied to archaeofaunal assemblages, valuable results with implications for wildlife conservation will be achieved.

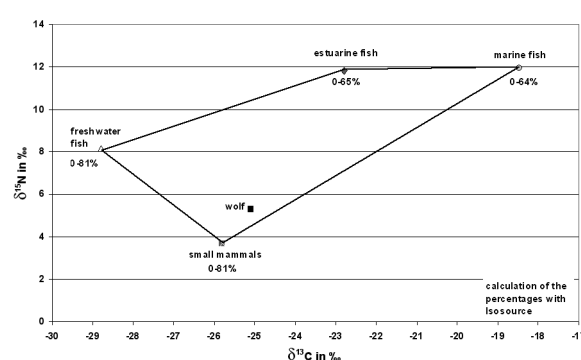


Fig. 9: Failure of linear mixing models for opportunistic and generalistic feeders such as the wolf.

Fishing with the Vikings

SPECIES	NUMBER	$\Delta^{13}\text{C}$ (coll)	$\Delta^{15}\text{N}$	$\Delta^{13}\text{C}$ (carb)	$\Delta^{18}\text{O}$	$\Delta \delta^{13}\text{C}$ (carb-coll)
TERRESTRIAL WILD MAMMALS						
aurochs	2	-21.2	7.3	-11.6	-8.3	9.6
		-21.8 – -20.5	4.0 – 10.5	-12.2 – -10.9	-9.0 – -7.6	9.6 – 9.7
black rat	1			-13.8	-6.8	
brown bear	2	-21.1	5.5	-13.8	-8.4	5.8
				-15.3 – -12.4	-8.7 – -8.1	
european hare	10	-22.3	4.5	-13.2	-8.2	9.3
		-23.4 – -21.2	3.8 – 6.2	-15.8 – -6.7	-10.0 – -6.7	6.3 – 11.9
european rabbit	2	-22.1	9.7	-11.1	-7.6	11
		-22.3 – -21.9	8.5 – 11.0	-11.8 – -10.5	-8.2 – -7.0	10.6 – 11.4
fallow deer	2	-21.7	9.4	-12.2	-8	9.5
		-22.8 – -20.6		-12.9 – -11.5	-9.4 – -6.6	7.7 – 11.3
moose	2	-21.5	4.9	-12.9	-7.2	10.1
				-14.5 – -11.4	-7.5 – -7.0	
pine marten	2	-19.9	8.4	-12.9	-8.2	7
		-19.9 – -19.8	8.2 – 8.6	-14.0 – -11.0	-8.2 – -8.2	5.9 – 8.1
red deer	9	-22.3	5.1	-13.6	-8.1	8.7
		-23.1 – -21.5	3.9 – 5.8	-15.2 – -11.4	-8.9 – -7.4	7.8 – 10.7
red fox	8	-20.5	9.4	-12.9	-6.8	7.6
		-21.9 – -19.3	7.5 – 11.2	-15.1 – -9.6	-8.6 – -4.8	5.6 – 10.8
roe deer	10	-22.2	4.9	-14.1	-8.8	8.1
		-24.0 – -20.1	3.7 – 5.4	-15.8 – -11.9	-10.1 – -7.5	6.8 – 9.5
squirrel	2	-21.3	2.9	-15.1	-11.4	6.6
				-15.6 – -14.6	-14.7 – -8.0	
wild boar	8	-21.2	6.4	-12.9	-7.9	8.1
		-21.7 – -20.6	4.7 – 9.1	-15.8 – -10.5	-9.3 – -6.1	5.6 – 10.9
wolf	2	-20.1	8.3	-11.5	-8	8.6
		-20.4 – -19.9	7.6 – 9.0	-12.0 – -11.1	-8.6 – -7.3	8.4 – 8.8
total	62					
AQUATIC WILD MAMMALS						
atlantic seal	12	-15.6	13.4	-11.4	-9.2	4.5
		-17.2 – -14.5	12.4 – 15.3	-14.5 – -9.2	-11.9 – -7.7	3.4 – 6.5
beaver	2	-22.3	4.6	-15.6	-8.4	6.3
				-16.1 – -15.2	-9.6 – -7.3	
common seal	10	-15.6	13.2	-9	-8.8	6.6
		-20.7 – -13.4	8.6 – 17.0	-11.2 – -6.2	-13.5 – -5.7	3.7 – 9.8
fish otter	4	-18.5	12.9	-13.3	-8.6	5.1
		-20.6 – -14.2	11.2 – 13.8	-16.3 – -6.8	-9.9 – -7.0	3.6 – 7.4
ringed seal	1	-12.5	15.2	-8.1	-8.9	4.4
saddleback seal	3	-16.4	12	-9.6	-9.4	6.8
		-16.7 – -16.0	11.2 – 12.5	-11.1 – -8.4	-12.8 – -7.5	5.5 – 8.3
sperm whale	3	-19.3	8.3	-17.6	-7	4.9
				-23.7 – -14.5	-9.8 – -5.4	
walrus	1	-14	12.3	-8.7	-6.3	5.3
white beaked dolphin	1			-12.6	-5	
total	37					
DOMESTICATED MAMMALS						
cattle	10	-21.7	5.2	-10.5	-7.1	11.1
		-22.5 – -21.3	4.1 – 6.8	-11.2 – -9.9	-7.4 – -6.4	10.4 – 12.0
dog	10	-19.7	9.1	-12.3	-8.2	7.5
		-22.0 – -18.3	6.7 – 10.8	-14.2 – -10.1	-9.9 – -6.6	4.9 – 9.8
domesticated cat	5	-19.5	9.5	-13.6	-8.1	5.8
		-20.4 – -18.2	7.9 – 11.0	-15.1 – -12.2	-10.6 – -6.7	4.3 – 7.5
pig	10	-21.4	5.7	-11	-8.5	10.4
		-21.9 – -20.9	3.2 – 7.4	-11.9 – -10.4	-10.2 – -7.1	9.9 – 10.6
horse	10	-22	5.5	-12.6	-7.8	9.4
		-22.5 – -21.4	4.2 – 6.7	-14.4 – -10.9	-9.2 – -6.9	7.7 – 11.2
sheep	7	-21.6	5.6	-10.5	-6.4	11.1
		-22.3 – -21.0	4.3 – 7.6	-12.1 – -9.5	-8.9 – -5.1	9.8 – 12.1
total	52					

Tab. 1: Stable isotopic ratios (mean and variability) of vertebrate taxa recovered at Haithabu and Schleswig (Schild site). (Continued.)

FISH						
cod	9	-15.9	14.1	-0.7	-7.7	15.8
		-17.4 – -14.7	12 – 17.4	-5.4 – 2.3	-14.2 – -3.8	14.2 – 18.5
common bream	5	-25.6	7.1	-1.9	-12.2	23.6
		-27.7 – -22.4	5.4 – 10.7	-4.5 – -0.6	-15.1 – -9	20.8 – 27.1
garfish	4	-13.8	10.2	1.3	-6.9	15.1
		-14.3 – -13.5	7.6 – 11.5	-1.8 – 3.2	-11.6 – -3.3	12.5 – 17.0
haddock	5	-15.7	13.3	2.6	-10.5	18.1
		-16.1 – -14.9	12.0 – 15.0	0 – 4.1	-15.1 – -4.9	15.9 – 20.2
perch	9	-15.4	11.4	0	-9.4	15.4
		-24.0 – -11.5	9.0 – 15.3	-7.2 – 3.5	-13.1 – -6.7	12.8 – 19.1
pike	10	-22	10.3	-5.4	-10.5	16.6
		-25.7 – -16.3	5.4 – 14.4	-7.5 – -3.2	-13.8 – -6.5	13.0 – 19.9
plaice	1	-14.9	10.7	2.8	-14.7	17.7
sander	5	-21.8	10.4	-6.9	-11.7	14.8
		-22.9 – -20.0	9.7 – 11.5	-7.9 – -6.4	-14.6 – -9.6	13.3 – 16.5
sturgeon	5	-14	13.1	2.2	-7.6	16.3
		-14.9 – -13.5	12.8 – 13.5	-0.9 – 4.8	-12.4 – -5.3	12.8 – 18.5
tench	1	-24.8	6.3	-3.2	-14.5	21.6
total	54					
BIRDS						
black grouse	7	-21.2	4.9	-12	-7.2	9.1
		-21.7 – -20.8	3.5 – 6.3	-13.8 – -11.0	-12.4 – -5.7	7.9 – 10.2
carrion crow	3	-19.9	10.7	-9.5	-8.0	10.4
		-20.9 – -19.2	9.6 – 11.8	-13.7 – -6.5	-12.2 – -5.3	6.0 – 14.4
common crane	7	-21.4	9.9	-10.3	-7.8	11.1
		-25.0 – -19.1	9.0 – 10.5	-14.1 – -6.1	-12.5 – -5.2	7.1 – 18.9
common eider	5	-16.8	8.2	-8.7	-9.2	8.1
		-17.1 – -16.5	7.2 – 9.0	-12.5 – -5.9	-12.0 – -8.0	4.1 – 10.9
common goldeneye	14	-21.4	8.4	-13.0	-9.2	8.5
		-26.7 – -18.3	7.1 – 10.8	-16.5 – -9.0	-11.3 – -7.3	6.0 – 10.1
common merganser	9	-17.8	12.1	-9.6	-8.7	8.2
		-25.5 – -12.7	7.1 – 15.2	-12.9 – -6.4	-10.4 – -6.8	5.4 – 12.6
common raven	9	-19.6	11.7	-10.5	-8.1	9.1
		-21.7 – -16.1	9.7 – 13.7	-13.3 – -5.3	-11.6 – -5.6	6.9 – 10.8
common tern	4			-11.4	-10.2	
				-16.0 – -8.9	-15.9 – -6.5	
cormorant	10	-14.1	11.6	-7.8	-7.7	6.3
		-17.5 – -10.3	10.4 – 12.4	-10.6 – -3.4	-11.4 – -5.3	4.3 – 8.4
domestic chicken	9	-20.9	8.7	-13.1	-8.3	7.8
		-21.7 – -20.2	7.1 – 11.0	-14.5 – -11.1	-11.2 – -6.6	5.9 – 10.1
domestic goose	10	-22.5	8.3	-14.0	-7.5	8.5
		-23.2 – -21.9	6.5 – 10.3	-15.9 – -11.8	-10.4 – -6.0	7.2 – 10.2
dunlin	2			-10.9	-12.3	
				-11.4 – -10.3	-12.6 – -11.9	
eurasian jackdaw	4			-10.6	-6.4	
				-13.3 – -5.0	-8.2 – -3.8	
european widgeon	2	-23.0	6.8	-14.5	-12.7	8.5
		-23.0 – -23.0	5.2 – 8.4	-15.5 – -13.5	-13.6 – -11.9	7.5 – 9.5
goshawk	15	-20.1	9.1	-11.4	-6.7	9.2
		-21.9 – -19.1	6.5 – 11.9	-15.2 – -3.2	-8.9 – -4.5	6.1 – 16.9
greater scaup	6	-20.5	8.1	-12.4	-10.8	8.1
		-25.4 – -14.8	6.0 – 9.6	-15.4 – -7.9	-16.4 – -7.4	5.3 – 10.9
guillemot	10	-16.5	14.4	-8.9	-5.8	7.8
		-17.5 – -15.5	12.7 – 16.4	-11.7 – -4.9	-8.7 – -4.0	4.8 – 11.3
mallard	19	-21.2	9.5	-12.4	-8.5	
		-25.5 – -12.5	4.9 – 15.5	-16.4 – -6.6	-11.7 – -6.7	5.9 – 12.9
mute swan	5	-13.6	7.3	-5.1	-8.1	10.1
		-20.9 – -10.6	4.6 – 12.1	-11.6 – -1.2	-11.4 – -5.4	6.3 – 19.7
peregrine falcon	4	-19.7	9.9	-9.2	-8.2	10.5
		-20.5 – -19.0	8.1 – 11.0	-10.6 – -8.4	-10.9 – -6.2	9.7 – 11.5
pintail duck	6	-18.8	8.5	-12.0	-9.4	6.8
		-24.3 – -12.5	5.8 – 10.4	-18.1 – -6.7	-12.5 – -6.7	5.2 – 9.4
red breasted merganser	5	-16.4	10.0	-9.5	-9.8	6.9
		-20.7 – -12.6	6.4 – 12.7	-11.9 – -7.6	-12.5 – -7.3	4.8 – 9.3
shelduck	3	-19.0	10.1	-11.9	-10.6	7.1
		-20.8 – -17.0	7.6 – 11.7	-13.2 – -9.3	-13.6 – -6.4	6.1 – 7.7
smew	5	-18.3	9.1	-13.0	-10.7	7.3
				-15.3 – -11.0	-11.6 – -10.0	
tufted duck	13	-22.2	8.1	-13.1	-11.1	8.6
		-30.5 – -10.8	7.0 – 9.8	-19.4 – -3.2	-13.1 – -8.3	7.0 – 11.7
white fronted goose	2	-21.8	7.2	-13.0	-9.2	8.8
		-22.6 – -21.0	5.5 – 8.9	-13.4 – -12.6	-11.7 – -6.8	8.4 – 9.2
white tailed eagle	20	-17.5	11.9	-9.5	-8.2	8.5
		-24.9 – -12.1	9.9 – 14.1	-13.9 – -2.3	-11.7 – -5.3	5.9 – 11.6
whooper swan	19	-19.3	6.5	-9.6	-10.3	9.7
		-23.6 – -11.8	3.0 – 8.7	-13.9 – -4.7	-13.3 – -6.8	7.2 – 12.8
total	227					

Tab. 1: Stable isotopic ratios (mean and variability) of vertebrate taxa recovered at Haithabu and Schleswig (Schild site).

ALL ANIMALS	d ¹³ C	%C	d ¹⁵ N	%N	C/N _{molar}
mean Haithabu	-20.2	38.6	7.4	14.6	3.1
mean Schleswig	-20.4	39.2	8.5	14.3	3.5
EXCL. BIRDS					
mean Haithabu	-20.8		7.2		3.1
mean Schleswig	-21.3		7.2		3.2

Tab. 2: Mean collagen stable isotopic ratios of all specimens analysed, and collagen integrity data.

Acknowledgements

Special thanks are to the editors of this volume for inviting me to contribute. It was a pleasure for me (G.G.) to dedicate this manuscript to Winfried Henke. Thank you, Winfried, for your helpful scientific advice, and for the many friendly conversations!

This study was financially supported by the Deutsche Forschungsgemeinschaft (Gr 959/16–1,2). The text was edited by Dr. George McGlynn.

References

Ambrose SH 1993. *Isotopic analysis of paleodiets: Methodological and interpretive considerations*. In: Sandford MK (ed). *Investigation of ancient human tissue. Chemical analyses in anthropology*. Gordon & Breach. Langhorne, Pennsylvania, 59–127.

Ambrose SH, Butler BM, Hanson DB, Hunter-Anderson RL, Krueger HL 1997. *Stable isotopic analysis of human diet in the Marianas archipelago, Western Pacific*. American Journal of Physical Anthropology 104: 343–361.

Björck S 1995. *A Review of the History of the Baltic Sea, 13.0–8.0 ka BP*. Quaternary International 27: 19–40.

Bryant J, Koch P, Froelich P, Showers W, Genna B 1996. *Oxygen isotope partitioning between phosphate and carbonate in mammalian apatite*. Geochimica et Cosmochimica Acta 60: 5154–5148.

Clementz MT, Koch PL 2001. *Differentiating aquatic mammal habitat and foraging ecology with stable isotopes in tooth enamel*. Oecologia 129: 461–472.

Coltrain JB, Hayes MG, O’Rourke DH 2004a. *Sealing, whaling and caribou: the skeletal isotope chemistry of Eastern Arctic foragers*. Journal of Archaeological Science 31: 39–57.

Coltrain JB, Harris JM, Cerlin TE, Ehleringer JR, Dearing M-D, Ward J, Allen J 2004b. *Rancho La Brea stable isotope biogeochemistry and its implications for the palaeoecology of late Pleistocene, coastal southern California*. Palaeogeography, Palaeoclimatology, Palaeoecology 205: 199–219

Craig OE, Ross R, Andersen SH, Milner N, Bailey GN 2006. *Focus: sulphur isotope variation in archaeological marine fauna from northern Europe*. Journal of Archaeological Science 33: 1642–1646.

Del Rio CM, Wolf BO 2005. *Mass-Balance Models for Animal Isotopic Ecology*. In: Starck JM, Wang T (eds.). *Physiological and Ecological Adaptations to Feeding in Vertebrates*. Science Publishers. Enfield, New Hampshire, 141–174.

DeNiro MJ 1985. *Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction*. Nature 317: 806–809.

Doppler S, Vohberger M, von Carnap-Bornheim C, Heinrich D, Peters J, Grupe G, in press. *Biodiversity of archaeological fauna in the estuarine palaeoecosystem of the Schlei fjord, Northern Germany: Isotopic evidence*. Documenta Archaeobiologiae 8, 2010.

Grupe G, Heinrich D, Peters J 2009. *A brackish water aquatic foodweb: trophic levels and salinity gradients in the Schlei fjord, Northern Germany, in Viking and medieval times*. Journal of Archaeological Science 36: 2125–2144.

Grupe G, Peters J, Schmidt K, Mayr C in press. *Human/animal relationships at the Neolithic Transition in the Upper Euphrates Basin*. Proceedings of the 7th ICAANE, London 2010.

Harbeck M, Grupe G 2009. *Experimental chemical degradation compared to natural diagenetic alteration of collagen: implications for collagen quality indicators for stable isotope analysis*. Archaeological and Anthropological Sciences 1: 43–57.

Hobson KA 1999. *Tracing origins and migration of wildlife using stable isotopes: a review*. Oecologia 120: 314–326.

Holmström KE, Berger U 2008. *Tissue distribution of perfluorinated surfactants in common guillemot (Uria aalge) from the Baltic Sea*. Environmental Science and Technology 42: 5879–5884.

Iacumin P, Bocherens H, Mariotti A, Longinelli A 1996. *Oxygen isotope analysis of co-existing carbonate and phosphate in biogenic apatite: a way to monitor diagenetic alteration of bone phosphate?* Earth and Planetary Science Letters 142: 1–6.

Jacobson BS, Smith BN, Jacobson AV 1972. *Alloxan induced change from carbohydrate to lipid oxidation in rats as determined by prevalence of C-13 in expired carbon dioxide*. Biochemical and Biophysical Research Communications 47: 398–402.

Jankuhn H 1986. *Haithabu. Ein Handelsplatz der Wikingerzeit*. Karl Wachholtz. Neumünster, 8. ed.

Kennett DJ 1996. *Oxygen isotopic analysis of archaeological shells to detect seasonal use of wetlands on Southern Pacific coast of Mexico*. Journal of Archaeological Science 23: 689–704.

Koch PL, Tuross N, Fogel ML 1996. *The effects of sample treatment and diagenesis on the isotopic integrity of carbonate in biogenic hydroxylapatite*. Journal of Archaeological Science 24: 417–429.

- Kohn MJ, Cerling TE 2002. *Stable isotope compositions of biological apatite*. In: Kohn MJ, Rakovan J, Hughes JM (eds). *Phosphates. Geochemical, geobiological, and materials importance*. Reviews in Mineralogy and Geochemistry 48, Washington: Mineralogical Society of America, 455–488.
- Krueger HW 1991. *Exchange of Carbon with Biological Apatite*. Journal of Archaeological Science 18: 355–361.
- Lanting JN, Aerts-Bijma AT, van der Plicht J 2001. *Dating cremated bones*. Radiocarbon 43: 249–254.
- Lee-Thorp JA, Sealy JC, van der Merwe NJ 1989. *Stable carbon isotope ratio differences between bone collagen and bone apatite, and their relationship to diet*. Journal of Archaeological Science 16: 585–599.
- Minagawa M, Wada E 1984. *Stepwise enrichment of ^{15}N along food chains: further evidence and the relation between $\delta^{15}\text{N}$ and animal age*. Geochimica et Cosmochimica Acta 48: 1135–1140.
- Mook WG 1971. *Paleotemperatures and chlorinities from stable carbon and oxygen isotopes in shell carbonate*. Palaeogeography, Palaeoclimatology, Palaeoecology 9: 245–263.
- Newsome SD, Phillips DL, Culleton BJ, Guilderson TP, Koch PL 2004. *Dietary reconstruction of an early to middle Holocene human population from the central California coast: insights from advanced stable isotope mixing models*. Journal of Archaeological Science 31: 1101–1115.
- Olsen J, Heinemeier J, Bennike P, Krause C, Hornstrup KM, Thrane H 2008. *Characterisation and blind testing of radiocarbon dating of cremated bone*. Journal of Archaeological Science 35: 791–800.
- Phillips DK, Gregg JW 2003. *Source partitioning using stable isotopes: coping with too many sources*. Oecologia 136: 261–269.
- Phillips DL, Koch PL 2002. *Incorporating concentration dependence in stable isotope mixing models*. Oecologia 130: 114–125.
- Rheinheimer G (ed) 1996. *Meereskunde der Ostsee*. Springer. Berlin, 2. Auflage.
- Rutz C 2003. *Assessing the breeding season diet of goshawks *Accipiter gentilis*: biases of plucking analysis quantified by means of continuous radio-monitoring*. Journal of Zoology, London 259: 209–217.
- Schoeninger MJ, DeNiro MJ 1984. *Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals*. Geochimica et Cosmochimica Acta 48: 625–639.
- Sellin D 1983. *Gänse der Gattungen *Anser* und *Branta* als Beute des Habichts, *Accipiter gentilis**. Beiträge zur Vogelkunde 29: 34–38.
- Simek R 2002. *Die Wikinger*. Beck. München, 3rd ed.
- Sonntag N, Hüppop O 2005. *Snacks from the depth: Summer and winter diet of common guillemots *Uria aalge* around the island of Helgoland*. Atlantic Seabirds 7: 1–48.
- Taastrøm H-M, Jacobsen L 1999. *The diet of otters (*Lutra lutra* L.) in Danish freshwater habitats: comparison of prey fish populations*. Journal of Zoology 248: 1–13.
- Van der Zanden & Rasmussen JB 1999. *Primary consumer $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and the trophic position of aquatic consumers*. Ecology 80: 1395–1404.
- Vogel V 1983. *Archäologische Stadtkernforschung in Schleswig 1969–1982*. In: Caselitz P, Unverhau D, Vogel V (eds). *Ausgrabungen in Schleswig, Berichte und Studien 1*. Karl Wachholtz. Neumünster, 9–54.
- Wang Y, Cerling TE 1994. *A model of fossil tooth and bone diagenesis: Implications for paleodiet reconstruction from stable isotopes*. Palaeogeography, Palaeoclimatology, Palaeoecology 107: 281–289.
- Winkler FJ, Schmidt H-L 1980. *Einsatzmöglichkeiten der ^{13}C -Isotopen-Massenspektrometrie in der Lebensmitteluntersuchung*. Zeitschrift für Lebensmitteluntersuchung und -forschung 171: 85–94.

Address:

Gisela Grupe
 Dept. I, Fakultät für Biologie der LMU, Biozentrum
 Grosshaderner Str. 2
 82152 Martinsried
 Germany
 Tel.: +49 (0) 892 180 074 320
 Fax: +49 (0) 892 180 743 31
 E-mail: g.grupe@lrz.uni-muenchen.de

**Kann ein modernes Gesundheitsmanagement von
der physischen Anthropologie profitieren?
Das anthropologische Konzept der Variabilität zur Hermeneutik
von Über-, Unter- und Fehlversorgung in der gesundheitlichen Versorgung**
**[Can modern health management benefit from physical anthropology?
The anthropological concept of variability with regard to
the hermeneutics of too much, too little or wrong treatment in health care]**

HARDY MÜLLER

Wissenschaftliches Institut für Nutzen und Effizienz im Gesundheitswesen (WINEG), Hamburg, Deutschland

Zusammenfassung

Die Anthropologie wird als Wissenschaft von der biologischen Variabilität des Menschen in Raum und Zeit definiert. Ihre Zielsetzung und Erfahrung begründen eine anthropologische Exzellenz beim Umgang mit Variabilität. Der Beitrag geht der Frage nach, ob diese Kompetenz für das Management und die Versorgungsforschung im Gesundheitswesen hilfreich sein kann. Die Effekte medizinischer Versorgung werden oft auf einzelne Interventionen zurückgeführt (wie z.B. die Medikalisierung oder eine operative Prozedur). Die anthropologische Analyse belegt dagegen starke Heterogenität in (Sub-)Populationen. Am Beispiel regionaler Mortalitätsanalysen werden das Ausmaß und die Bedeutung dieser Disparitäten illustriert. Demnach ist bei der Einschätzung des medizinischen Outcomes die Berücksichtigung dieser *a priori* Variabilität in Untersuchungspopulationen zu fordern. Auch bei der Bewertung medizinischer Outcomes selbst sind Variabilitätsanalysen unverzichtbar – dennoch werden hierfür notwendige Daten im Gesundheitswesen bislang nicht immer erhoben oder erschlossen. Am Beispiel der Haltbarkeit von Knieendoprothesen wird das Spektrum der Behandlungsergebnisse illustriert. Die Ergebnisse unterstreichen die Bedeutung der längst überfälligen Einrichtung von Behandlungsregistern in Deutschland. Schließlich können Variabilitätsanalysen zur Identifizierung von Problemlagen der gesundheitlichen Versorgung dienen. Vorgestellt wird eine Auswertung von Folgen der in Deutschland bevölkerungsweit durchgeführten Früherkennungsuntersuchung auf Zervixkarzinom. Erstmals wird die Häufigkeit und regionalen Varianz von Konisationen dargestellt. Die Beispiele zeigen, dass Variabilitätsanalysen wertvolle Beiträge zur Über-, Unter- und Fehlversorgung in der medizinischen Versorgung leisten. Darüber hinaus ist die Berücksichtigung des Phänomens Variabilität von prinzipieller Bedeutung für die Analyse und Steuerung des Gesundheitswesens. Die Erfahrungen im Umgang mit Variabilität in der Anthropologie sind hilfreich zur Hermeneutik der gesundheitlichen Versorgung in einem modernen Gesundheitswesen und stimulierend bei der anstehenden theoretischen Fundierung der Versorgungsforschung.

Schlüsselwörter: Anthropologie; Variabilität; Über-, Unter-, Fehlversorgung; Versorgungsforschung; Zervix-Screening

Summary

Anthropology is defined as the science of the biological variability of man in space and time. Its target and experience is the basis of an anthropological excellence handling variability. The essay discusses the question whether this competence can be useful for both the management and the health care research in the health care sector. The effects of medical supply are often ascribed to individual interventions (such as medicalization or an operative procedure). Anthropological analysis proves strong heterogeneity in (sub-)populations. Regional mortality illustrates the extent and importance of these disparities. We therefore have to claim this *a priori* variability in trial populations to be taken into consideration when assessing the medical outcome. Variability analyses are essential when evaluating medical outcomes. The data necessary are, however, still not collected or extracted from the health care sector. The durability of knee endoprotheses illustrates the spectrum of treatment results. The results emphasize that it is long overdue to establish treatment registers in Germany. Variability analyses can be used to identify problems in health care. An early detection of cervical carcinoma has been carried out among the German population. The results of the consequences are presented. For the first time the frequency and regional variance of conization is described. The examples show that variability analyses offer valuable contributions to overuse, underuse, and misuse (subsumed under health care utilization) in health care. It is of basic importance to consider the phenomenon variability for the analysis and control and management of the health care sector. The experience gained when handling variability in anthropology is useful for hermeneutics of health care in a modern health care sector as well as stimulating for the coming theoretical foundation of health care research.

Key words: anthropology; health care sector; health care utilization; health care research; cervical screening

Zum Wesen der Anthropologie

Die Anthropologie ist als Wissenschaft von der biologischen Variabilität des Menschen in Raum und Zeit definiert (Henke 2007). Die Variation des lokalen, letztlich auch des ubiquitär Humanen in phylo- wie ontogenetischer Perspektive steht im Zentrum anthropologischer Analyse. Erkenntnis-Ziel sind die real-historischen Zusammenhänge bei der Entwicklung des Menschen in lokaler, multi-regionaler und globaler Perspektive.

Zum Wesen der Anthropologie als Wissenschaft zählt die Variabilitätsanalyse. Der Umgang mit Vielfalt und Unsicherheit sowie die Systematisierung und Taxonomie von begründeter Wahrscheinlichkeit sind konstitutiv für die physische Anthropologie und daher in ihrem klassischen Methodeninventar prominent ausgebildet.

Dieser Beitrag geht der Frage nach, ob ein Transfer dieser „anthropologischen Exzellenz bei der Behandlung von Variabilität“ zur Bewältigung von Management-Aufgaben in einem modernen Gesundheitsmanagement hilfreich sein kann.

Im Folgenden wird die These vertreten, dass der Transfer und die Berücksichtigung speziell der anthropologischen Exzellenz im Umgang mit Variabilität in Bereichen des Gesundheitsmanagement und der Versorgungsforschung für alle Seiten profitabel ist, heute selten praktiziert wird und ein intensiverer Austausch lohnenswert ist. Die Erfahrungen im Umgang mit Variabilität in der Anthropologie sind wertvoll zur Hermeneutik der gesundheitlichen Versorgung in einem modernen Gesundheitswesen und elementar bei der anstehenden theoretischen Fundierung der Versorgungsforschung (Raspe *et al.* 2010, IMVR, WINEG 2010, Raspe 2011).

Das anthropologische Konzept der Variabilität

Zum Kern der Anthropologie zählen die Lehren von Charles Darwin. Seine Evolutionstheorie ist eine der prägendsten Theorien für das Fach (wiewohl für die Menschheit insgesamt). Am weitesten verbreitet ist die Idee des „*survival of the fittest*“, das oft als das Überleben des Stärkeren (miss-)verstanden wird. Gemeint ist der Fortbestand jener Entitäten, die am besten an ihre Umwelt angepasst sind und die größten Anpassungspotentiale haben. Gibt es in einer Population unterschiedliche Ausprägungen, steigt also die Variabilität von Merkmalen, so erhöht sich auch die Anpassungsfähigkeit an sich verändernde Umwelten. Die Variabilität ist Voraussetzung für Evolution.

Variabilität steht im Zentrum des anthropologischen Denkens. Abweichungen oder Varianz biologischer Merkmale werden nicht als Devianz einer Norm interpretiert, sondern als wertvolle Entwicklungschance geschätzt.

Damit sind zwei Unterschiede zwischen den verwandten Fächern Medizin und Anthropologie benannt: Die Medizin als Wissenschaft beschäftigt sich grundsätzlich mit dem Pathologischen, die Anthropologie prinzipiell mit dem „Normalen“. Erstere betrachtet Variabilität gemeinhin als dysfunktional und eine Gefahr, letztere primär funktional und als evolutionäre Tatsache und evolutionäres Potential. Durch diese fachliche Prägung wird auch der Umgang mit Sicherheit und Unsicherheit bestimmt. Medizin versucht Unsicherheit zu meiden. Hier wird die These vertreten, dass der Umgang mit Wahrscheinlichkeiten in der Medizin vergleichsweise wenig ausgeprägt und entwickelt ist.

An der unterschiedlichen Konnotation und normativen Bewertung des Begriffes Variabilität werden verschiedene Hermeneutiken in Anthropologie und Medizin deutlich. Die Theoriebildung, das Verstehen und Interpretieren von Fakten, die Begründung von Handlungen sind abhängig und bestimmt von diesen Denkhorizonten.

Das moderne Management im Gesundheitswesen, national wie international, ist stark von der medizinischen Lehre geprägt. Eine Erweiterung des Theoriekonzeptes, zumindest eine Reflektion des Umganges mit Variabilität, würde neue wertvolle und unverzichtbare Impulse zur Optimierung der gesundheitlichen Versorgung bieten.

„*Wrestling with Variation*“: eine Disziplin zur Hermeneutik der gesundheitlichen Versorgung

Tradition und Motive

In dem unter der Überschrift „*Wrestling with variation*“ publizierten programmatischen Interview wurde Jack Wennberg (Dartmouth) zugleich als der „Christopher Columbus und der Johnny Appelseed der Analyse klinisch relevanter Variabilität“ bezeichnet (Mullan 2004): Wennberg entdeckte das Thema medizinische Behandlungs-Variabilität und machte es in der gesundheitswissenschaftlichen und -politischen Arena bekannt.

Der Begriff Variation der medizinischen Versorgung war vor Wennberg in der wissenschaftlichen Literatur nicht existent. Die Veröffentlichung dieser ersten Arbeit

von Wennberg wurde von medizinischen Journalen abgelehnt, da die Analyse medizinischer Variation keine veröffentlichungswerte Nachricht war. Es herrschte die Idee einer gleichmäßigen guten Versorgung. Variationen der Behandlungsarten und -qualitäten konnten und durften nicht sein. Das Wissenschafts-Journal *Science* interessierte sich schließlich für das Thema (Wennberg und Gittelsohn 1973).

Seitdem hat die Analyse der Behandlungsvariationen in den USA verschiedene Konjunkturen erlebt. Im Vergleich zu Deutschland besitzt sie eine vergleichsweise lange Tradition. Berühmt wurde der „Dartmouth Atlas“, mit dem für alle Nutzer einfach erreichbar eine Menge von Analysen zur Verfügung gestellt wird (www.dartmouthatlas.org). In Deutschland ist eine erste Konjunktur der Variabilitätsanalysen medizinischer Behandlungsvariationen abzusehen. Derzeit existieren verschiedene Initiativen zur kartographischen Darstellung der gesundheitlichen Versorgung (z.B. die Kassenärztliche Bundesvereinigung mit dem sogenannten „Versorgungsatlas“ oder die Bertelsmann-Stiftung mit einem „Versorgungsreport Gesundheit“).

Die Analyse der Variabilität der gesundheitlichen Versorgung dient dazu, ungleiche Strukturen und Effekte (Outcomes) deutlich zu machen, um Interventionsfelder für Politik und Gesundheitsmanagement aufzuzeigen.

Die Varianz der Versorgung lässt Rückschlüsse auf Unter-, Über- und Fehlversorgungen zu. Ein Manko der heutigen Medikationen, oder allgemeiner der medizinischen Verfahren, ist oftmals der fehlende Nutzenbeleg (Müller 2007). Nach einer Zulassung von Verfahren oder Medikamenten kann von einer Wirksamkeit ausgegangen werden. Diese besagt aber noch nichts über den für den Patienten zu erwartenden Effekt. Der Nutzen ist damit noch nicht belegt, aus einer Wirksamkeit lässt sich kein Nutzen unmittelbar ableiten.

Die Begriffe der Über-, Unter- und Fehlversorgung sind in einem Gutachten des Sachverständigenrates für die gesundheitliche Versorgung aus dem Jahr 2000 breit in die deutsche Diskussion eingeführt worden (SVR-Gesundheit 2001, 19f). Nach deren Definition liegt eine bedarfsgerechte Versorgung vor, wenn die erbrachten Leistungen für den Patienten nützlich sind, die Leistungen indiziert sind und fachgerecht erbracht werden.

Als Überversorgung gelten Leistungen, die über die bedarfsgerechte Versorgung hinaus erbracht werden (medizinische Überversorgung) sowie Leistungen, die unwirtschaftlich erbracht werden (ökonomische Überversorgung). Werden an sich bedarfsgerechte Leistun-

gen, die in wirtschaftlicher Form zur Verfügung stehen, nicht erbracht bzw. nicht in erreichbarer Form zur Verfügung gestellt, spricht man von Unterversorgung.

Als Fehlversorgung gilt ein Angebot, das nicht dem gebotenen Stand des Wissens und des gebotenen fachlichen Könnens entspricht. Den Patienten entsteht dadurch ein Schaden.

Fehlversorgung lässt sich am Beispiel der Behandlungsfehler illustrieren. In Deutschland infizieren sich im Jahr 2006 schätzungsweise 400.000–600.000 Menschen im Krankenhaus. Die Zahl der Todesfälle durch Krankenhausinfektionen schätzt das RKI auf ungefähr 15.000 jährlich. Ein Drittel davon gilt als durch Hygienemaßnahmen vermeidbar (Gastmeier und Geffers 2008, zur systematischen Schätzung zu Fehlern in der Medizin s. Aktionsbündnis Patientensicherheit 2006).

In der Summe produzieren Über-, Unter- und Fehlversorgungen nicht intendierte, unerwünschte Folgen medizinischer Behandlung. Sie werden damit zwangsläufig auch zum Thema des Gesundheitsmanagement in Krankenkassen, da es zur Verantwortung von Krankenkassen und Leistungserbringern gehört, die von den Versicherten eingezogenen Beiträge wirtschaftlich und sachgerecht einzusetzen (SGB V §§ 2, 12, 70).

Die zukünftige Finanzierung der gesetzlichen Krankenversicherung wird in der Öffentlichkeit ausschließlich mit zwei Begründungen in Frage gestellt: Höhere Finanzbedarfe sind zum einen wegen der demographischen Entwicklung (bewertend oft als *Über*-Alterung beschrieben) notwendig, zum anderen auf Grund der medizin-technischen Entwicklung. Beide Motive werden zur Erhöhung der Beitragszahlungen in der gesetzlichen Krankenversicherung (GKV) immer wieder bemüht. Nicht erwähnt wird ein Hauptgrund der Finanzierungsproblematik: Der hohe Anteil von nicht effektiven, ineffizienten und oft sogar schädlichen Verfahren im Angebotsspektrum der Medizin ist ein Hauptkostentreiber und maßgeblicher Grund für die Finanzierungsproblematik in der GKV.

Die Analyse der Variabilität stellt sich insofern der zentralen Herausforderung des Gesundheitssystems, da mit dieser Methode Ineffizienzen entdeckt und Gestaltungsmöglichkeiten bei der gesundheitlichen Versorgung beschrieben werden können. Leider müssen wir davon ausgehen, dass Verschwendungen und Ineffizienzen im Gesundheitswesen immer noch eine starke Finanzierungsquelle darstellen. Mit Variabilitätsanalysen lassen sich diese Quellen erschließen.

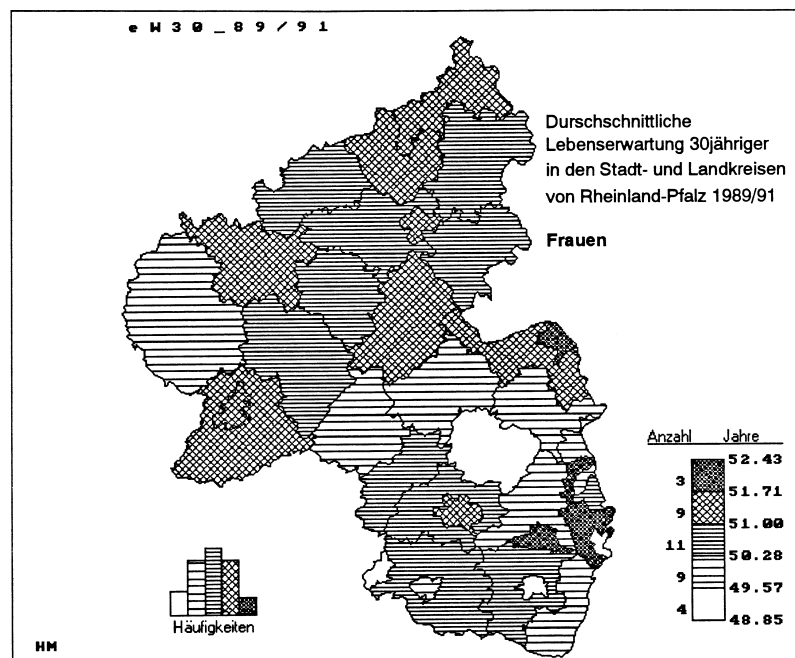


Abb. 1: Die durchschnittliche weitere Lebenserwartung 30jähriger Frauen in den Stadt- und Landkreisen von Rheinland-Pfalz 1989/1991 (aus Müller 1993, 48).

Das Ausmaß der Ungleichheit von Beanspruchungen und Belastungen in der Bevölkerung

Die Politik verfolgt als eine hochrangige Aufgabe die Schaffung gleichmäßiger Lebensbedingungen. Infrastruktur- und Bildungspolitik, Steuerrecht, nicht zuletzt die Gesundheitspolitik – alle Politikfelder haben für gerechte und ausgeglichene Lebensbedingungen zu sorgen. Disparitäten sollen vermieden werden.

Ein anerkannter Indikator für die Effekte unterschiedlicher Lebensbedingungen sind variierende Lebenserwartungen. Eine geringe Variabilität in der regionalen Lebenserwartung lässt sich als Surrogat-Parameter für gleichmäßige Lebensbedingungen verstehen. Die Mortalität gehört zu den wesentlichen patientenrelevanten Outcome-Parametern bei der Bewertung medizinischer Verfahren. Dazu zählen des Weiteren die Morbidität (Beschwerden und Komplikationen) und die gesundheitsbezogene Lebensqualität. Ergänzend können der interventions- und erkrankungsbezogene Aufwand und die Zufriedenheit der Patienten mit der Behandlung berücksichtigt werden (IQWiG 2008, 32, G-BA 2010).

In einer Analyse regionaler Sterblichkeitsunterschiede und ihrer sozialen Determinanten am Institut für Anthropologie der Uni Mainz wurde für die Landkreise

in Rheinland Pfalz die Lebenserwartung und die Entwicklung zwischen den Regionen im Zeitverlauf berechnet (Müller 1993, Henke und Müller 2002). Mit Modellen zur multiplen Regression wurde ein hoher Anteil der Varianz durch soziale Faktoren erklärt.

Nach der politischen normativen Zielsetzung sollten Unterschiede in der Lebenserwartung gering ausfallen und sich im Laufe der Zeit nivellieren.

Die Auswertungen zeigen (erneut) nach wie vor große Unterschiede in der Lebenserwartung (Übersicht dazu z.B. Helmert *et al.* 2000). Die weitere Lebenserwartung von Frauen im Alter von 30 Jahren in den Stadt- und Landkreisen von Rheinland-Pfalz gibt Abbildung 1 wieder (Müller 1993, 48). Die Unterschiede zwischen den Landkreisen betrugen bis zu 3,6 Jahre. In der Stadt Speyer lebt eine 30jährige Frau durchschnittlich weitere 48,9 Jahre, in der Kreisfreien Stadt Neustadt dagegen 52,4 Jahre.

Betrachtet man die Entwicklung der Unterschiede in der Lebenserwartung zu verschiedenen Zeitpunkten, so lässt sich keine Nivellierung feststellen. Im Gegenteil. Die in der Lebenserwartung benachteiligten Regionen weisen eine unterdurchschnittliche Steigerungsrate im beobachteten Zeitraum von 1983 bis 1991 auf. Die Regionen gleichen sich nicht an, vielmehr bleiben die Unterschiede bestehen oder werden sogar stärker.

REGRESSOR	Standardisierte Regressionskoeffizienten Regressand: Männliche Lebenserwartung		
	bei der Geburt	im Alter von 30....	... von 70 Jahren
Sozialhilfebedürftigkeit	-0,79***	-0,68***	-0,03
Anteil mit niedrigem Bildungsabschluss	-0,73***	-0,61***	-0,79***
Beschäftigte in Handel und Verkehr	+0,26	+0,25*	+0,15
Wohnungen ohne Sammelheizung	-0,22	-0,27*	+0,05
Ferienwohnungs-Dichte	+0,12	+0,33*	+0,25
vH der erklärten Varianz	73	76	58
Signifikanzniveau: * p<0,05; **p<0,01; ***p<0,001 (zweiseitiger Test)			

Tab. 1: Schätzung der Lebenserwartung 1989/91 in den Stadt- und Landkreisen von Rheinland-Pfalz anhand von sozialen Indikatoren in einer Region. Ergebnisse einer linearen multiplen Regression der männlichen Lebenserwartung (Müller 1993, 92).

Die Unterschiede zwischen den Landkreisen sind zudem im Zeitverlauf stabil. Die Rangkorrelation der regionalen Lebenserwartung zu den Zeitpunkten 1979/81, 1983/85, 1986/88 und 1989/91 ist signifikant. Die regionalen Muster bleiben konstant.

Zur Erklärung regionaler Mortalitätsunterschiede können soziale Faktoren genutzt werden. Die Abhängigkeit des Gesundheitszustandes und letztlich auch der Lebenserwartung von sozial bestimmten Lebensbedingungen der Menschen ist evident. In einem Modell zur Schätzung der regionalen Lebenserwartung lässt sich die Varianz der Lebenserwartung zu drei Viertel anhand von nur fünf Sozial-Indikatoren bestimmen (Tabelle 1). Die gesetzliche Krankenversicherung ist auch zur „Verminderung sozial bedingter Ungleichheit von Gesundheitschancen“ (§ 20 SGB V) verpflichtet. Das Modell zeigt einmal mehr die überragende Bedeutung des Bildungsstandes.

Auch jüngste Studien zur Variabilität der Lebensverhältnisse und der Einfluss auf die Gesundheit belegen weiterhin die Bedeutung für das Krankheitsgeschehen (Voigtländer *et al.* 2010). Demnach sind die regionalen Merkmale derart unterschiedlich und bedeutsam, dass sie als Einflussfaktoren bei der Beschreibung medizinischen Outcomes berücksichtigt werden müssen (ebd.).

Die Variabilität von Behandlungsprozessen und -ergebnissen

Variabilitätsanalysen sind zur Bewertung der Effekte medizinischer Behandlungen unverzichtbar. Dies wird

im Folgenden am Beispiel der Versorgung mit künstlichen Gelenken und einer Prozedur im Rahmen einer Untersuchung zur Krebsfrüherkennung illustriert.

Standzeiten von Endoprothesen

350.000 künstliche Gelenke werden in Deutschland jährlich implantiert (BQS 2008). Eine Operation sollte dem Patienten helfen und für viele Jahre Erleichterung verschaffen. Eine erneute Operation oder der baldige Ersatz des neuen Gelenkes sollte die Ausnahme sein. Doch immer wieder wird über Materialfehler und Probleme mit künstlichen Gelenken (Demmer und Ludwig 2009) berichtet. Über die Häufigkeit von Materialfehlern gibt es keine offiziellen Angaben. Ein Register zur Dokumentation von Endoprothesen wird in Deutschland seit 30 Jahren gefordert, bis heute steht die Realisierung aus. Um dennoch Transparenz über die Operations-Ergebnisse zu erhalten, analysiert das Wissenschaftliche Institut für Nutzen und Effizienz im Gesundheitswesen (WINEG) Daten der Techniker Krankenkasse über die Leistungen nach einer Operation zum Einsatz einer Prothese.

Auf der Basis von Behandlungs- und Abrechnungsdaten von Versicherten der Techniker Krankenkasse wurde untersucht, wie viele der Knieprothesen innerhalb eines zwei Jahres-Zeitraumes erneut operiert werden mussten (Linder *et al.* 2010). Untersucht wurden u.a. Knieendoprothesen, die im Zeitraum von 2005 bis 2007 bei Versicherten der Techniker Krankenkassen implantiert wurden. In der untersuchten Population (n=5.000.000 Versicherte) wurden 13.466 Endoprothesen-Operationen durchgeführt.

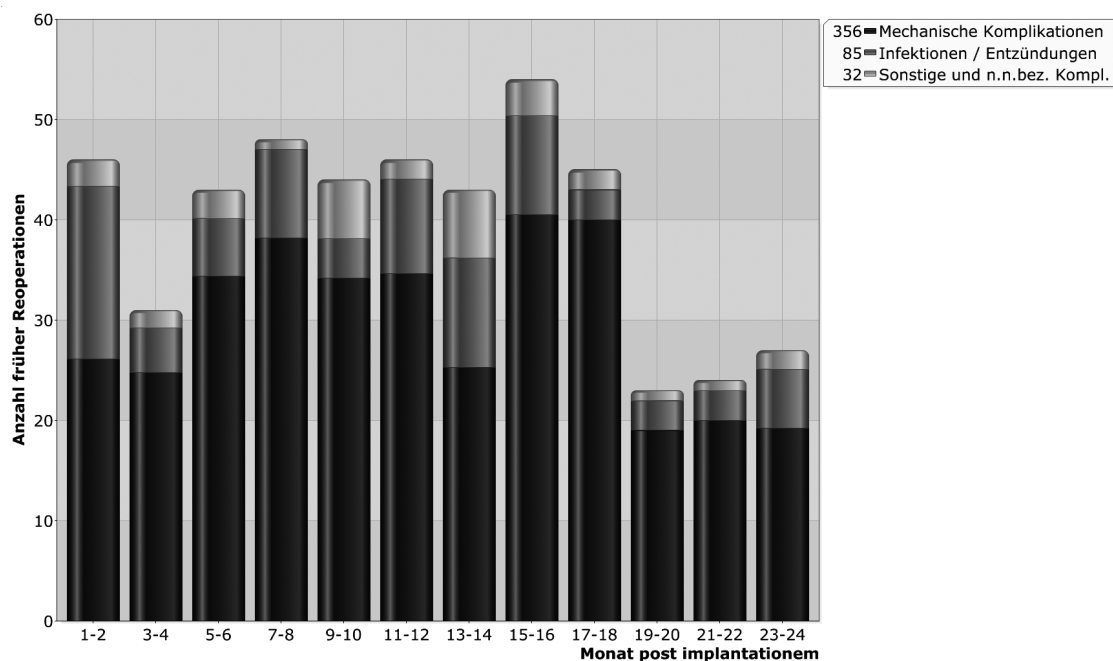


Abb. 2: Frühe Reoperationen in den ersten zwei Jahren nach Implantation eines künstlichen Kniegelenkes. Erläuterungen im Text.

Die Implantationen wurden in Beziehung gesetzt zu der jeweils ersten Reoperation (Wechsel oder Entfernung der Knieendoprothese) bei einem Zeitraum von zwei Jahren *post implantationem*.

Die Haltbarkeit der Knieendoprothesen betrug in 3,8% (n=513) der Fälle weniger als zwei Jahre. Die Verteilung der Folgeeingriffe auf die Ursachen „mechanische Komplikation“, „Infektion“ oder „Sonstiges“ innerhalb des Zwei-Jahres-Zeitraums ist in Abbildung 2 dargestellt.

Eine signifikante positive Korrelation besteht zwischen den Behandlungszahlen der Kliniken und dem Outcome im Sinne niedriger Raten an frühen Reoperationen (Abb. 3). Diese Analysen dienen den Krankenversicherungen als eine Grundlage bei der Auswahl von bevorzugten Leistungserbringern. Durch diese Form des qualitätsorientierten selektiven Kontrahierens von Leistungserbringern durch die Krankenversicherungen werden nachweislich performante Einrichtungen gestärkt und gefordert.

Graues Screening mit dunklen Folgen: das Beispiel Zervixkarzinom. Früherkennungsuntersuchung und die Häufigkeit von Konisationen

Die Früherkennung von Erkrankungen gilt als vorzügliche Aufgabe moderner Gesundheitssysteme. Das Angebot von Früherkennungsmaßnahmen wird als Beleg für die Leistungsfähigkeit der gesundheitlichen Versorgung gewertet. Idealerweise wird für Screening-Verfahren unterstellt, dass die Tests in der Lage sind, Krankheiten sicher zu erkennen und die Tests bei Erkrankungen durchgeführt werden, bei denen eine frühe Behandlung auch sinnvoll ist und zur Verfügung steht (Wilson und Jungner 1968).

Erst seit wenigen Jahren werden Screening-Verfahren differenziert-kritisch gesehen (in Deutschland z.B. Weymayr und Koch 2003, Koch und Weymayr 2008, Bartens 2008). Heute findet sich eine ausgewogene Darstellung über die Vor- und Nachteile nicht mehr nur in der Fachpresse sondern auch in der Publikums-Presse (Grill 2009). Aktuell werden Positionen formuliert, wonach die Screening-Verfahren nicht länger als Qualitätsbeleg eines Gesundheitssystems verstanden werden sollten (Welch 2010).

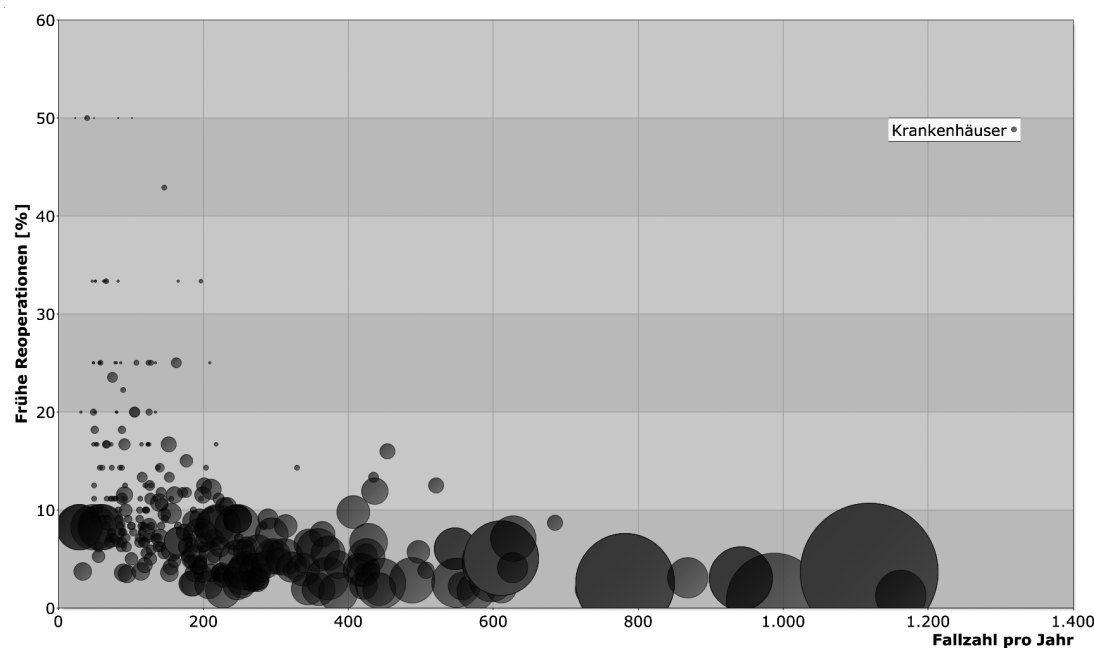


Abb. 3: Häufigkeit von Knieendoprothesen-Operationen. Jeder Kreis repräsentiert ein Krankenhaus. Seine Fläche korreliert mit der Zahl an Knieendoprothesen-Implantationen bei TK-Versicherten. Auf der Abszisse abgetragen sind die jährlichen Fallzahlen insgesamt.

Grund ist die Einsicht, dass alle Screening-Programme auch Schaden verursachen. Besonders problematisch ist dies, da sich Früherkennungs-Untersuchungen an gesunde Menschen richten. Als Schaden müssen falsch positive oder falsch negative Befunde und die damit verbundenen physischen und psychischen Belastungen für die Menschen verstanden werden (vergleichsweise unbedeutend sind die prinzipiell schädigenden Röntgenstrahlen; dennoch wurden dieses Schadenspotential jahrelang als einziger möglicher Nachteil in den Informationsbroschüren auch der bundesweiten Screening-Programme genannt). Die Überdiagnosen und in Folge die Übertherapien sind hoch relevant, da der Nutzen dieser Programme selbst oft nur gering ausfällt. Jedenfalls ist eine ausgewogene, verständliche Darstellung aller Effekte des Screenings für die Zielpopulation, die sich an einem Screening beteiligen soll, notwendig (Arbry *et al.* 2008). Nur auf der Basis einer evidenzbasierten Information (DNebM 2010), die im Kern das Für und Wider der Untersuchung sowie die Folgen verständlich und untendenziös darstellt, kann es zu der ethisch-normativ geforderten informierten Entscheidung (*informed consent*) kommen.

Wie schwer es ist, diese notwendigen Voraussetzungen zu erfüllen, soll am Beispiel des Screenings auf Gebärmutterhals-Krebs illustriert werden.

Das Zervixkarzinom ist eine bösartige Neubildung des Gebärmutterhalses (*Cervix uteri*) und nach dem Brustkrebs die zweithäufigste Krebserkrankung der Frau. 2006 erkrankten in Deutschland etwa 5.470 Frauen am Zervixkarzinom. Es starben 1.492 Frauen. Für das Jahr 2010 ist mit einer 5-Jahres-Prävalenz von etwa 23.800 Frauen zu rechnen (RKI 2010).

Im Vergleich zum Zervixkarzinom liegt die Inzidenz der zervikalen Präkanzerosen (Krebsvorstufen) um das Hundertfache höher. Damit dürfte in Deutschland die Inzidenz schwergradiger Präkanzerosen der *cervix uteri* bei ca. 1% liegen.

Die Früherkennungsuntersuchung dient der Entdeckung dieser Krebsvorstufen. Üblicherweise wird ein Abstrich der Zellen des Gebärmutterhalses entnommen und untersucht. Bei auffälligen Zellen erfolgt eine Kolposkopie, in deren Rahmen weitere diagnostische Schritte durchgeführt werden, einschließlich der Entnahme einer Gewebeprobe zur histologischen Untersuchung. Unter bestimmten Voraussetzungen und bei entsprechender Indikationsstellung wird dann eine Konisation durchgeführt. Als Konisation wird das Ausschneiden eines kegelförmigen Gewebestückes aus der *Portio vaginalis* der *Cervix uteri* unter teilweiser bzw. subtotaler Entfernung der Schleimhaut des Zervixkanals bezeichnet. Diese kann

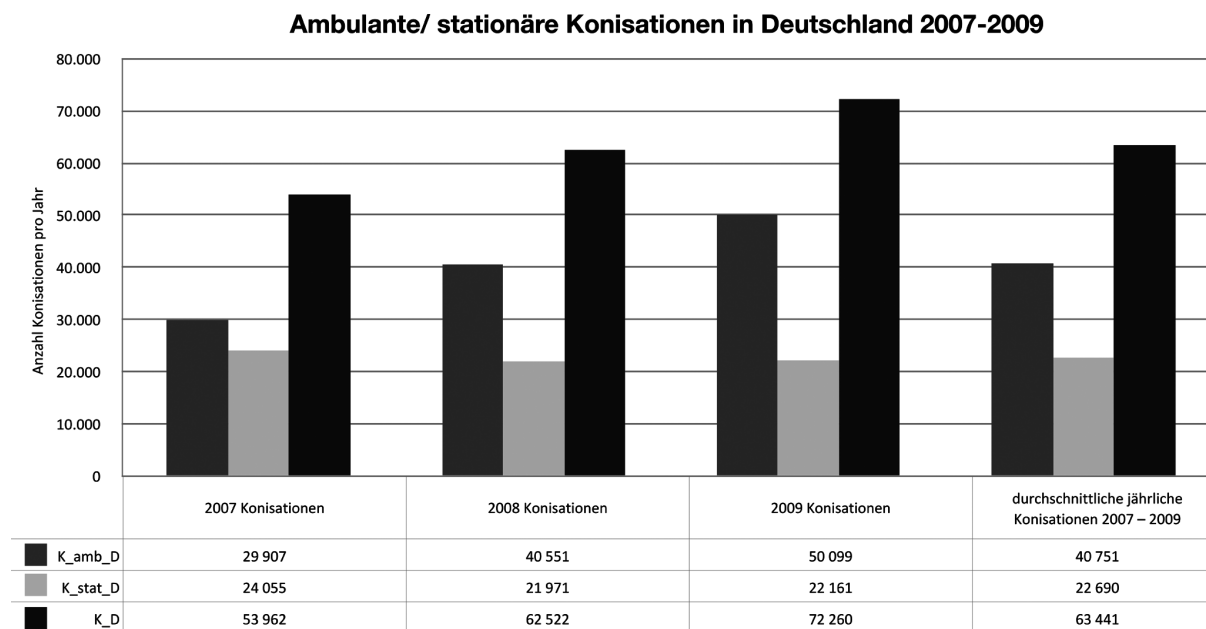


Abb. 4: Häufigkeit von ambulanten (K_amb_D) und stationären (K_stat_D) Konisationen in den Jahren 2007, 2008 und 2009. Hochrechnung auf der Basis von Abrechnungsdaten von TK-Versicherten. Operationalisierung orientiert am Bericht „Konisation“ des AQUA-Institut (2010) (K_D, Gesamtzahl der Konisationen).

sowohl im stationären als auch im ambulanten Bereich erfolgen und mit unterschiedlichen Techniken ausgeführt werden (z.B. Schlinge, Laser, Skalpell). Die Konisation ist die Grundlage für weitere therapeutische Entscheidungen und dient zugleich als Behandlungskontrolle (AQUA Bericht 2010, IQWiG Rapid Report 2009).

Die Konisationen führen möglicherweise zu einer Insuffizienz der Gebärmutter. Es wird der Verdacht diskutiert, dass Frauen nach Konisationen häufiger Komplikationen während einer Schwangerschaft erleiden (Kyrgiou *et al.* 2006, Arbyn *et al.* 2008, Kühn 2010). Diese Komplikationen müssen als schwere Nebenwirkung oder Folge der Früherkennungs-Untersuchung bewertet werden, schließlich ist diese für Fehl- oder Missgeburten bei den Frauen verantwortlich. Trotz dieser für die Frauen möglicherweise dramatischen Konsequenzen nach Konisationen ist in Deutschland nicht bekannt, wie häufig, mit welcher Qualität und bei welchen Frauen die Konisationen durchgeführt werden.

Für das Screening auf Zervixkarzinom gibt es in Deutschland kein qualitätsgesichertes Programm. Die gesetzlichen Krankenversicherungen bezahlen dennoch für Frauen ab 20 Jahren jährlich einmal eine Krebsfrüherkennungsuntersuchung. Die Vergütung für diese

Verfahren erfolgt außerhalb von festen Budgets, ist nicht gedeckelt und führt zu relevanten zusätzlichen Einnahmen für die Ärzte. Sinnvoll und im Nutzen belegt sind deutlich höhere Untersuchungs-Intervalle. So wird in den USA ab dem Alter von 23 Jahren alle 3 Jahre eine Untersuchung empfohlen (Sawaya 2009). Nach den EU-Leitlinien empfiehlt sich ein Screening im Abstand von 3–5 Jahren bis zum Alter von 60 Jahren (Arbyn *et al.* 2008).

Europäische Leitlinien zur Ausgestaltung eines Zervix-Screenings liegen mittlerweile in der zweiten Auflage vor. Für Deutschland ist trotz Bemühungen im Rahmen eines „Nationalen Krebsplanes“ (BMG 2009) dennoch keine Umsetzung eines Zervix-Screening-Programmes abzusehen. Das bedeutet, dass jährlich millionenfach Frauen in Deutschland untersucht werden, ohne dass die Verfahren selbst qualitätsgesichert sind oder die Ergebnisse dieser Untersuchungen dokumentiert wären. Dieses sogenannte „opportunistische“ oder „graue“ Screening führt auch dazu, dass Zahlen über die Häufigkeit der Konisationen nicht existieren. Eine Analyse der Häufigkeit und der regionalen Verteilung von Konisationen im ambulanten und stationären Bereich wird im Folgenden erstmals vorgestellt.

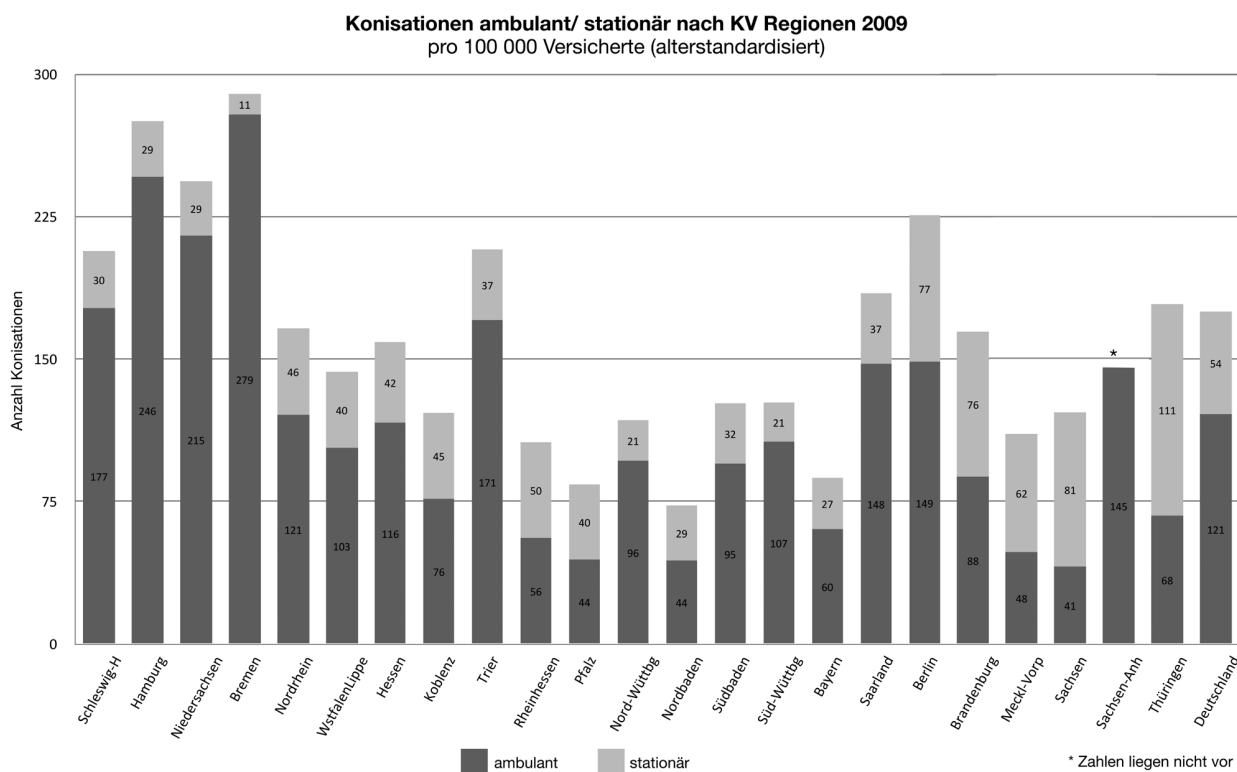


Abb. 5: Konisations-Häufigkeit nach Sektor und Region der Kassenärztlichen Vereinigung 2009. Vergleich altersstandardisiert.

Grundlage der Auswertungen sind die bei der Techniker Krankenkasse versicherten Frauen in den Jahren 2007 bis 2009 (dies waren im Jahre 2009 3.704.568 Frauen). Die Konisationen sind in den Abrechnungen der Kliniken und Ärzte mit den Krankenkassen mit bestimmten Operations-Schlüsseln codiert (Operationalisierung nach AQUA 2010). Für die folgenden Aussagen und Abbildungen wurden über 15.000 Konisationen ausgewertet.

Auffällig ist der starke Anstieg der Konisationen im beobachteten Zeitraum. Die Konisations-Raten stiegen von 130 im Jahre 2007 auf 175 pro 100.000 Frauen im Jahre 2009 an. Demnach ist für Deutschland 2009 mit insgesamt 72.000 Konisationen jährlich zu rechnen. Der Anstieg geht dabei ausschließlich auf die ambulant erbrachten Konisationen zurück. Pro Jahr sind dort zweistellige Steigerungsquoten der Konisationen im Vergleich zum Vorjahr zu verzeichnen: 2008 +36%, im Jahr 2009 +23%. Aufgrund der starken Zunahme ist in Abbildung 3 noch der jährliche Durchschnitt der Konisationen aus dem untersuchten Drei-Jahreszeitraum angegeben.

Im Jahr 2009 wurden 70% der Konisationen ambulant erbracht, 2007 waren es 55%.

Die Häufigkeit der erbrachten Leistungen variiert stark zwischen den Regionen. Während in Bremen 290 Konisationen/100.000 Versicherten jährlich durchgeführt werden, sind es in der Region Nordbaden nur 73 Konisationen. Der Unterschied der Konisations-Häufigkeit zwischen den Regionen in Deutschland beträgt 400% (Abb. 5).

Die folgende Abbildung verzeichnet zudem das Verhältnis zwischen ambulanten und stationären Konisationen in den Arzt-Regionen (Kassenärztliche Vereinigung). Auch hier existieren eklatante Unterschiede. In Bremen erfolgen 4% der Konisationen stationär, in Sachsen dagegen 66%. (Sachsen-Anhalt hat einen noch zu klärenden Sonderstatus, dort erfolgen nach ersten vorliegenden Zahlen 60% der Konisationen stationär auf einer hohen Basis von 145 Konisationen/100.000 Versicherte im ambulanten Bereich.)

Lege artes werden nur schwere Fälle im Krankenhaus durchgeführt. Die Art der Schwere ist einem Kriterien-Katalog geregelt (Katalog „Ambulant

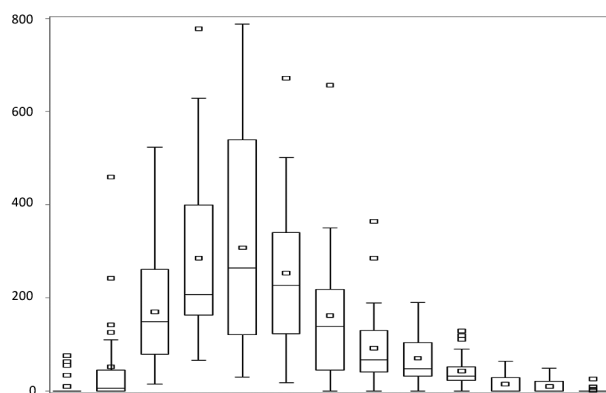


Abb. 6: Häufigkeit ambulanter Konisationen (OPS) in den Arzt-Regionen (Kassenärztlichen Vereinigung) nach dem Alter der konisierten Frauen pro 100.000 Versicherte, 2009. Neben den Statistiken über alle Arzt-Regionen hinweg (Box-Plot) sind die KV-Regionen mit extremen Werten als Quadrate wiedergegeben.

durchführbare Operationen und sonstige stationärsersetzende Eingriffe gemäß §115b SGB V“) Dass sich die Schwere-Grade der Konisations-Fälle zwischen den Regionen so stark unterscheiden wie es die Verteilung stationäre vs. Ambulante Konisation nahelegt, ist wenig glaubhaft. Hier sind Angebotsstrukturen und Angebots-induzierte Nachfragen zu diskutieren.

Die Abbildung 6 zeigt wie häufig Frauen in den unterschiedlichen Altersklassen in den einzelnen Regionen konisiert werden. Die gewählte Darstellung – wie auch die Skalierung – identifiziert auffällige Regionen mit einer fragwürdigen Praxis. In einer Altersgruppe unter 15 Jahren, sind Konisationen z.B. nicht angezeigt. Die Prävalenz hochgradiger Dysplasien ist in dieser Altersgruppe sehr selten. Häufig verändern sich dort festgestellte Auffälligkeiten später so dass die Indikations-Stellung für eine Konisation sehr eng gefasst ist. Hinweise auf Konisationen in diesen Altersgruppen müssen im Zusammenhang mit den Fragen zur Übertherapie und Fehl- wie Überversorgung diskutiert werden.

Finale: Folgerungen und Forderungen

Ein Pionier der Sozialmedizin im deutschsprachigen Raum, Ludwig Teleky, stellte bereits in den 30er Jahren des vergangenen Jahrhunderts fest: „*Wir wissen kaum, was wir mit manchen Abweichungen vom Normalen, die wir bei solchen Untersuchungen feststellen, anfangen*

sollen: Was bedeutet ein leichtes Herzgeräusch im Entwicklungsalter? ... Was bedeutet eine orthostatische Albuminurie, was eine andere Albuminurie?“ (Teleky 1939 zitiert nach Schmacke 2005, 33f)

Dieser Befund ist heute ebenfalls gültig und zumindest genauso beklagenswert wie damals. Um derartige Fragen zukünftig zu beantworten sind Variabilitätsanalysen zu praktizieren und diese Praxis systematisch in einer Theorie des Gesundheits-Managements und der Versorgungsforschung zu fundieren.

Stärker als bisher ist die Ausgangsvariabilität in der Bevölkerung zu thematisieren. Obschon die großen Unterschiede in den Belastungen und Beanspruchungen in den Untersuchungs-Populationen prinzipiell bekannt und anerkannt sind, werden diese bei der Bewertung von Effekten verschiedener Gesundheits-Technologien oftmals nicht berücksichtigt. Die *a priori* Variabilität in regionaler und sozio-struktureller Perspektive in der Untersuchungspopulation sollte prinzipiell beschrieben und ihr Einfluss auf die Outcomes gesundheitlicher Interventionen geklärt sein.

Die Effekte von medizinischen Interventionen sind vielfältig. Statistisch gesichert werden hauptsächlich Mittelwerte im Sinne von erstrebten oder angezielten Effekten untersucht und berichtet. Die Abweichungen von den Zielwerten sind zur Ausgestaltung und Korrektur gesundheitlicher Interventionen ebenso bedeutsam und ggf. noch wertvoller als die im Mittel erreichten oder erreichbaren Ziele selbst. Die Abweichungsanalyse im Rahmen der Gesundheits-Berichterstattung samt Beschreibung von statistischen Ausreißern gilt als obligat. Die Umsetzung scheitert häufig an fehlenden Datenzugängen oder fehlenden Datenquellen. So ist die Einrichtung eines Behandlungs-Registers z.B. für die Endoprothetik, in Deutschland überfällig.

Auch ganz neu zu entwickelnde Variabilitätsanalysen werden benötigt. Auszubauen ist die Evaluation und Qualitätssicherung von massenhaft und routinemäßig durchgeführten medizinischen Interventionen über die wir heute keine Einsicht haben aber dringend Einsicht benötigten. Zur verantwortungsvollen Durchführung etwa von Screening-Verfahren werden Informationen über Nutzen und Schaden der Prozeduren benötigt. Dieses ambivalente Verhältnis von Nutzen und Schaden anzuerkennen und ehrlich systematisch zu analysieren steht weitgehend aus.

Neben der praktischen Anwendung der Variabilitätsanalysen ist schließlich eine systematische Auseinandersetzung mit dem Phänomen der Variabilität erforderlich. Der „theoretische Corpus der Versorgungsforschung“ ist heute noch wenig ausgeprägt (Raspe 2011). Es ist zu

wünschen, dass bei der noch zu leistenden systemischen und theoretischen Fundierung der Versorgungsforschung für das Gesundheitswesen in Deutschland der Behandlung des Phänomens Variabilität weitergehende intensive Beachtung geschenkt wird. Ein modernes Gesundheitsmanagement wird dabei von den Theorien und dem Methodeninventar der Anthropologie profitieren.

Schlussbemerkung

Ich danke meinem akademischen Lehrer und Mentor Herrn Prof. Henke für seine Anregungen und Ermutigungen, die mir vor mittlerweile fast zwei Jahrzehnten als Anthropologen Eintritt in das Gesundheitsmanagement der gesetzlichen Krankenversicherung ermöglichten. Prof. Henkes Wegbereitung und Begleitung meiner Entwicklung in einem scheinbar Anthropologie-fernen Bereich hat uns seitdem freundschaftlich verbunden. Ich freue mich auf eine weitere, lange, gemeinsame Wegstrecke.

Literatur

[Alle Links am 29.11.2010 geprüft]

- Aktionsbündnis Patientensicherheit 2006. *Agenda Patientensicherheit 2006*. http://www.aktionsbueundnis-patientensicherheit.de/apsside/Agenda_Patientensicherheit_2006.pdf
- AQUA 2010. *Sektorübergreifende Qualitätssicherung im Gesundheitswesen. Konisation*. Abschlussbericht. Stand 26. 10. 2010.
- Arbyn M et al. (eds) 2008. *European guidelines for quality assurance in cervical cancer screening Second Edition*. International Agency for Research on Cancer.
- Bartens W 2008. *Vorsicht Vorsorge! Wenn Prävention nutzlos oder gefährlich wird*. Frankfurt.
- BMG, Bundesministerium für Gesundheit (ed.) 2009. *Informationspapier zur Nationalen Krebskonferenz*. <http://www.bmg.bund.de/SharedDocs/Downloads/DE/Standardartikel/K/Glossar-Krebs/Infopapier-Krebskonferenz-2009,templateId=raw,property=publicationFile.pdf/Infopapier-Krebskonferenz-2009.pdf>
- BQS 2008. *Qualitätsreport*. <http://www.bqs-qualitaets-report.de/>
- Braun B, Müller R 2003. *Auswirkungen von Vergütungsformen auf die Qualität der stationären Versorgung. Ergebnisse einer Längsschnittanalyse von GKV-Routinedaten und einer Patientenbefragung*. Schriftenreihe zur Gesundheitsanalyse, Bd. 26., St. Augustin. Asgard.
- Campbell M, Fitzpatrick R, Haines A 2000. *Framework for the design and evaluation of complex interventions to improve health*. British Medical Journal 321: 694–696.
- Demmer U, Ludwig U 2009. *Wie ein Stromschlag*. Der Spiegel 1/2009: 36–37.
- DNebM Deutsches Netzwerk Evidenzbasierte Medizin 2010. *Gute Praxis Gesundheitsinformation*. Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen 104: 66–68.
- Edwards A, Elwyn G (eds.) 2009. *Shared Decision-Making in Health Care*. Achieving Evidence-Based Patient Choice. Oxford.
- Gastmeier P, Geffers C 2008. *Nosokomiale Infektionen in Deutschland. Wie viele gibt es wirklich? Eine Schätzung für das Jahr 2006*. Deutsche Medizinische Wochenschrift 133: 1111–1115.
- G-BA. Gemeinsamer Bundesausschuss 2010. *Verfahrensordnung*. http://www.g-ba.de/downloads/62-492-422/VerfO_2009-12-17.pdf
- Gigerenzer G 2002. *Das Einmaleins der Skepsis. Über den richtigen Umgang mit Zahlen und Risiken*. Berlin.
- Grill M 2009. *Risiko Vorsorge*. Der Spiegel 17: 124–135.
- Helmert U, Bammann K, Voges W, Müller R 2000 (eds.). *Müssen Arme früher sterben? Soziale Ungleichheit und Gesundheit in Deutschland*. Weinheim, München, 223–242.
- Henke W 2007. *Historical Overview of Paleoanthropological Research*. In: Henke W and Tattersall I (eds.). *Handbook of Palaeoanthropology. Vol I. Principles, Methods, and Approaches*. Springer. Berlin, Heidelberg, New York, 1–56.
- Henke W, Müller H 2002. *Regionale Mortalität in Rheinland-Pfalz*. In: Cromm J, Scholz RD (ed.). *Regionale Sterblichkeit in Deutschland*. WiSoMed. Göttingen, 205–230.
- IMVR, WINEG 2010. *Expertenworkshop Zukunftsthemen der Versorgungsforschung*. Köln, 8. November 2010. s. u. www.versorgungsforschung-deutschland.de
- IQWiG 2008. *Allgemeine Methoden. Version 3.0*. Köln. http://www.iqwig.de/download/IQWiG_Methoden_Version_3_0.pdf
- IQWiG 2009. *Orientierende Aufbereitung für das Thema „Konisation der Cervix uteri“*. *Rapid Report*. http://www.iqwig.de/download/V09-01B_Rapid-Report_Orientierende_Aufbereitung_Konisation_der-Cervix_uteri.pdf
- Kasper J 2011. *Evidenzbasierte Patienteninformation*. In: Pfaff H et al. (eds.). *Lehrbuch Versorgungsforschung*. Schattauer. Stuttgart, 58–63.
- Koch K, Weymayr C 2008. *Kritik der Krebsfrüherkennung*. Onkologie 14:181–188.
- Kühn W 2010. *Die Kolposkopie-Empfehlungen der AG Zervixpathologie und Kolposkopie*. Frauenarzt 51: 434–440.

- Kyrgio M *et al.* 2006. *Obstetric outcomes after conservative treatment for intraepithelial or early invasive cervical lesions: systematic review and meta-analysis.* Lancet 367: 489–98.
- Linder R, Müller H, Stockheim M 2010. *Standzeiten von Knieendoprothesen. Eine Analyse der Techniker Krankenkasse.* Orthopädie im Profil 1: 2–3.
- MRC, Medical Research Council 2002. *A Framework for Development and Evaluation of RCTs for Complex Interventions to Improve Health.* <http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC003372>
- Mühlhauser I 2010. *Vorsorge und Früherkennung – Präventionshandeln zwischen gesellschaftlicher Verpflichtung und individueller Selbstbestimmung.* In: Hensen P, Kölzer C (eds.). *Die gesunde Gesellschaft – Sozio-ökonomische Perspektiven und sozialethische Herausforderungen.* Wiesbaden, 235–253.
- Mühlhauser I, Filz M 2008. *Screening auf Zervixkarzinom ... Informationen zur Beratung von Frauen.* In: Sonderbeilage arznei-telegramm 39: 29–38.
- Müller H 1993. *Regionale Mortalitätsunterschiede und ihre sozialen Determinanten.* M.A. Arbeit. Universität Mainz.
- Müller H 2007. *Mythos Innovation? Anmerkungen zu medizintechnischen Entwicklungen aus Sicht der Gesetzlichen Krankenversicherung.* In: Groß D, Jakobs EM (eds.). *E-Health und technisierte Medizin – Neue Herausforderungen im Gesundheitswesen.* Lit-Verlag. Berlin, 101–111.
- Müller R, Braun B (eds.) 2006. *Vom Quer- zum Längsschnitt. Möglichkeiten der Analyse mit GKV-Daten.* St. Augustin, Asgard.
- Mullan F 2004. *Wrestling with variation. An interview with Jack Wennberg.* Health Affairs, 73–80. <http://content.healthaffairs.org/cgi/reprint/hlthaff.var.73v1>
- Raspe H *et al.* 2010. *Versorgungsforschung in Deutschland. Stand – Perspektiven – Förderung. Stellungnahme. Standpunkte.* Deutsche Forschungsgemeinschaft. Bonn.
- Raspe H 2011. *Geleitwort.* In: Pfaff H, Neugebauer EAM, Glaeske G, Schrappe M (eds.). *Lehrbuch Versorgungsforschung. Systematik – Methodik – Anwendung.* Schattauer. Stuttgart.
- RKI 2010. *Verbreitung von Krebserkrankungen in Deutschland. Entwicklung der Prävalenzen zwischen 1990 und 2010.* Beiträge zur Gesundheitsberichterstattung des Bundes. Robert Koch-Institut 2010. Berlin.
- Sawaya GF 2009. *Cervical-Cancer Screening – New Guidelines and the Balance between Benefits and Harms.* New England Journal of Medicine. doi. 10.1056/NEJMp0911380
- Schmacke N 2005. *Wieviel Medizin verträgt der Mensch. 2. Auflage.* Kompart. Bonn, Bad Homburg.
- Silberer G 2010. „Sequence matters“. *Die Sequenzanalyse in ihrer Bedeutung für die Markt- und Marketingforschung.* Institut für Marketing und Handel. Georg-August-Universität Göttingen. unveröffent. Manuskript.
- Smith PC 2010. *Measuring and improving health-system productivity.* The Lancet 376: 1198–1200.
- SVR-Gesundheit 2001. *Gutachten 2000/2001 des Sachverständigenrates für die Konzertierte Aktion im Gesundheitswesen. Bedarfsgerechtigkeit und Wirtschaftlichkeit. Band III. Über-, Unter- und Fehlversorgung.* <http://dipbt.bundestag.de/doc/btd/14/068/1406871.pdf>
- Swart E, Ihle P, Geyer S, Grobe T, Hofmann W 2005. *GPS – Gute Praxis Sekundärdatenanalyse.* Arbeitsgruppe Erhebung und Nutzung von Sekundärdaten AGENS der Deutschen Gesellschaft für Sozialmedizin und Prävention DGSMP. Das Gesundheitswesen 67: 416–421.
- Voigtländer S, Berger U, Razum O 2010. *Zunehmende regionale Unterschiede bei den Lebensverhältnissen in Deutschland und ihre Bedeutung für die Erklärung gesundheitlicher Ungleichheit.* Das Gesundheitswesen 72: 301–308.
- Welch HG 2010. *Screening Mammography – a long run for a short slide?* The New England Journal of Medicine 363: 1276–1278.
- Wennberg J, Gittelsohn A 1973. *Small area variations in healthcare delivery.* Science 182: 1102–1108.
- Weymayr C, Koch K 2003. *Mythos Krebsvorsorge. Schaden und Nutzen der Früherkennung.* Eichborn. Frankfurt.
- Wilson JM, Jungner G 1968. *Principles and practice of screening for disease, WHO.* Geneva, 343.

Adresse:

Hardy Müller
Wissenschaftliches Institut für Nutzen
und Effizienz im Gesundheitswesen (WINEG)
Bramfelder Straße 140
22305 Hamburg
Deutschland
Tel.: +49 40 6909 2439
Fax: +49 40 6909 82439
E-mail: hardy.mueller@wineg.de

The ties that bind – the impact of godparents on baptisand survival

ARIANE KEMKES

Tholius Institute, Scottsdale AZ, USA / Caris Life Sciences, Phoenix AZ, USA

Summary

Based on 2,288 baptismal events extracted from the birth register of Stockheim (East Prussia, 1772–1874), the impact of godmothers and godfathers was investigated using differentials in baptisand lifespan. All analyses controlled for significant biological and socio-demographic co-predictors (cohort, birth rank, paternal SES, maternal age at birth, loss of mother before age 15). The results indicate that neither the total number of godparents ($p = .352$) nor the number of godfathers ($p = .200$) achieved statistical significance, while the number of godmothers remained an independent predictor of baptisand survival ($p = .015$). The resulting survival curves attest to the fact that the number of godmothers displays a positive relationship with baptisand survival odds, which suggests that the role of the female sponsor was primarily one of a benevolent, nurturing co-parent. This supports the paradigm that fictive kin, when carefully selected, can play an important role within a network designed to secure mutual assistance and protection. Moreover, the observed correlation ties in well with the sociobiological paradigm of alloparenting.

Keywords: Godparents, kinship networks, survival odds, village genealogy, historical demography

Zusammenfassung

Auf der Basis von 2,288 Taufen aus dem Stockheimer Taufregister (Ostpreußen, 1772–1874) wurde der Einfluß von Patenschaften auf die Lebenserwartung der Täuflinge untersucht. Alle Analysen wurden vor dem Hintergrund wesentlicher *statistischer Prädiktoren*, d.h. unter Berücksichtigung biologischer und soziodemographischer Einflussfaktoren durchgeführt (Geburtskohorte und Geburtsrang des Täuflings, beruflicher/ökonomischer Status des Vaters, Alter der Mutter bei Geburt, frühzeitiger Tod der Mutter). Die Ergebnisse belegen, daß weder die Gesamtzahl ($p = .352$) noch die Anzahl der männlichen Paten ($p = .200$) Einfluß auf die Lebensspanne der Täuflinge hatte, während sich ein positiver Zusammenhang zwischen Zahl der Taufpatinnen und der durchschnittlichen Lebenserwartung der Täuflinge ableiten lies ($p = .015$). Diese Positivbilanz läßt sich zwanglos mit dem Bild der “Patentante” als Ersatzmutter in Zusammenhang bringen und bestätigt, daß rituelle oder fiktive Verwandtschaften, d.h. Beziehungsgeflechte, welche mittels der Verwendung von Verwandtschaftstermini als Verwandtschaften in Erscheinung treten, ohne dass diesen echte Blutsbeziehungen zugrunde liegen, durchaus ihren evolutionsbiologischen Wert haben, so z.B. im Rahmen des soziobiologischen Paradigmas der “Helfer am Nest”.

Keywords: Taufpaten, Verwandtschaftsnetze, Lebenserwartung, Ortsfamilienbuch, historische Demographie

Baptismal kinship nexus – beyond socio-historical perspectives

Historically, the institution of godparenthood has played an important role in communities where kinship represents the dominant principle of organisation. Each new baptism conveys opportunities of network expansion and social support. Moreover, godparenthood can breach social boundaries, when matrimonial alliances are restricted or impractical. And lastly, baptismal bonds can be activated at will, which at times gives them precedence over blood ties (Lynch 1986; Jussen 2000; Naumoviæ and Jovanoviæ 2004).

The belief that baptismal sponsorship creates an intimate spiritual bond has long permeated European

societies. Initially, sponsorship was merely designed to guarantee religious education and guidance. However, over time, the practical and social function of godparenthood began to expand. By the 16th century, the godparent began to take on the dual role of nurturer and carer, thereby following a newly emerging social tenant that godparents have an intrinsic obligation to help their religious charge through all of life's challenges, not only those covered by the immediate baptismal rite (Karant-Nunn 1997; Spinks 2006).

In 1989, Voland observed that in the East Frisian parish of Reepsholt (1650–1700), the sons and daughters of farmers who survived their first year had been given more godparents, than their siblings who died as infants. Voland deemed it unlikely that infant

survival was directly dependent on the number of godparents. Rather, he argued, the selection of godparents merely reflected the parents' joy or indifference toward the child and serves as a proxy for parental interest, as well as the extent and quality of infant care. However, in light of the pivotal economic, social and increasingly emotional role of sponsorship, the question arises why the strategy of baptismal alliances should not be associated with tangible benefits for the recipient of these attentions? Incorporating the perspective of a nurturing and helpful godparent, the current study was designed to provide insights. On the basis of complete 18th–19th century vital statistics, the question will be addressed, whether baptisands with numerous godparents received survival benefits as a by-product of a well-structured godparent selection process. In line with evolutionary paradigms, two predictions are made: First, if baptismal network extension is a primary strategy, the number of sponsors should show a positive interaction with survival odds. Second, it is hypothesized that the number of godmothers should have a particularly strong effect on godchild longevity, which would mimic the well-known beneficial effect of female kin. According to kin selection theory, behavioral adaptations evolved to regulate investment in kin according to the degree of genetic certainty. These adaptations are hypothesized to produce gender-specific investment strategies, as have been observed for grandparental solicitude (Euler and Weitzel 1996; Steinbach and Henke 2000), aunts and uncles (Gaulin *et al.* 1997) and even cousins (Jeon and Buss 2007). In order to ensure that the observed relationships are non-spurious, the godparent effect will be tested against a number of known bio-medical and socio-demographic background variables.

The sample population: Stockheim, County Friedland, East Prussia (1772–1874)

In brief, the village of Stockheim, County Friedland, is situated in the former German state of East Prussia, located along the southeastern Baltic Coast. Its first documentation can be traced to 1352, with its economic base deeply steeped in manoralism. In 1760, Stockheim – together with the main manor located in Puschkeiten – was purchased by the district administrator Ludwig August von Ostau. Stockheim and neighboring Sommerfeld retained their status as “noble” villages, which assured that judicial and police power remained with the feudal lord. During the Napoleonic Wars, the area repeatedly fell prey to maroding troops and had to accommodate refugees from southern parts of the

county. Both the French Revolutionary War and the Napoleonic War required Prussia to pay contributions and to accept French occupation. In 1810, wide-ranging administrative, social, and military reforms were introduced, which included the emancipation of serfs (begun in 1807), various measures for local self-government, and the reshaping of the central government, which created a new framework for markets in agricultural land and labor (Bruns 2007; Monski 1998).

The birth and baptismal register of Stockheim (County Friedland, East Prussia,) contains entries for 9,586 infants (5,078 males and 4,508 females), who were baptised in the local Lutheran church between 1599 and 1944 (Bruns 2007). Ideally, each entry yields the first and last name of the baptisand, birth day, birth place, and day of baptism. In addition, the names of the parents, their marital status, as well as information about the attending sponsors (name, residency, and occupation) are included. The fact that godchildren were detailed by name and birth facilitates record linkage with the village genealogy of Stockheim, which chronicles individual life histories. Since much of the older parish archive perished in a fire in the 18th century, analyses had to be limited to the years 1772–1874. The investigation was further restricted to legitimate births. Similarly, emergency baptisms, premature births and stillbirths were excluded. This left 2,288 baptismal events for analysis – with a grand total of 6,367 sponsors (1554 godfathers, 4723 godmothers, 90 undetermined sponsors, Table 1).

Data preparation

Identification of godparents

To obtain information about the sponsors raises the problem of identification. In most cases, the primary information contained in the baptismal record had to suffice, as individualization proved impractical if not impossible. First, while many sponsors were fully identifiable, for example “Gottfried Erdmann, free peasant from the village of Sommerfeld”, some individuals were referred to only by their last name (“Frau Klein”), in some instances even without gender identifiers (“Bessel”). The problem is further compounded by a high rate of recurring names. This makes exactitude impossible. Second, since baptisms were events of some importance, godparents were drawn from Stockheim, neighboring villages as well as places outside the county. The latter means that insights into familial relationships and socio-demographic

BAPTISAND BIOLOGICAL, FAMILIAL AND SOCIO-DEMOGRAPHIC CHARACTERISTICS		BAPTISMS		SPONSORS	
		N	%	GF	GM
Cohort (N=2288)	1772–1799	673	29.4	2.6	1.2
	1800–1824	523	22.9	2.3	0.8
	1825–1849	502	21.9	1.7	0.4
	1850–1874	590	25.8	1.6	0.3
Gender (N=2288)	Male	1231	53.8	0.7	2.8
	Female	1057	46.2	0.6	2.8
Birth rank (N=2288)	1	858	37.5	0.5	2.2
	2–4	947	41.4	0.8	3.2
	5–7	388	17.0	0.8	3.2
	8–10	86	3.8	0.6	2.9
	11+	9	0.4	0.4	2.9
Paternal SES (N=2011)	Landed nobility	12	.5	2.0	4.8
	Free peasantry, county officials	56	2.4	1.3	4.3
	Peasants (~19 acres), clergy	57	2.5	1.2	3.8
	Master craftsmen, academics	136	5.9	0.8	3.1
	Craftsmen, peasants (<10 acres)	754	33.0	0.8	3.2
	Share laborers, coach men	500	21.9	0.8	3.0
	Day laborers, servants, lodgers	463	20.2	0.5	2.7
	Farm hands, pauper	33	1.4	0.6	2.8

Tab. 1: Average number of sponsors (godfathers/GF, godmothers/GM) by baptismal event, stratified by baptisand biological, familial and socio-demographic characteristics. [Source: Stockholm, County Friedland, East Prussia, 1772–1874].

characteristics of non-Stockheim inhabitants could not be captured, as these individuals elude the village genealogy.

Reconstruction of kinship ties

Familial relationships were seldom documented within the baptismal register and when they were, they stated more or less the obvious (mother of the baptisand). However, parents rarely acted as sponsors, and when they did, it was most often in connection with an emergency baptism. In order to overcome the dilemma of disentangling kin relationships, similarities in natal surnames were used, using both the father's last name as well as the mother's maiden name. Homonymy has long been used to establish familial relationships and is a valuable proxy in distinguishing kin from non-kin. (Salaris and Poulain 2006).

Socio-economic aspects

The well-studied Prussian system of landownership permits differentiation of various socio-economic strata. Based on Land Tax Lists (Prästationstabellen), Mill Tax Lists (Mahllisten, Mühlen-Consignationen), and New Deed Records such as the "Hypotheken-Acta" a composite system of landownership based on an eight-tiered hierarchy – combining economic and social standing – emerges: (1) Landed nobility, (2) Free peasantry and county officials, (3) Peasants (<19 acres) and clergy, (4) Master craftsmen and academics, (5) Craftsmen and peasants (<10 acres), (6) Share laborers

and coach men, (7) Day laborers, servants, and lodgers, and (8) Farm hands and pauper (S. Bruns, personal communication).

Table 2 elucidates the familial and socio-demographic characteristics of the Stockholm godparents by gender. Based on 2,288 baptismal events, a highly stratified baptismal network emerges that is highly extensive – i.e. based on the incorporation of non-family members as godparents. As the table demonstrates, less than 20% of the godparents were recruited from the family fold. The results further suggest (data not shown) that the benefits associated with godparental solicitude were largely tied to maintaining material gains (horizontal bonds), while at the same time allowing for alliances with social superiors (vertical bonds), particularly within the lower socio-economic strata. The maximum number of godparents per baptism was seven, the average was three.

Data analyses

All statistical analyses were performed with SPSS 13. In order to model the godparent effect, a Cox Proportional Hazards Model was implemented. The Cox model is a well-recognised statistical technique for exploring the relationship between survival and various explanatory variables. In order to substantiate godparent solicitude, lifespan differentials were tested controlling for a variety of confounders. To this end, the analyses incorporated both biological as well socio-demographic copredictors (1–9) related to the baptisands themselves

SPONSOR'S SOCIO-DEMOGRAPHIC CHARACTERISTICS		GF		GM		TOTAL	
		N	%	N	%	N	%
Maternal kin (N=6259)	no relation	1250	82.5	3838	82.4	5088	82.4
	related	265	17.5	819	17.6	1084	17.6
Paternal kin (N=6259)	no relation	1221	80.6	3814	81.9	5035	81.6
	related	294	19.4	843	18.1	1137	18.4
Marital status (N=6364)	single	96	6.2	1187	25.1	1283	20.4
	married	1458	93.8	3536	74.9	4994	79.6
SES (N=2315)	Landed nobility	2	0.2	4	0.3	6	0.3
	Free peasantry, county officials	100	10.8	126	9.1	226	9.8
	Peasants (~19 acres), clergy	40	4.3	46	3.3	86	3.7
	Master craftsmen, academics	27	2.9	58	4.2	85	3.7
	Craftsmen, peasants (<10 acres)	559	60.2	795	57.4	1354	58.5
	Share laborers, coach men	100	10.8	295	21.3	395	17.1
	Day laborers, servants, lodgers	17	1.8	16	1.2	33	1.4
	Farm hands, pauper	84	9.0	46	3.3	130	5.6

Tab. 2: Sponsor's familial and socio-demographic characteristics at time of the baptismal event, stratified by gender (godfathers/GF, godmothers/GM) and total number. [Source: Stockheim, County Friedland, East Prussia, 1772–1874].

Godfathers	Baptisand gender	Estimate	Std. err	lower	upper	Total N	N of Events
none	male	47.1	2.3	42.6	51.7	484	91
1–2		47.4	1.7	44.1	50.7	613	158
3+		54.3	8.3	38.1	70.5	27	9
Overall		47.6	1.3	44.9	50.2	1124	258
none	female	47.7	2.1	43.5	51.9	479	104
1–2		47.9	1.9	44.1	51.6	484	132
3+		52.7	7.4	38.2	67.1	22	11
Overall		48.0	1.4	45.3	50.7	985	247
Godmothers	Baptisand gender	Estimate	Std. err	lower	upper	Total N	N of Events
none	male	52.6	2.7	47.4	57.8	185	61
1–4		46.0	1.6	42.9	49.0	926	192
5–7		41.5	13.9	14.3	68.6	8	4
Overall		47.5	1.3	44.8	50.1	1119	257
none	female	50.6	2.6	45.5	55.7	180	73
1–4		46.5	1.7	43.2	49.8	793	168
5–7		55.2	9.3	37.0	73.4	9	4
Overall		47.9	1.4	45.1	50.6	982	245

Tab. 3: Kaplan-Meier survival analysis (KMSA) – differences in mean baptisand lifespan, stratified by gender and number of religious sponsors. Differences between subsets did not achieve statistical significance. [Source: Stockheim, County Friedland, East Prussia, 1772–1874].

Results

as well as their family: (1) Gender; (2) Birth cohort; (3) Birth season; (4) Birth rank; (5) Paternal SES; (6) Paternal age at birth; (7) Maternal age at birth; (8) Loss of father before age 15; and (9) Loss of mother before age 15. The status (event) variable was set at 15 years (i.e., death/survival at age 15). Besides granting insights into long-term effects of godparent ties, selecting a cutoff set within the teenage years guaranteed that the majority of data would not be censored.

Table 3 summarizes differences in age, stratified by baptisand gender, as a function of the number of male and female godparents. This exploratory analysis via Kaplan-Meier survival analysis (KMSA) is a first indicator that the number of godparents displays a positive relationship with baptisand survival odds in a unifactorial model. This is particularly evident in the association between godfathers and baptisand mean lifespan (Log Rank/Mantel-Cox: Chi-Square=1,490, df=2, p=.475, adjusted for baptisand gender), while the

The impact of godparents on baptisand survival

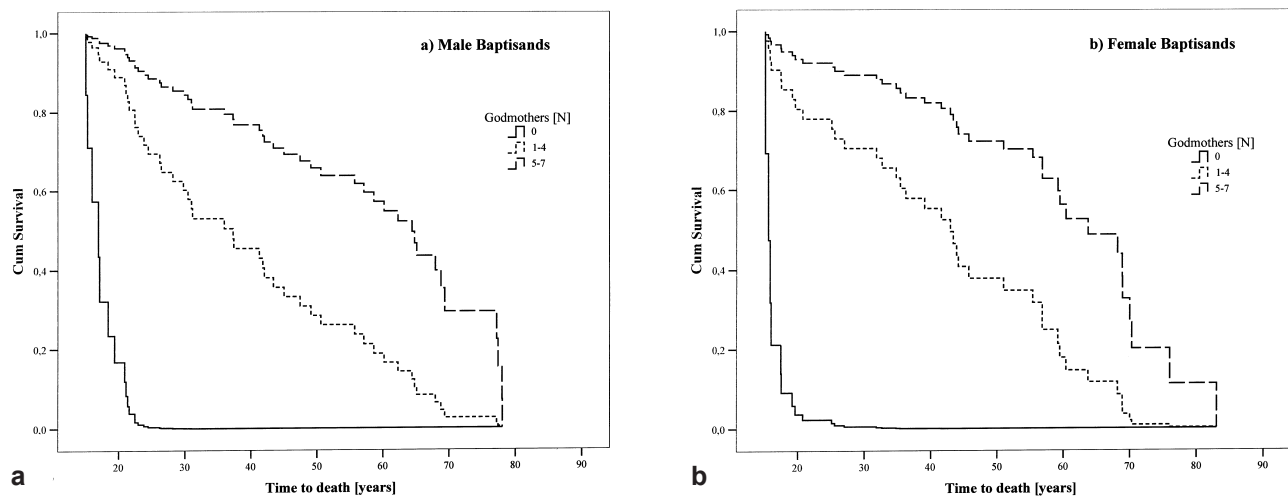


Fig. 1 a, b: Kaplan-Meier gender-specific baptisand survival curves evaluating the number of godmothers in relation to overall survival ($P=.015$). The models controls for cohort, birth rank, paternal SES, maternal age at birth as well as mother's death before age 15. Gender differences did not achieve statistical significance. [Source: Stockheim, County Friedland, East Prussia, 1772–1874].

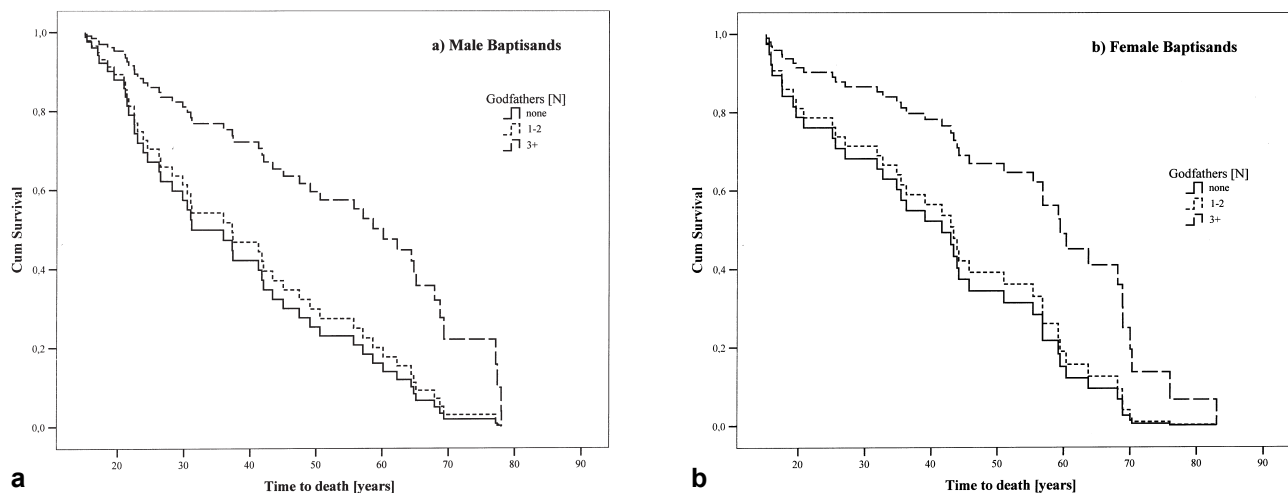


Fig. 2 a, b: Kaplan-Meier gender-specific baptisand survival curves evaluating the number of godfathers in relation to overall survival ($P=.200$). The models control for cohort, birth rank, paternal SES, maternal age at birth as well as mother's death before age 15. Gender differences did not achieve statistical significance. [Source: Stockheim, County Friedland, East Prussia, 1772–1874].

number of godmothers shows a slightly more varied picture (Log Rank/Mantel-Cox: Chi-Square=4,174, $df=2$, $p=.124$, adjusted for baptisand gender).

However, the KMSA is largely descriptive and not designed to assess the differential effects of covariates. In order to gain insights into the long-term effects of godparental solicitude, baptisand survival odds have to be tested controlling for a variety of biological as well

socio-demographic confounders. In order to identify the best subset of predictors which were significantly associated with negative outcome (baptisand death before age 15), univariate Cox proportional hazard analyses were performed. The analyses indicated that neither baptisand gender ($p=.435$), birth season ($p=.681$), nor father's age at birth ($p=.293$) or paternal death before age 15 ($p=.500$) achieved statistical

significance, while cohort ($p < .001$), birth rank ($p = .022$), paternal SES ($p = .006$), maternal age at birth ($p = .002$), mother's death before age 15 ($p = .022$), as well as the number of female, male and total number of godparents ($p < .001$ for all) were highly significant.

In a second step, all variables that exhibited trends to be associated with survival were included in a multivariate Cox regression. Of these, birth rank ($p = .024$), paternal SES ($p = .011$) and maternal age at birth ($p < .001$) retained statistical significance, while cohort did not ($p = .876$). The analyses further indicated that when all potential confounders are controlled for, neither the total number of godparents ($p = .352$) nor the number of godfathers ($p = .200$) achieved statistical significance. Only the number of godmothers remained an independent predictor of baptisand survival ($p = .015$).

The resulting survival curves, shown in figures 1 a, b and 2 a, b, document the impact of the number of godparents, stratified by baptisand and godparent gender. It should be noted that gender differences in baptisand survival did not achieve statistical significance and are of informative value only. As is evidenced, the number of godmothers displays a positive relationship with baptisand survival odds. The graphs indicate that baptisands without godmothers incurred pronounced risks of premature death when compared to their contemporaries with at least one female sponsor. More importantly, survival odds increased when individuals with an above average number of godmothers are considered. Intriguingly, a similar picture is evident when the number of godfathers is taken into consideration. While the latter differences did not achieve statistical significance, it is nevertheless obvious that an above average number of male sponsors markedly reduced the odds of premature death.

Discussion

The results of the current study support a structural functional approach to godparenthood that reveals an underlying complexity of social kinship ties. Parents chose sponsors to gain patrons for their child, as well as allies for themselves. According to Paul (1942), two kinds of godparent relationships can be distinguished. Those that are primarily "intensive" – chosen explicitly among kin with the purpose of intensifying existing familial bonds – and those that are "extensive" – created to encourage the extension of familial social relations. The latter has both a vertical and a horizontal element. Vertical relationships link individuals of different social status and power, while horizontal relationships keep members of a group or a class together. For Stockheim,

a highly stratified and extensive baptismal network emerges that suggests that the benefits associated with godparental solicitude were largely tied to maintaining material gains (horizontal bonds), while at the same time allowing for alliances with social superiors (vertical bonds), particularly within the lower socio-economic strata.

It was hypothesized that if baptismal bonds were generated to create alliances of mutual assistance and care, networks based on a large godparent support system should convey more tangible benefits than intimate circles of godparents. In addition, it was stipulated that godmothers would exert a more beneficial impact on the survival prospects of their (religious) charges than their male counterparts. The presented results support both of these a priori assumptions. By controlling for diverse socio-demographic background factors, empirical evidence emerged that choosing many godparents – particularly above average numbers of female sponsors – was advantageous to baptisand longevity. Thus, by carefully selecting godparents, parents implemented a fitness-maximising strategy, which proved to be successful. This distinctive sociobiological perspective may at first sight run counter to socio-cultural or historical interpretations of behavior, but has high explanatory power within the particular context of godparenthood – independent of whether said strategy was based on quantity, quality or a measure of both.

The finding that the number of godparents was a relevant predictor of baptisand survival, even after controlling for various biological and socio-economic background factors, indicates that by way of baptismal rites, fictive kinship ties were created, which went beyond the mere building of inter-familial alliances. This suggests that extended kinship systems – formalized through the ritual of infant baptism – obliged the godparent to provide the baptisand and his/her natal family with economic assistance, encouragement and guidance and reinforces the sociological paradigm that baptismal networks were aimed at securing mutual assistance and protection. With each baptism new opportunities of network expansion, both numerically as well as spatially, were created. However, cross-cultural comparisons also show that the number of godparents could not be extended ad infinitum but necessarily reflected a trade-off between parental aspirations, economic standing and what was deemed proper. Thus, while choosing many sponsors or inviting outsiders into the kinship fold may have been a core element, parents were also careful to avoid excessiveness or loose opportunities by selecting the same individual twice (Ericsson 2000; Foster 1969; Jussen 2000; Lynch 1986).

As evidenced here, the function of baptismal kin seemed to follow distinct gender rules. This may explain, why the “godparent effect” was more pronounced in female than male sponsors. While it is conceivable that the observed differentials were in part mitigated by the overrepresentation of female sponsors and the fact that the number of male sponsors varied by socio-economic strata, the survival benefits associated with many godmothers appear to be directly related to notions of co-motherhood and alloparenting. After rigorously controlling for confounders, the number of godmothers continued to exert a strong and positive impact on baptisand survival, regardless of the index child’s gender. This female dominance in the Stockheim alliances is worth examining not only because of its impact on baptisand well-being but because women are often underrepresented in the baptismal record (Hardwick 1998; Klapisch-Zuber 1985). It is likely that the overabundance of godmothers signals the presence of a female-controlled baptismal kinship nexus, replete with its own strategies and goals. Outside the male-dominated economic sphere, these female-oriented networks appear to have closely resonated with the core meaning of co-mother, with a strong emphasis on nurturing attributes (Kahler 1950; Klapisch-Zuber 1985; Fagerlund 2000;).

Intriguingly, the finding that godmothers enhance baptisand survival prospects also ties in with the evolutionary concept of alloparenting. Since a child’s ability to self-support falls below its consumption level, human offspring has to be subsidized throughout much of their growth and development (Kramer 2005; Sear and Mace 2008). Alloparenting is usually closely tied to kinship relations, but it appears that cooperation is reserved for kin as well as reciprocating partners, which lays the foundation for altruism (Gintis 2000). Godparenthood represents such a reciprocal network system, as baptismal bonds initiate lifetime obligations, binding those who confer the role to those who accept it, thereby strengthening existing ties and forming new political alliances (Kahler 1950; Moss and Cappannari 1960; Jütte 1994). With each baptism individuals became increasingly enmeshed in a web of ritual kinship that lasted throughout their life. With each generation, new opportunities of network expansion arose, which may well explain the preference for godparents from outside the consanguineal kinship fold (Zschuncke 1984; Cerutti 1991). Thus, in the eyes of many, this spiritual kinship was infinitely superior to the natural family, because it was not only built on sacramental grace but also on altruistic behaviour (Lynch 1986; Fine 1994).

Acknowledgement

I am deeply indebted to Steffan Bruns for providing me with the data as well as invaluable advice and numerous discussions related to the cultural ideosyncracies of the study population.

References

- Bruns S 2007. *Ortsfamilienbuch Stockheim (Kr. Friedland, Opr.) mit den zugehörigen Dörfern, Gütern und Vorwerken Beschluß, Dommelkeim, Domnauswalde, Eisenbart, Lawo, Lisettenfeld, Meisterfelde, Puschkeiten, Schleuduhnen, Schwönau, Sommerfeld, Waldhaus Bögen (Amen)*. Eigenverlag.
- Cerutti S 1991. *Group strategies and trade Strategies: The Turin tailors' guild in the Late Seventeenth and the Early Eighteenth Centuries*. In: Woolf S (Ed.). *Domestic strategies: Work and family in France and Italy 1600–1800*. Cambridge University Press. Cambridge, MA, 102–147.
- Ericsson T 2000. *Godparents, witnesses, and social class in mid-nineteenth century Sweden*. *The History of the Family* 5: 273–286.
- Euler HA, Weitzel B 1996. *Discriminative grandparental solicitude as reproductive strategy*. *Human Nature* 7: 39–59.
- Fagerlund S 2000. *Women and men as godparents in an early modern Swedish town*. *The History of the Family* 5: 347–357.
- Fine A 1994. *Parrains, marraines: La parenté spirituelle en Europe*. Fayard. Paris.
- Foster GM 1969. *Godparents and social networks in Tzintzuntzan*. *Southwestern Journal of Anthropology* 25: 261–278.
- Gaulin SJC, McBurney DH, Brakeman-Wartell SL 1997. *Matrilateral biases in the investment of aunts and uncles: A consequence and measure of paternity uncertainty*. *Human Nature* 8: 139–151.
- Gintis H 2000. *Strong reciprocity and human sociality*. *Journal of Theoretical Biology* 206: 169–179.
- Hardwick J 1998. *The practice of patriarchy. Gender and politics of household in Early Modern France*. The Pennsylvania State University Press. State College, PA.
- Jeon J, Buss DM 2007. *Altruism towards cousins*. *Proceedings of the Royal Society of London, Biological Sciences* 274: 1181–1187.
- Jussen B 2000. *Spiritual kinship as social practice: Godparenthood and adoption in the early Middle Ages*. University of Delaware Press. Newark, NJ.
- Jütte R 1994. *Poverty and deviance in Early Modern Europe*. Cambridge University Press. Cambridge, MA.

- Kahler C 1950. *The Godmother concept – Its place in the socio-economic structure*. Journal of Educational Sociology 24: 207–210.
- Karant-Nunn SC 1997. *The reformation of ritual: An interpretation of Early Modern Germany*. Routledge. New York.
- Kramer KL 2005 *Children's help and the pace of reproduction: Cooperative breeding in Humans*. Evolutionary Anthropology 14: 224–237.
- Klapisch-Zuber C 1985. *Women, family, and ritual in Renaissance Italy*. University of Chicago Press. Chicago.
- Lynch JH 1986. *Godparents and kinship in Early Medieval Europe*. Princeton University Press. Princeton, NJ.
- Monski P 1998. *Geschichte des Kirchspiels Stockheim, Kreis Bartenstein/Ostpreußen*. Heimatarchiv Nienburg. Nienburg.
- Moss LW, Stephen C 1960. *Cappannari patterns of kinship, comparaggio and community in a south Italian village*. Anthropological Quarterly 33: 24–32.
- Naumoviæ S, Jovanoviæ M 2004. *Childhood in South East Europe: Historical perspectives on growing up in the 19th and 20th Century*. LIT Verlag. Berlin, Hamburg, Münster.
- Paul BD 1942. *Ritual kinship, with special reference to coparenthood in Middle America*. Thesis, University of Chicago.
- Salaris L, Poulain M 2006. *The Use of Family Reconstructed Database in the Study of Human Longevity: The Population of Villagrande Strisaili (Sardinia)*. Chaire Quetelet 2006 – 29/11–1/12 Louvain-la-Neuve (Belgium).
- Sear R, Mace R 2008. *Who keeps children alive? A review of the effects of kin on child survival*. Evolution and Human Behavior 29: 1–18.
- Spinks BD 2006. *Reformation and modern rituals and theologies of baptism: From Luther to Contemporary Practices*. Ashgate Publishing. Aldershot/Burlington.
- Steinbach I, Henke W 2000. *Großelterninvestment – eine empirische interkulturelle Vergleichsstudie*. In: Schultz M et al. (Eds.). *Internationale Anthropologie, Tagungsband des 3. Intern. Kongresses der GfA Göttingen*. Cuvillier-Verlag. Göttingen, 103–106.
- Voland E 1989. *Differential parental investment: some ideas on the contact area of European social history and evolutionary biology*. In: Standen V, Foley RA (Eds.). *Comparative socioecology: the behavioural ecology of humans and other mammals*. Blackwell. Oxford, 391–403.
- Zschunke P 1984. *Konfession und Alltag in Oppenheim*. F. Steiner. Wiesbaden.

Address:

Ariane Kemkes
Tholius Institute
PO Box 28712
Scottsdale, AZ 85255
USA
Phone: +1 480 254 7223
Fax: +1 480 445 9765
E-mail: akemkes@tholiusinstitute.com

and

Caris Life Sciences
Biomarker Evidence (Target Now Division)
4750 S. 44th Place
Phoenix AZ, 85040
USA
direct: 602 792 2412
E-mail: akemkes@carisls.com

Parietal expansion during later hominin evolution, and the validity of *H. heidelbergensis* – A quantitative approach

MARTIN FRIESS

Département Hommes, Natures, Sociétés, UMR 7206 du CNRS, Paris, France

Summary

The evolution of the modern cranial shape and globularity is the result of a variety of morphological changes that occurred during the later Pleistocene, parietal expansion being one of them. However, this trend has also been described in Neandertals, which bears the question, when and where this character appears, and what it implies for middle Pleistocene human phylogeny. This study presents a quantitative comparison of parietal shape in various species of *Homo* based on 3D geometric morphometrics. The results confirm the existence of a shared trend toward parietal expansion found in both *H. sapiens* and *H. neanderthalensis*, but absent in *H. erectus* and *H. rhodesiensis*. If confirmed by additional samples, this would be consistent with an afro-european last common ancestor of modern humans and Neandertals, though to the exclusion of Petralona and Kabwe.

Key words: Cranial globularity, parietal expansion, middle Pleistocene *Homo*, geometric morphometrics

Zusammenfassung

Die Evolution der modernen Schädelform und Globularität resultiert aus einer Reihe morphologischer Änderungen im Laufe des späteren Pleistozän, darunter die Expansion der Scheitelbeine. Solch ein Trend zu ausladenderen Parietalia wurde jedoch auch bei Neandertalern beschrieben, was zur Frage des zeitlichen und geographischen Ursprungs dieses Merkmals, sowie dessen phylogenetischen Implikationen für mittelpleistozäne Homininen führt. Die vorliegende Studie unternimmt einen geometrisch morphometrischen Vergleich des Parietale in verschiedenen *Homo*-Arten. Die Ergebnisse bestätigen quantitativ, dass der Trend zur erweiterten Parietalregion sowohl in Neandertalern als auch in Sapiënten zu finden ist, jedoch weder in *H. erectus* noch *H. rhodesiensis*. Dies bedarf zwar weiterer Daten und Untersuchungen, erweist sich jedoch vorläufig als übereinstimmend mit der Idee, dass der gemeinsame Vorfahr von *H. sapiens* und *H. neanderthalensis* im Afro-Europäischen Raum zu finden ist, jedoch nicht von Funden wie Kabwe und Petralona repräsentiert wird.

Schlüsselwörter: Kraniale Kugelform, Parietale Expansion, mittelpleistozäner *Homo*, geometrische Morphometrie

Introduction

The phylogeny of later Pleistocene hominins still remains a widely discussed issue in paleoanthropology, despite recent advances, particularly in the area of ancient DNA (Endicott *et al.* 2010, Green *et al.* 2010). While a consensus appears to assign Neandertals the role of sister taxon of the lineage leading up to anatomically modern humans, the exact time and mode of this evolutionary process remains open to debate (cf. Havarti *et al.* 2010, Hublin 2009, Rightmire 2009, Tattersall 1992). It is generally assumed that *H. heidelbergensis* gave rise to the Neandertals, but its phylogenetic relation to *H. sapiens* remains unclear. In

this debate, two fundamentally different models oppose each other, depending on how this relation is seen: Either *H. heidelbergensis* is the exclusive ancestor to Neandertals, and its distribution is therefore limited to Europe (Bermúdez de Castro *et al.* 1997). Or, according to the alternative view, it is the common ancestor of Neandertals and *H. sapiens*, in which case its definition includes African fossils as well (Rightmire 2009, Tattersall 1992). Because the Kabwe skull is often grouped with European specimens (Sima de los Huesos, Arago, Petralona among others) as representing this common ancestor, Hublin (2009) has suggested to use the term *H. rhodesiensis*, of which Kabwe is the type specimen. In a recent study of calvarial shape in

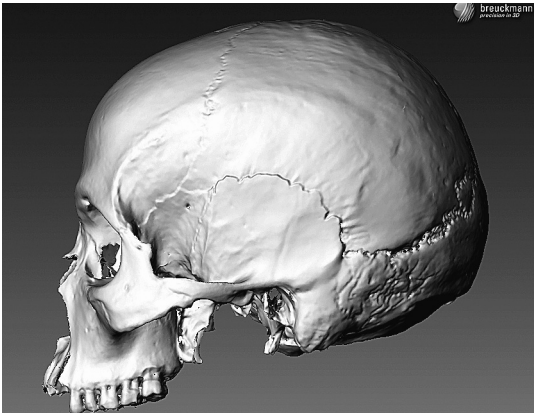


Fig. 1: 3D surface scan of a modern human skull.

the Middle Pleistocene, Friess (2010) suggested to reserve this species name (for now) to Kabwe and Petralona, whose strong affinities have been noted in the past (Stringer *et al.* 1979).

In terms of morphology, recognized Neandertal apomorphies, such as the midfacial prognathism, suprainiac fossa, or the occipital bun are often used as demonstrating the phylogenetic link to older European and African material (Dean *et al.* 1998, Rightmire 1998). At the same time, the increase in endocranial volume and associated parietal expansion is identified as apomorphic in both Neandertals and *H. sapiens*, in opposition to the elongated and flat vault in *H. erectus* (Day *et al.* 1980, Lieberman *et al.* 2002, Stringer *et al.* 1979, Rightmire 2009). The difficulty in assessing Middle Pleistocene phylogeny and taxonomy is accentuated by the fragmentary state of fossils and issues with quantifying some of the features involved (Hublin 2009, Friess 2010, Harvati *et al.* 2010). The former problem has been addressed by separately comparing the various cranial portions, the latter by the statistical analysis of landmark data (Rohlf and Marcus 1993, Friess 1998, Harvati *et al.* 2010). Of particular interest is the use of 3D scan data, which allow for the analysis of large surfaces without “good” landmarks (type I according to Bookstein 1991). This study represents one such attempt in characterizing the shape of a surface, in this case that of the parietal. Because it is directly subjected to the anatomical consequences of increased endocranial volume, it can be theorized that its shape variation provides further insight into Mid-Pleistocene hominin phylogeny.

Specimen	Presumed Taxonomy
La Ferrassie I (o)	
Guattari (o)	
La Chapelle-aux-Saints (o)	
La Quina H5 (o)	
Neandertal 1 (o)	
Spy 1 (o)	
Spy 2 (o)	<i>H. neanderthalensis</i>
Amud (c)	
Tabun C (o)	
Fontchevade (o)	
Forbes' Quarry (o)	
Saccopastore 1 (c)	
Shanidar 1 (c)	
Reilingen (o)	
SH5 (c)	
Steinheim (o)	<i>H. heidelbergensis</i>
Saldanha	
Arago 47 (c)	
Swanscombe (o)	
Petralona (c)	<i>H. rhodesiensis</i>
Kabwe (o)	
Dmanisi 2280 (c)	
Sinanthropus pekinensis (c)*	<i>H. erectus sensu lato</i>
KNM-ER3733 (c)	
Singa (o)	
Irhoud 1 (c)	<i>H. sapiens</i>
Skhul V (c)	
Mladec 1 (o)	

Tab. 1: Sample composition. Scan made from original specimens are marked by (o), all others are casts.
* Reconstruction by Tattersall and Sawyer (1996), courtesy of Dept. Anthropology, AMNH.

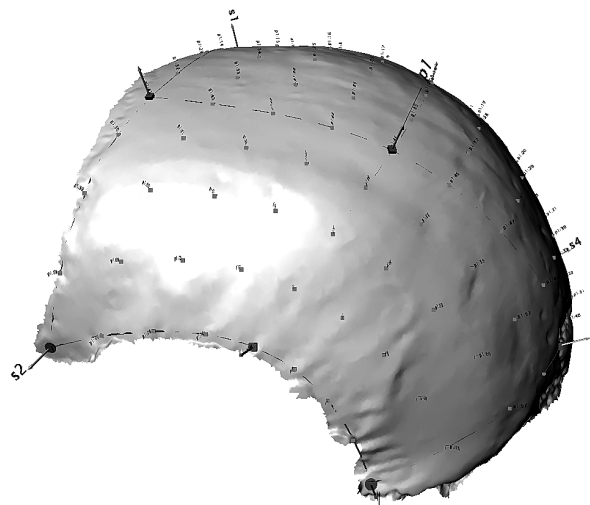


Fig. 2: Landmarking along the surface of the parietal using Landmark editor (Wiley *et al.* 2005).

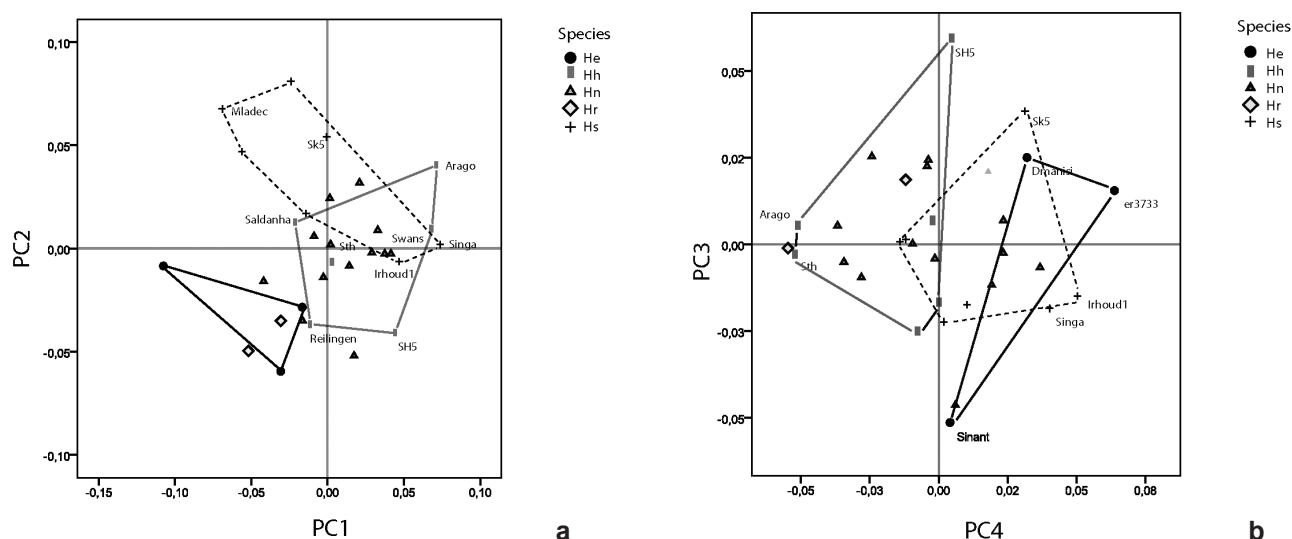


Fig. 3: PCA, components 1–2 (a) and 3–4 (b).

Material and Methods

The present study is based on 3D surface data of fossil hominins and modern human skulls. A total of 28 parietals of fossil specimens were measured, to which 3 anatomically modern humans were added from the collections of the Musée de l'Homme, Paris. Surface scans were obtained with a portable 3D scanner (Breuckmann smartscan stereo), which generates a digital model of the outer surface with a spatial resolution of about 0.26mm (Fig. 1). Surface scanning is a rapid, non-invasive technique for digitally archiving human remains, and making them accessible to 3D analysis. It has become increasingly available in paleoanthropology, mostly due to its relatively low cost and ease of application when compared to CT-scanning (Friess 2006, 2010, Friess *et al.* 2002, Harcourt-Smith *et al.* 2008, Lyons *et al.* 2000, Tocheri *et al.* 2005). Only in one case (Guattari), CT-scan data were used to create a 3D mesh by applying thresholding techniques (Spoor *et al.* 1993). Table 1 lists the specimens included, and also notes whether the original or a cast was used. All specimens were given operational taxonomy based on the most common assignments found in the literature. However, Petralona was grouped together with Kabwe (cf. Friess 2010, and discussion below). Note that group affiliation has no impact on the shape statistics. Once scanned, 3D data were post-processed with standard off-the-shelf software. Post-processing included mesh

decimation and, in several cases, completion through repairing and mirror-imaging. The use of virtually reconstructed specimens in paleoanthropology is a topic beyond the scope of this paper (see Gunz *et al.* 2009). It should be pointed out, however, that for the purposes of the present study, reconstruction was minimal. The process also ensured that major asymmetries, due to plastic deformation or alike, had no significant effect on data analysis.

3D coordinates were recorded for each specimen using “landmark-editor” (Wiley *et al.* 2005). The landmarks (Fig. 2) included standard anthropometric points (bregma, lambda, pterion and the base of the parietal notch) as well as 81 semi-landmarks, evenly spaced across the parietal and bordered by the 4 standard landmarks (Wiley *et al.* 2005, Harcourt-Smith *et al.* 2008).

Landmarks were aligned by a generalized Procrustes Analysis (GPA), in which the semilandmarks were treated as type III landmarks (Maddux and Francis 2009, Niewoehner 2001). Procrustes residuals were submitted to a Principal Components Analysis (PCA) to explore major directions of shape variation in the sample. Centroid size (log-transformed) was used as an overall size estimator, and its influence on evolutionary allometry was assessed through scatter plots against the principal components. Landmark configurations along the directions of interest were estimated by multivariate regression, and visualized by NURBS (non-uniform

rational B-splines) surfaces, which were fitted to the semilandmarks to enhance interpretation and readability. GPA and PCA were performed in MorphoJ (Klingenberg 2008), NURBS surfaces were generated in Rhino3D.

Results

The overall shape variation of the parietals across the sample can be summarized quite efficiently with the first few components, seeing that PC 1 through 4 account for 66% of the total variance (31.2%, 14.2%, 11.7% and 9.1% respectively). Hence, by far the largest amount of variance describes the shape difference between *H. erectus* and *H. rhodesiensis* on the one hand and modern humans on the other, with both Neandertals and *H. heidelbergensis* interspersed and partially overlapping. Kabwe and Petralona are always in close proximity (Fig. 3).

The shape changes associated with this component (Fig. 4) combine antero-posterior shortening with moderate vertical expansion, most notably along the temporal suture and, when seen from above, around the parietal eminence. In frontal view, the lateral portions are vertically oriented, and the vault appears more wide than high. The second component, accounting for a rather small portion of the total variance, mostly reflects changes in the width/height proportions, as the vault increases vertically along with pc scores, while the relative width decreases. The lateral walls are also less vertical, more convex, the temporal margin becoming narrower. PC 3 also yields a scatter that appears pertinent with respect to hominin phylogeny. It mainly contrasts between *H. heidelbergensis* and *H. erectus*, whereas both Neandertals and *H. sapiens* overlap, and *H. rhodesiensis* falls within the *H. heidelbergensis* scatter.

Significant size differences exist at the species level, albeit only between *H. erectus* and all other groups, which display comparable ranges for log centroid size (Fig. 5). The smallest value is found for Dmanisi, ER 3733 and *Sinanthropus*, the largest value is shown by Shanidar 1, followed by Singa and several other modern humans and classic Neandertals.

The first PC is significantly correlated with log centroid size ($r=0.5$, $p<0.005$), thus reflecting mostly the small size and distant shape of *H. erectus*, when compared to all other hominins in this analysis.

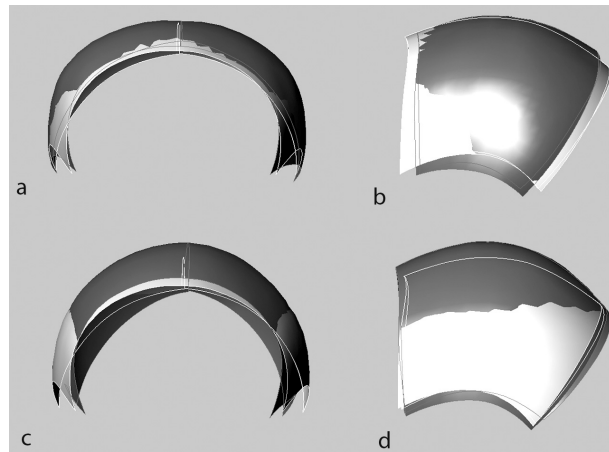


Fig. 4: Shape differences along PC. Shape change from consensus associated with positive scores along pc 1 (a – frontal view, b – lateral view) and 2 (c,d).

Discussion

Reconstructing Middle Pleistocene hominin phylogeny has long been a main research focus in paleoanthropology, and has been accentuated by Mayr's recognition of only 2 species, *H. erectus* and *H. sapiens* (Mayr 1950). The ensuing uncertainty regarding the phylogenetic status of fossils of presumably more ambiguous/intermediate morphology led to what some have referred to as the "muddle" in the middle (Butzer and Isaac 1976), and to the unsatisfactory, for obviously preliminary creation of the grab bag called "archaic *H. sapiens*". Following Stringer *et al.* (1979), current research has predominantly replaced this term, in a back-to-the-roots-like effort, by the species *H. heidelbergensis* (Schoetensack 1908), whose recognition predates Mayr's revision, without achieving a consensus on which fossils should be part of it and which should not. While it is true, as Hublin (2009) points out, that the argument is further hampered by the incompleteness of fossil specimens, this issue can hardly be regarded specific to the Middle Pleistocene. Regardless of which characters are used to define the various species involved, researchers recognize unanimously that the evolutionary trend toward increased encephalization was accommodated, in part, by parietal expansion, making this feature in theory a good measure of evolutionary state (Day *et al.* 1982, Lieberman *et al.* 2002). In Neandertals, horizontally expanded parietals contribute to the characteristic oval shape in posterior view, while modern humans undergo

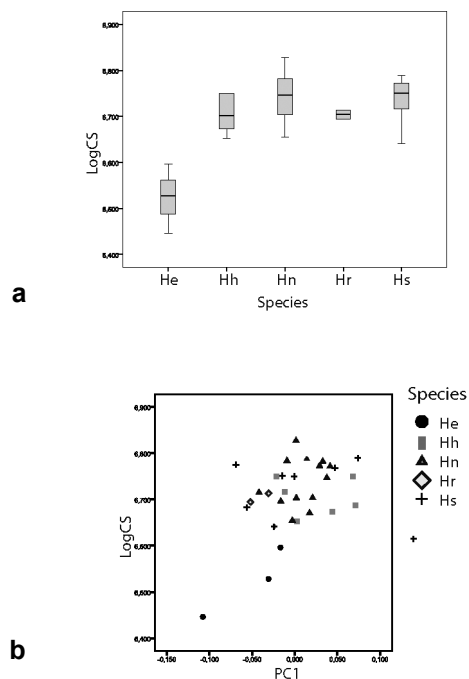


Fig. 5: Size variation (a) and Allometry (b – log size against pc 1).

an additional vertical expansion. However, in the absence of significant size differences, the existence of allometric differences (Bruner *et al.* 2003; Bruner 2010) as driving the shape differences is not corroborated. Therefore, an improved means of quantifying parietal shape should yield a better understanding of the pattern of expansion throughout the Later Pleistocene and across various species. However, when considered isolated, the parietal shape appears much more similar in all later Pleistocene groups including anatomically modern humans. The ancestral condition, low parietal expansion, is found in *H. erectus* and *H. rhodesiensis*, whereas most Neandertals and *H. heidelbergensis* share the trend toward the shortened, and more convex shape of modern humans. Still, antero-posterior lengthening is also seen in some modern humans, most notably Mladec 1, but in these cases the vertical expansion and increased convexity fall into the modern pattern. Several representatives of *H. heidelbergensis* show more affinities to modern humans with respect to parietal shape, while others are much more ancestral, and therefore closer to *H. erectus*. Thus, Arago 47 and Swanscombe, appear surprisingly modern, though at least Swanscombe shows otherwise clear Neandertal apomorphies in the occipital (Hublin 1978). Reilingen,

on the other hand, is marginal to most Neandertals and falls in the vicinity of *H. erectus/rhodesiensis*, despite it being considered a “pre-Neandertal” (Dean *et al.* 1998). SH5, often associated with *H. heidelbergensis*, exhibits antero-posterior shortening akin to modern humans, but is rather ancestral in its vertical height and low convexity. Fossil *H. sapiens* are widespread across the first two components, and it could be argued that this is due mostly to the position of Singa and Irhoud 1. The former might be affected in its parietal shape by pathology (Stringer 1979), the latter may be far from other modern humans because of plastic deformation, or it may be less modern than previously suggested. As was previously noted (Stringer *et al.* 1979, Friess 2010), Petralona and Kabwe are overall quite similar craniofacially, and the present study corroborates these similarities with respect to parietal shape.

Conclusion

The aim of this study was to quantify hominin parietal shape variation by means of 3D morphometrics, in order to reassess the evolution of modern humans and their immediate ancestors. The results, while still preliminary and to be confirmed by extended samples, do provide an additional argument to link Petralona and Kabwe and support their affinities with *H. erectus*, while removing them a little further from the Neandertal lineage and its presumed ancestor *H. heidelbergensis*. The latter, in return, appears to have more modern-like parietals than previously described. However, additional samples may provide a better resolution of this particular aspect of the issue, which therefore remains open until further investigation.

Acknowledgments

I would like to thank the following individuals for providing access to specimens and scans: Robert Kruszynski, Roberto Macchiarelli, Philippe Menecier, Michael Schmauder, Patrick Semal, Chris Stringer, Ian Tattersall, Maria Teschler-Nicola, Gerhard Weber, Reinhard Ziegler.

I would like to thank the persons in charge of inviting me to contribute to this volume in honor of W. Henke, who guided me through my first steps in paleoanthropology.

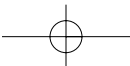
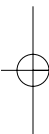
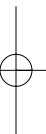
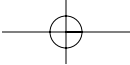
References

- Bermúdez de Castro JL, Arsuaga JM, Carbonell E, Rosas A, Martínez I, Mosquera M 1997. *A Hominid from the Lower Pleistocene of Atapuerca, Spain: Possible Ancestor to Neandertals and Modern Humans*. Science 276: 1392–1395.
- Bookstein FL 1991. *Morphometric Tools for Landmark data: Geometry and Biology*. Cambridge University Press. Cambridge.
- Bruner E 2004. *Geometric morphometrics and paleoneurology: brain shape evolution in the genus Homo*. JHE 47: 279–303.
- Bruner E 2010. *Morphological differences in the Parietal Lobes within the Human Genus*. Current Anthropol. 51, suppl. 1: S77–S88.
- Bruner E, Manzi G, Arsuaga JL 2003. *Encephalization and allometric trajectories in the genus Homo: Evidence from the Neandertal and modern lineages*. PNAS 100, 26: 15335–15340.
- Butzer KW, Isaac GL 1976. *After the Australopithecines: stratigraphy, ecology, and culture, change in the Middle Pleistocene*. International Congress of Anthropological and Ethnological Sciences 9C1. The Hague, Mouton, 911.
- Day MH, Leakey MD, Magori C 1980. *A new hominid fossils skull (LH18) from the Ngaloba Beds, Laetoli, northern Tanzania*. Nature 284: 55–56.
- Day MH, Stringer CB 1982. *A reconsideration of the Omo Kibish remains and the erectus-sapiens transition*. In: de Lumley MA (Ed.). *L'Homo erectus et la place de Tautavel parmi les hominidés fossiles*. Premier Congrès de L'Institut de Paléontologie Humaine. Nice, 573–594.
- Dean D, Hublin J-J, Holloway R, Ziegler R 1998. *On the phylogenetic position of pre-Neandertal specimen from Reilingen, Germany*. Journal of Human Evolution 34: 485–508.
- Endicott P, Ho SYW, Stringer CB 2010. *Using genetic evidence to evaluate palaeoanthropological hypotheses for the timing of Neanderthal and modern Human origins*. Journal of Human Evolution 59: 87–95.
- Friess M 1999. *Taille et conformation crânienne Durant la fin du Pleistocène. L'approche de la morphométrie géométrique qu'il débat sur m'origine de l'Homme moderne*. BAR International Series 799. Oxford.
- Friess M 2006. *The study of craniofacial growth patterns using 3D laser scanning and geometric morphometrics*. In: Corner BD, Li P and Tocheri M (Eds.). *Three-Dimensional Image Capture and Applications*. Proceedings SPIE, Vol 6056, 184–188.
- Friess M 2010. *Calvarial shape variation among Middle Pleistocene hominins – An application of surface scanning in paleoanthropology*. CR Palevol 9: 435–443.
- Friess M, Marcus LF, Reddy DP, Delson E 2002. *The Use of 3D Laser Scanning Techniques for the Morphometric Analysis of human Facial Shape Variation*. In: Mafart B and Delingette H (Eds.). *Proceedings of the XIVth UISPP Congress, 2001, Three-Dimensional Imaging in Paleoanthropology and Prehistoric Archaeology*. British Archaeological Reports, S1049. Archaeopress. Oxford, 31–35.
- Green RE, Krause J, Briggs AW, Maricic T, Stenzel U, Kircher M, Patterson N, Li H, Zhai W, Hsi-Yang Fritz M, Hansen NF, Durand EY, Malaspina A-S, Jensen JD, Marques-Bonet T, Alkan C, Prüfer K, Meyer M, Burbano HA, Good JM, Schultz R, Aximu-Petri A, Butthof A, Höber B, Höffner B, Siegemund M, Weihmann A, Nusbaum C, Lander ES, Russ C, Novod N, Affourtit J, Egholm M, Verna C, Rudan P, Brajkovic D, Kucan Z, Gusic I, Doronichev VB, Golovanova LV, Lalueza-Fox C, de la Rasilla M, Fortea J, Rosas A, Schmitz RW, Johnson PLF, Eichler EE, Falush D, Birney E, Mullikin JC, Slatkin M, Nielsen R, Kelso J, Lachmann M, Reich D, Pääbo S 2010. *A Draft Sequence of the Neandertal Genome*. Science 328(5979): 710–722.
- Gunz P, Mitteroecker P, Neubauer S, Weber GW, Bookstein FL 2009. *Principles for the virtual reconstruction of hominid crania*. Journal of Human Evolution 57(1): 48–62.
- Harcourt-Smith WEH, Tallman M, Frost SR, Wiley DF, Rohlf FJ, Delson E 2008. *Analysis of selected hominoid joint surfaces using laser scanning and geometric morphometrics: A preliminary report*. In: Sargis EJ and Dagosto M (Eds.). *Mammalian Evolutionary Morphology. A tribute to Frederick S. Szalay*. Springer. New York, 373–383.
- Harvati K, Hublin JJ, Gunz P 2010. *Evolution of middle-Late Pleistocene human cranio-facial form: a 3-D approach*. Journal of Human Evolution 59(5): 445–464.
- Hublin JJ 1978. *Quelques caractères apomorphes du crâne néanderthalien et leur interprétation phylogénique*. CRAS (D) 287: 399–403.
- Hublin JJ 2009. *The origin of Neandertals*. Proceedings of the National Academy of Sciences 106(38): 16022–16027.
- Klingenberg CP 2008. *MorphoJ*. Faculty of Life Sciences, University of Manchester, UK, http://www.flywings.org.uk/MorphoJ_page.htm.
- Lieberman DE, McBratney BM, Krovitz G 2002. *The evolution and development of the cranial form in Homo sapiens*. Proceedings of the National Academy of Sciences 99: 1134–1139.
- Lyons PD, Rioux M, Patterson RT 2000. *Application of a Three-dimensional Color Laser Scanner to Paleontology*. Paleontologia Electronica 3(2): 1–16.
- Maddux SD, Franciscus RG 2009. *Allometric scaling of infraorbital surface topography in Homo*. Journal of Human Evolution 56(2): 161–174.
- Mayr E 1950. *Taxonomic categories in fossil hominids*. Cold Spring Harbor Symp. Quantitative Biology 15: 109–118.
- Niewoehner WA 2001. *Behavioral inferences from the Skhul/Qafzeh early modern human hand remains*. Proceedings of the National Academy of Sciences 98: 2979–2984.

- Rightmire GP 1998. *Human evolution in the Middle Pleistocene: The role of H. heidelbergensis*. *Evolutionary Anthropology* 6(6): 218–227.
- Rightmire GP 2009. *Middle and later Pleistocene hominins in Africa and Southwest Asia*. *Proceedings of the National Academy of Sciences* 106(38): 16046–16050.
- Rohlf FJ, Marcus LF 1993. *A revolution in morphometrics*. *Trends in ecology and evolution* 8(4): 129–132.
- Schoetensack O 1908. *Der Unterkiefer des Homo heidelbergensis aus den Sanden von Mauer bei Heidelberg*. Engelmann. Leipzig.
- Spoor CF, Zonneveld FW, Macho GA 1993. *Linear measurements of Cortical bone and dental enamel by computed tomography: Applications and Problems*. *American Journal of Physical Anthropology* 91: 469–484.
- Stringer CB 1979. *A re-evaluation of the fossil human calvaria from Singa, Sudan*. *Bulletin of the British Museum (Natural History, Geology)* 32(1): 77–83.
- Stringer CB, Howell FC, Melentis JK, 1979. The significance of the fossil hominid skull from Petralona, Greece. *Journal of Archaeological Science* 6: 235–253.
- Tattersall I 1992. *Species concepts and species identification in human evolution*. *Journal of Human Evolution* 22: 341–349.
- Tattersall I, Sawyer GJ 1996. *The skull of "Sinanthropus" from Zhoukoudian, China: a new reconstruction*. *Journal of Human Evolution* 31(4): 311–314.
- Tocheri MW, Razdan AR, Williams C, Marzke MW 2005. *A 3D quantitative comparison of trapezium and trapezoid relative articular and nonarticular surface area in modern humans and great apes*. *Journal of Human Evolution* 49(5): 570–586.
- Wiley DF 2005. *Landmark v 3.0*. Institute for Data Analysis and Visualization, University of California. Davis.

Address:

Martin Friess
 Département Hommes, Natures, Sociétés,
 UMR 7206 du CNRS
 43, rue Buffon
 75013 Paris
 France
 Tel.: +33 140 798 056
 Fax: +33 140 793 891
 E-mail: friess@mnhn.fr



Execution and determent – Giving a face to the Langenfeld skull

STEFAN SCHLAGER¹, PETER PIEPER², URSULA WITTEW-BAKOFEN^{1*}

¹*Dept. of Anthropology, Medical Faculty, Albert-Ludwigs-University, Freiburg, Germany*

²*Institute of Forensic Medicine, Heinrich Heine-University, Düsseldorf, Germany*

**Corresponding author*

Summary

The finding of the impaled skull of a young upper class woman in Langenfeld/Rhineland, who had apparently been sentenced to death by decapitation during the late 17th or early 18th century, attracted the interest of scientists across the disciplines. Following a first detailed anthropological description by Winfried Henke it was possible to reconstruct the rare case of a non-local woman who received death penalty possibly by breaking on the wheel and exhibition of her head after decapitation. This specific case was used to apply a variety of recent developments in virtual facial reconstruction techniques. The results will be presented in the local museum of Langenfeld.

Keywords: Facial reconstruction, facial soft tissue, geometric morphometrics, death penalty, decapitation

Zusammenfassung

Der bislang einzigartige Fund des genagelten Schädels einer jungen Frau aus wohlhabender Schicht in Langenfeld/Rheinland aus dem späten 17. oder frühen 18. Jh. erregte die Aufmerksamkeit von Wissenschaftlern unterschiedlicher Disziplinen. Nach einer ersten ausführlichen anthropologischen Untersuchung durch Winfried Henke konnte der Fall einer Frau nichtrheinischer Herkunft rekonstruiert werden, die offenbar zum Tod durch Enthauptung mit oder ohne vorhergehendem Rädern und unter anschließender Zurschaustellung des durch einen langen Nagel fixierten Kopfes verurteilt worden war. Dieser besondere Fall wurde zum Anlass genommen, neue Entwicklungen der virtuellen Gesichtsrekonstruktion zu demonstrieren. Die Ergebnisse werden dem Besucher nun im Stadtmuseum Langenfeld zugänglich gemacht.

Schlüsselwörter: Gesichtsrekonstruktion, Gesichteweichteile, geometrische Morphometrie, Todesstrafe, Dekapitation

Introduction

In the “*Bonner Jahrbücher*” 1981, Winfried Henke reported in detail about a skull which attracted great attention since its discovery in 1964. The skull was found speared with a large iron nail still *in situ* (Fig. 1). In 1966, it was first described by Weber: “*Skull of a young woman with a 47 to 48 cm long iron nail which penetrated the first cervical vertebra. The vertebra is still intact, surrounding the nail. Only half of the mandible is preserved. Additionally found: two fragments of a brocade cap or band placed around the head in the temple area. Silver filaments which are woven to a mesh are visible. Fine silver wires are also adhered to different areas of the skull. Adjoined to the larger textile fragment a small bronze piece was preserved. Two further bronze fragments were also*

found. They seem to originate from the fixation of the brocade band.” (Weber 1966, p. 160; translation by the authors).

The specific features of this apparently historical finding aimed at the reconstruction of a peculiar situation: a head impaled for exhibition after decapitation by nailing on a stake or wheel. Therefore this particular skull received a lot of attention as an example of decapitation used as a punishment in historical jurisprudence, helping to understand former social structures and rules. What kind of a delict could have resulted in such a punishment and how does the individual living profile of the respective person fit to the facts known for such a jurisprudence? This led to intensive research of the physical profile of the unknown person to be reconstructed from the skull and the accompanying materials.

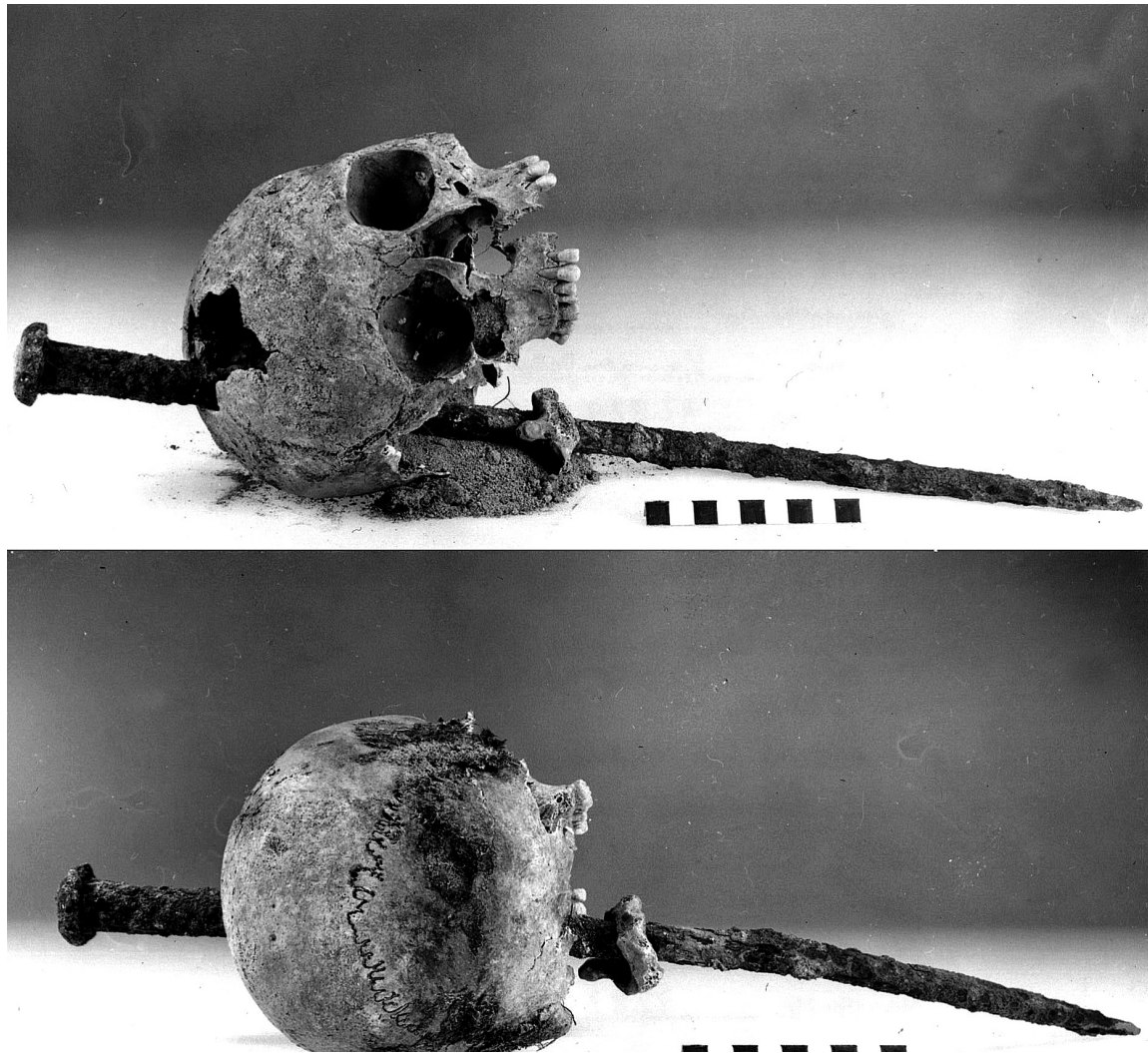


Fig. 1: Original situation of the Langenfeld skull with penetration of a long nail.

Following the comprehensive anthropological analysis by Henke (1981), facial soft tissue reconstructions of the skull were performed by developing various new technical approaches in virtual anthropology. The results will be exhibited in a museum context trying to bring history close to visitors by facing an individual's destiny.

The discovery of the Langenfeld skull and previous studies

As Weber reported, half of the mandible originally was preserved but it was not present anymore when

Henke examined the skull in 1979. Thus, he described a calvarium that showed significant damage which can be traced back to the nailing and impaling procedure as well as to soil decomposition effects. The right viscerocranium shows numerous fractures and dislocations that have to be considered for the facial reconstruction. The vertex shows a large keyhole-shaped damage around the nail penetration position. This as well as extensive damage of the area around the foramen magnum and the completely missing right temporal bone aided the significant distortion of the skull during soil exposure.

Additionally, a single postcranial segment has been completely preserved – the second cervical vertebra, the axis, which was found with the iron nail penetrating the

vertebral canal without destructing it. The impaling procedure was reconstructed the way that the long nail had been attached to the vertex, then imbossed with a firm blow through the cut off head towards the vertebral canal, and finally leaving the head through the cervix wound.

Sex diagnosis had been performed with undoubted results. Weber (1966, then Henke 1981) described the skull as female based on its gracile appearance, whereas Henke (1981) added a list covering the whole anthropological spectrum of morphological traits on shape and size of the skull. A discriminant function including three metric variables supports the impression of a hyperfeminine skull (Henke 1981). A revision was recently performed by genetic fingerprinting and haplotyping using a tooth root. Amelogenin fragment length polymorphism was tested and led to the estimation of female sex with high probability (Pieper 2010, investigation performed by Susanne Hummel and Verena Seidenberg, Göttingen).

Based on Infrared Spectroscopy and AMS-C14 dating the postmortem interval could be estimated and led to a relatively narrow dating between the years of 1668 and 1707 (Pieper and Schlüter 2008, investigation performed by Pieter M. Grootes *et al.*, Kiel).

The age-at-death estimation had to be limited to traits of the skull and could not include the whole spectrum of aging traits of the entire skeleton. Single aging traits occasionally can deviate from the mean age derived from a larger number of aging traits. Thus cranial suture closure and an indirect consideration about completed sphenobasilar ossification, concluded from the degree of occipital damage, point towards an age of around 30 years (Henke 1981). However, dental records and particularly dental attrition point towards a younger adult or even suggest juvenile age. Concluding from the somewhat diverse results an age around 30 years with a tendency towards a younger age is most probable. So far, no tooth root was investigated for the more precise chronological aging method using Tooth Cementum Annulation.

The preserved brocade materials were recently studied with regard to textile classification and chemical composition. Scanning Electron Microscopy (SEM) and Energy Disperse X-ray Spectroscopy (EDX) showed that most precious materials had been used: Besides woven silk gold coated silver fibres were detected. The golden bands are interpreted as ornaments influenced by the Spanish Court costume habits displayed among the nobility all over Europe during the 16th century (Pieper 2010, investigation performed by Elke Michler and Annemarie Stauffer, Cologne).

Computed tomography was performed at the Bonn University Clinic of Radiology to digitally visualize

morphology and postmortem damage of the skull and to serve as basic three-dimensional data for facial reconstruction. A spiral CT technique with a 0,4 mm increment was applied (Pieper 2010, investigation performed by Attila Kovács, Bonn). Together with the macroscopic paleopathological investigation of Henke (1981), the described damage of the skull was interpreted as consistent with impaling by nailing in a perimortem context or after a short postmortem interval when soft tissue still held the skull and cervical vertebrae in place.

Historical nailing and staking procedures in the context of the Langenfeld skull

The historical context of impaling and nailing procedures has been described in detail by Henke (1981), Pieper (2003), and Pieper and Schlüter (2008). According to the literature jurisprudence during the 13th to 18th century imposed the punishment of breaking on the wheel, partly combined with nailing or impaling of the head, quite commonly for a variety of delicts in central Europe. Individual cases have been confirmed, mostly by finding skulls in specific execution places or gallows squares (Auler 2008, 2010). Thus, in such cases historical jurisprudence becomes comprehensible and complements written legal sources and historical case documents. Bringing all sources together, it helps understanding historical society codes and laws (Bonte and Pieper 1995, 1996). It is known from such sources that the decapitation of a delinquent causing sudden death by a sword cut was regarded as a comparatively respectable punishment for a long time. In the Cologne region, close to Langenfeld, decapitation as a mode of executing female delinquents was introduced quite late, but it was still verified in the case of a female triple murderer at Düsseldorf in 1712, and is documented by an execution protocol concerning a female fourfold murderer in the Mark Brandenburg as late as 1770 (Henke 1981). In such cases decapitation, limb breaking on the wheel, impaling, nailing or staking were applied in various combinations, mainly connected to procedures of exhibiting the body and/or the head of a delinquent.

Including the individual data retrieved from the Langenfeld skull a historical picture of this specific case can be drawn. The skull belonged to a young woman who was killed in the late 17th or early 18th century at an age of about 30 years or less. Her precious cap, hairband or -net with brocade containing fine silken, silver and golden applications suggests that she belonged to a higher social class. Considering her

healthy dentition, which also can be regarded as an indicator for a cultivated lifestyle, she might have been a member of a noble lineage. As the style of her headgear indicates she might have been of Dutch provenance, having passed earlier along a frequently used trade route connecting northwestern and central Europe. She might have been considered to be a witch, but other possible reasons for her execution include infanticide, homicide by intoxication or the commitment of adultery. Decapitation must be assumed, although not directly proved, e.g., by cutting marks at the preserved second vertebra. Her head was exhibited by nailing and thus impaling it on a hard substrate, possibly a wooden pile or a wheel. However, the head did not remain there for a long time as a major part of her mandible was still present *in situ* when found in 1964. This allows the interpretation that the skull was removed from the place it was displayed prior to the decay of the soft tissue which holds the mandible in anatomical position. Family members could have exerted their influence to avoid the usual procedure of leaving the remains to act as a deterrent. Fleshing by ravens should have been common, so that in most cases the mandible cannot be expected to be found still joining the skull (Henke 1981).

Facial Reconstruction Techniques

Facial reconstruction techniques have been applied for more than a century now and have undergone a variety of methodological changes and adaptations. Early reconstructions were performed mostly by artists. Scientists then started to look for scientifically sound foundations of the artists' approaches (Wittwer-Backofen 2010). In the course of the last hundred years these methods have evolved and today a growing interest is noticeable: within the last 20 years the rapidly evolving computative power of modern computer systems has brought new advances and possibilities (a comprehensive survey on computer-based methods can be found in Claes *et al.* (2010).

The current methods to approximate an individual's face from skeletal remains can be roughly separated into three categories:

Manual reconstruction using clay modelling techniques that simulate the facial tissue on a skull (Gerasimov 1967).

Computer-assisted 2D-reconstructions that superimpose facial regions with appropriate patches from photographs (Ubelaker *et al.* 1992, Wittwer-Backofen 2003).

Computer-assisted statistical reconstructions of a 3D-representation (Claes *et al.* 2010).



Fig. 2: CT-scan of the Langenfeld skull showing defective regions.

The virtual reconstruction of the Langenfeld skull

To reconstruct a face from a dry skull the presence of a non-deformed midfacial region and of a mandible is necessary. In this specific case both those parts had to be reconstructed or estimated.

The midfacial region of the skull was mostly intact apart from the right upper and central part of the zygomatic bone. The right temporal mastoid region was missing completely (Fig. 2) – it is, however, essential for the draft version of the 3D-reconstruction software that should be applied. For the reconstruction of the missing or deformed areas of the skull we used a mathematical toolkit of rigid and non-affine transformations: Initially a set of landmarks was placed on the areas that were not affected; especially bilateral landmarks were emphasized. The 3D-mesh representing the skull was mirrored and the bilateral landmarks relabelled according to the corresponding counterparts. Thus, a perfectly mirrored representation of the original bone structure was generated. To take into account the existing non-pathological asymmetry, the mirrored skull then not only was rotated but also mapped onto the original one by using a Thin-Plate-Spline deformation algorithm (e.g. Bookstein 1989). This resulted in a very reasonable 3D-representation of a complete and mostly unaffected skull (Fig. 3).

Reconstruction of the mandible was much more challenging: Since the original mandible was entirely missing a substitute had to be estimated. Therefore, landmark-configurations of German female mandibles extracted from CT-scans were taken into account. 46 landmarks were set on the mandibles and a population



Fig. 3: Langenfeld skull with reconstructed areas.

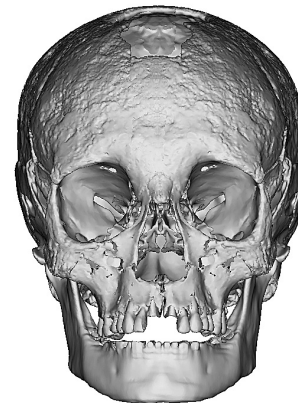


Fig. 4: Reconstruction of the Langenfeld skull with estimated mandible.

mean was estimated from the Procrustes superimposed data (e.g. Dryden and Mardia 1998). To generate a 3D-model a template had to be fitted onto those landmarks. To evade strong individual bias, those individuals closest to the mean (measured in Procrustes distance) were warped onto the landmark-mean and the arithmetic mean was calculated from their meshes' vertices. The resulting mandible is a statistically sound estimation of the German female population. Placed and scaled onto the dimensions of the reconstructed skull it proves to be a valid approximation of an actual mandible (Fig. 4).

The virtual 2D-reconstruction

In forensic case studies a facial soft tissue reconstruction is among the steps leading towards identification. Its major aim is the recognition of missing persons either through public media or screening of missing persons' databases in the investigation process. This requires a technical approach which ascertains the recognition of a specific person from the face presented. For this application earlier methods of manual clay modelling procedures on skull casts are more or less obsolete. With the 2D-superimposition method, a simple but effective way of constructing a face according to the knowledge of facial element positioning and soft tissue thickness has been developed (Wittwer-Backofen 2003).

Starting with a frontal view of the skull in the Frankfort plane extracted from computed tomography, surface scannings or photography distance markers are to be placed at defined landmarks of the skull to indicate the surface. This step has to be performed within a scaled virtual room to assure for size fitting between

skull and length of soft tissue thickness markers (Fig. 5). The length of the distance markers, dependant on sex, age and ethnicity, is determined in studies of facial soft



Fig. 5: Set of size adjusted soft tissue thickness markers (bars) positioned on the Langenfeld skull.



Fig. 6: 2D-Superimposition of facial elements on the Langenfeld skull.



Fig. 7: 2D-facial reconstruction of the Langenfeld skull.

tissue thickness. Research is necessary in that regard, as the data available still lack important individual indicators such as nutritional status. Once the distance markers are set, a large database of digital facial photographs is necessary to give a selection of facial elements which meet the individual criteria needed. The adaptation of size and position of the selected facial elements is performed by superimposing the skull with an image processing software (Fig. 6). Thus, a newly composed face may consist of elements from twenty to fifty different faces. In a last step these facial snippets are fused to a face consistent with the skull (Fig. 7).

This method is not only applicable to modern forensic cases but also helpful for historical cases to visualize the appearance of celebrated public characters or unknown persons revealing living conditions and cultural practices in the past. Standing vis-à-vis an individual's face helps interested museum visitors to empathize with people of the past and their individual fate. This was the reason for a facial reconstruction of the Langenfeld skull.

The virtual 3D-reconstruction

To reconstruct the individual's face, a computer-aided approach was taken that aims to estimate the surface of the facial skin from a database containing skull and corresponding skin surfaces extracted from CT-scans taken in hospitals.

As there still is, at the moment, a significant dose of radiation involved in this type of data-acquisition from patients, access to such data is restricted to clinical material for ethical reasons. Due to this, pathologically unaffected scans containing information of the whole face are rather rare, which makes it very difficult to establish a valid and representative sample of the given population. To deal with that fact, studies of the authors are still in progress to involve information from partial head scans which are much more often available.

Nevertheless, a draft version of a computer software that estimates the skin surface of a given skull from a database containing 14 individuals was employed: first a well defined set of 21 anatomical landmarks was placed

throughout the Langenfeld skull, representing the shape of the osseous structure. Given this information, similarity and dissimilarity towards the already known configurations in the database can be calculated using Procrustes distance (Kendall 1984).

Based on those distance measures, similar configurations within the database were identified and an initial skin template based on weighted influence of the closest hits was generated (Claes *et al.* 2006a, Fig. 8a). Additionally, Body Mass Index, gender and age were taken into account to adapt the initial estimation (Claes *et al.* 2006b). This surface mesh was fitted onto the original skull (Fig. 8b).

For future applications, however, a larger sample size, a denser set of landmarks and the implementation of recently developed modelling methods (Claes *et al.* 2010b; Smeets *et al.* 2010) should lead to a statistically sound model that is less biased by the individuals in the database.

Museum presentation

Soft tissue facial reconstructions serve different goals. In forensic cases, the identification process often requires a face approximated to the appearance of the missing person. The recognition process is the main purpose as it significantly helps to reduce the number of possible persons. This, however, is not a top priority for museum presentations. There, historical public figures, regional types of human diversity, paleoanthropological reconstructions of early hominids, or just anonymous individuals telling a story of their living conditions in the past are suitable applications. Summarizing all individual details, the skull of Langenfeld adds up an endless number of details that helps the museum visitor to understand past living conditions on the one hand and the limitations individuals faced within their community and which are quite different from our social norms and rules of today, on the other. Looking at a reconstructed face, the face of a person who was exposed to such unthinkable conditions helps museum visitors to sympathize with this unknown person of the past and to vividly activate their imagination. This was the purpose of the facial soft tissue reconstruction to be presented in the local Stadtmuseum of Langenfeld, close to the place where the skull with the nail inside once was found.



Fig. 8 a, b: Facial reconstruction of the Langenfeld skull without (a, left) and with additional information (b, right).

Acknowledgements

The facial reconstruction has been made available by financial support of the Stadt Langenfeld, Kulturelles Forum, which also put the CT-data of the skull at disposal and contributed with various information. We thank Mareen Kästner for her help with the English version and for numerous valuable notes. We also thank Frederick Wehrle for his support with the 3D-imaging processing and Andrea Tagliasacchi for a source code template based on the VCG libraries (<http://vcg.sf.net/>) that was applied for reconstruction of the mandible.

References

- Auler J 2008. *Richtstättenarchäologie*. Archaeotopos. Dormagen.
- Auler J 2010. *Richtstättenarchäologie 2*. Archaeotopos. Dormagen.
- Bonte W, Pieper P 1995. *Gerichtsmedizin und Sachsenspiegel*. In: Fansa M (ed.). *Der Sassen Speyghel. Sachsenspiegel – Recht – Alltag*. Isensee. Oldenburg, 423–432.
- Bonte W, Pieper P 1996. *Medieval death penalties and their morphological correlates*. *Medicina Legalis Baltica* 7: 27–31.
- Bookstein FL 1989. *Principal Warps: Thin-plate splines and the decomposition of deformations*. *IEEE Transactions on pattern analysis and machine intelligence* 11.
- Claes P, Vandermeulen D, De Greef S, Willems G, Suetens P 2006a. *Craniofacial reconstruction using a combined statistical model of face shape and soft tissue depths: Methodology and validation*. *Forensic Science International* 159: 147–158.
- Claes P, Vandermeulen D, De Greef S, Willems G, Suetens P 2006b. *Statistically Deformable Face Models for Cranio-Facial Reconstruction*. *Journal of Computing and Information Technology – CIT* 14: 21–30.
- Claes P, Vandermeulen D, Greef SD, Willems G, Clement JG, Suetens P 2010a. *Computerized craniofacial reconstruction: Conceptual framework and review*. *Forensic Science International* 201: 138–145.

- Claes P, Vandermeulen D, Greef SD, Willems G, Clement JG, Suetens P 2010b. *Bayesian estimation of optimal cranio-facial reconstructions*. Forensic Science International 201: 146–152.
- Dryden IL, Mardia KV 1998. *Statistical shape analysis*. John Wiley and sons. Chichester.
- Gerasimov MM 1967. *Gesichtsrekonstruktion historischer Persönlichkeiten*. Wissenschaft und Mensch.
- Henke W 1981. *Der gepfährte Schädel von Langenfeld*. Bonner Jahrbücher 181: 425–436.
- Kendall DG 1984. *Shape Manifolds, Procrustean Metrics, and Complex Projective Spaces*. Bull. London Math. Soc. 16: 81–121.
- Pieper P 2003. *Eine herausgehobene Persönlichkeit – nicht nur eine simple Nagelung*. In: Wiechmann R, Bräuer G, Püschel K (eds.). *Klaus Störtebeker. Ein Mythos wird entschlüsselt*. Wilhelm Fink. München, 135–147.
- Pieper P 2010. *Der menschliche Schädel mit Nagelungsbefund aus Langenfeld/Rhld. (Rheinisches Landesmuseum Bonn, Inventar-Nr. 64.809 a–c)*. In: Auler J (ed.). *Richtstättenarchäologie 2*. Archaeotopos. Dormagen, 452–468.
- Pieper P, Schlüter B 2008. *Genagelte menschliche Schädel*. In: Auler J (ed.). *Richtstättenarchäologie*. Archaeotopos. Dormagen, 388–411.
- Smeets D, Claes P, Vandermeulen D, Clement JG 2010. *Objective 3D face recognition: Evolution, approaches and challenges*. Forensic Science International 201: 125–132.
- Ubelaker D, Bubniak E, O'Donnel G 1992. *Computer-assisted photographic superimposition*. Journal of Forensic Sciences 37: 750–762.
- Weber L 1966. *Fundmeldungen Landesmuseum Bonn*. Bonner Jahrbücher 166: 606.
- Wittwer-Backofen U 2003. *Identifizierungshilfen am Leichnam: Die Gesichtsrekonstruktion*. Bundeskriminalamt Infoblatt Nr. 8. Wiesbaden.
- Wittwer-Backofen U 2010. *Facial Reconstruction of Mummies – The Example of Baron von Holz*. In: Wieczorek A, Rosendahl W (eds.). *Mummies of the World*. Prestel. Munich, Berlin, London, New York, 257–259.

Figure proof

Figure 1

Rheinisches Landesmuseum Bonn

Figure 2

Copyright: Attila Kovács & Peter Pieper; see Pieper 2010

Figure 3–8

Schlager, Wittwer-Backofen

Address:

Ursula Wittwer-Backofen
Dept. of Anthropology
Albert-Ludwigs-University Freiburg
Hebelstr. 29
79104 Freiburg
Germany
Phone: +49 (0) 761 203 6896
E-mail: ursula.wittwer-backofen@uniklinik-freiburg.de

Richtlinien zur Bergung, Entnahme und Archivierung von Skelettproben für palaeogenetische Analysen

[Guidelines for the recovery, acquisition and storage of skeletal samples for palaeogenetical analyses]

JOACHIM BURGER¹, RUTH BOLLONGINO¹

¹ *AG Palaeogenetik, Institut für Anthropologie, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Deutschland*

Zusammenfassung

Neben einer kurzen Beschreibung der nennenswerten Kontaminationsquellen enthält dieser Artikel in kurzer Form eine Auflistung der Richtlinien zur DNA-Kontaminationsvermeidung bei der Bergung und Archivierung menschlicher und tierlicher Skelette. Folgende Aspekte werden dabei behandelt: 1) Utensilien für kontaminationsarmes Graben und Beprobieren und Angaben zu ihrem Gebrauch 2) anatomische Beschreibung optimaler Beprobungsstellen am Skelett 3) Größe, Gewicht und Zahl der Proben und 4) Vorschläge zur optimalen Überführung und Lagerung von Skelettmaterial. Es werden darüberhinaus drei sogenannte „Bergungsstufen“ unterschieden, die verschiedene Reinheitsgrade der Bergung und Archivierung beschreiben und zugleich als Leitfaden im Feld dienen können.

Schlüsselwörter: Palaeogenetik, Probennahme, Bergung, Archivierung

Summary

This article summarizes the major sources of DNA contamination and provides a short list of procedures to avoid contamination during the sampling and storage of human and animal skeletal remains. This checklist provided in this article includes 1) a list of paraphernalia used for contamination-free excavation and sampling and instructions on their use 2) an anatomical description of the optimal skeletal elements for destructive sampling 3) the recommended size, weight, and number of samples 4) suggestions on how samples are ideally transported and stored after the excavation. Three “recovery grades” are defined. They represent different levels of “cleanness” of the excavation procedure and subsequent storage and may serve as field manual.

Keywords: palaeogenetics, sampling, storage

Einleitung

Im lebenden Organismus liegt DNA in Hartgeweben wie Knochen und Zähnen in äußerst geringen Mengen vor. Nach dem Tod eines Organismus, anschließender Autolyse und Fäulnis verschlechtert sich der Zustand der DNA in Knochen und Zähnen immer weiter und nimmt auch mengenmäßig rapide ab. Sie degradiert in Abhängigkeit von vielfältigen Milieufaktoren, allen voran Temperatur, pH-Wert und Feuchtigkeit im Erdreich (Burger *et al.* 1999). In der Folge ist die Menge und Qualität der alten DNA schon nach wenigen Monaten derart reduziert, dass endogene DNAs aus einem Skelett exogenen DNA-Kontaminationen

mengenmäßig unterlegen sein können. Um Kontamination zu vermeiden und möglichst reine und authentische prähistorische DNA-Moleküle zu erhalten, sind daher besondere Vorsichtsmaßnahmen geboten. Viele dieser Antikontaminationsregeln treten erst in den molekulargenetischen Labors selbst in Kraft. Doch bereits während der archäologischen Bergung und Archivierung können entscheidende Maßnahmen getroffen werden, die über den zukünftigen Analyseerfolg mitentscheiden. Neben der Vermeidung von Kontaminationen bei der Grabung stellt auch die sachgemäße Lagerung nach der Bergung dabei einen entscheidenden Faktor dar.

Im Folgenden werden die Vorsichtsmaßnahmen geschildert, die zu treffen sind, um Skelette bzw. Teile davon adäquat zu bergen und zu archivieren. Archäozoologische Proben sind dabei wesentlich geringeren Kontaminationsgefahren ausgesetzt als menschliche, so daß hier unterschiedliche Bergungsstrategien dargestellt werden (s.u.). Da darüber hinaus komplexe Grabungssituationen nicht immer eine optimale Bergungsstrategie erlauben, werden drei verschiedene „Stufen“ der Bergung und Archivierung unterschieden, um den verschiedenen Realitäten bei der Grabung und anschließenden Aufbewahrung von bioarchäologischem Fundgut gerecht zu werden. Abgesehen von den hier vorgestellten Richtlinien, die überschaubar und einfach gehalten sind, ist es wichtig, dass die möglichen Kontaminationsquellen dem Ausgräber, Kurator oder Studenten auch theoretisch bewusst sind, so dass er neue Situationen und Ausnahmen vom beschriebenen Schema kompetent selbst einzuschätzen in der Lage ist und entsprechend darauf reagieren kann. Grundsätzlich sind Kontaminationen zu unterscheiden die vor bzw. während der Analyse im Labor stattfinden.

Kontaminationsquellen im palaeogenetischen Labor

Im Umfeld eines Labors entstehen folgende Kontaminationsgefährdungen: zum einen die offensichtlichen Kontaminationen durch Bearbeiter und DNA aus der Umwelt, die entweder direkt oder über Chemikalien bzw. Laborutensilien auf die Probe gelangen; zum anderen bereits vervielfältigte (amplifizierte) Reaktionsprodukte aus vorherigen Analysen. Palaeogenetische Labors (Probenvorbereitung, DNA-Isolation, Erstellung von DNA Bibliotheken bzw. PCR-Ansatz) und Post-Amplifikationslabors (Arbeiten mit DNA-Bibliotheken, Sequenzierung, Klonierung etc.) sind daher am besten in verschiedenen Gebäuden oder zumindest Gebäudeteilen untergebracht. Übertragungen von Amplifikationsprodukten in ein palaeogenetisches Labor stellen ein potenziertes Risiko dar, das nur durch extreme infrastrukturelle Reinstraumbedingungen und entsprechende laborseitige Handlungsanweisungen vermieden werden kann. Archäologen und Kuratoren betrifft dies aber nur insofern als Postlieferungen unbedingt an eine vom üblichen (post-Amplifikation) Laborbetrieb gesonderte Anschrift erfolgen müssen, idealerweise direkt vor die palaeogenetischen Labors. Darüber hinaus obliegen die weiteren Dekontaminationsmaßnahmen den Palaeogenetikern und werden hier nicht näher ausgeführt (eine ausführliche Beschreibung findet sich in Burger 2006).

Kontaminationsquellen bei der Bergung oder Archivierung

In den meisten Fällen sind es Epithelzellen, die über die Hautoberfläche oder den Mundinnenraum aber auch durch Kot, Sputum und Urin (siehe Bollongino *et al.* 2008) in die Umgebung gelangen und das Untersuchungsgut kontaminieren können. Bei Tieren können es zusätzlich Produkte der Tierhaltung und -verwertung wie Fleisch, Wurst, Käse, Leime und Bindemittel oder aus Tieren gewonnene biologische Laborchemikalien sein. Zusätzlich kann ein Skelett durch die Leichensäfte eines Kadavers, der in seiner Nähe (etwa im gleichen Grab) verweste, stark kontaminiert werden. Abgesehen von solchen speziellen Fällen stellen die Ausgräber selbst und die ubiquitäre DNA aus der Umgebung die größte Gefahr dar. Folgende Richtlinien erläutern, wie und an welchen Stellen diese Verunreinigungen zu vermeiden bzw. zu reduzieren sind.

Regeln zur Kontaminationsvermeidung

Tier

Bei der Bergung und Archivierung archäozoologischer Proben ist darauf zu achten, dass möglichst wenig menschliche DNA aber v.a. keine Essensreste auf das Skelett gelangen. Dies kann durch das Tragen von Einmalhandschuhen und Gesichtsmaske ausreichend sichergestellt werden.

Da Leitungswasser immer verunreinigt ist und Kontamination tief in das Knochenmineral eindringen lässt, sollten Proben nie gewaschen und allerhöchstens durch eine trockene Bürste leicht gesäubert werden.

Mensch

Für humanes Material gelten folgende Regeln:

Regel 1: Zwei Paar Einmalhandschuhe übereinander tragen. Dabei Plastikhandschuhe (am besten aus Latex, alternativ Vinyl, Nitril oder Neotril) mit spitzen Fingern am oberen Ende, d.h. am Rand der Manschette, aus der Box nehmen ohne sie flächig zu berühren (s. Abb. 1–3). Es ist entscheidend, daß Handschuhe am vorderen Teil, d.h. an Handfläche, Handrücken und Fingern, nicht mit bloßen Händen berührt werden, da hierdurch der Handschuh kontaminiert würde. Das untere Paar Handschuhe wird konstant getragen, das obere regelmäßig gewechselt, vor allem dann, wenn i) eigene oder fremde Hautpartien berührt wurden ii) unsaubere Gegenstände berührt wurden iii) längere Pausen entstanden sind.



1



2



3

Abb. 1–3: Einmalhandschuhe nur am Rand der Handschuhmanschette anfassen und überziehen. Mit angelegtem erstem Handschuh den zweiten Handschuh entnehmen und ebenso überziehen. Danach ein zweites Paar Handschuhe nach demselben Muster über das erste Paar ziehen. Das Oberpaar kontinuierlich wechseln, das untere nur nach größeren Arbeitseinheiten oder wenn es kontaminiert wurde.

Regel 2: Werkzeuge erst mit Mineralwasser (sollte wenn möglich einen Spritzer Spülmittel aus der Flasche enthalten) und Küchenpapier gründlich abwischen. Nicht einreiben, sondern Oberfläche systematisch abstreifen. Es sollte stilles Mineralwasser verwendet werden und die Flasche frisch geöffnet sein. Die Wasserflasche vorher von außen mit Bleiche (s.u.) abwischen. Zum Abwischen und als Ablage frisch geöffnetes Küchenpapier verwenden (Abb. 4).

Danach werden alle relevanten Grabungsutensilien mit Haushaltsreiniger auf Chlorbasis abwaschen. Dieser ist als „Chlorix“ im Supermarkt, im Ausland auch als „Eau de Javel“ erhältlich. Es handelt sich hierbei um eine bisweilen als Bleiche bezeichnete Lösung < 5% Natriumhypochlorid (NaClO; engl.: *bleach* bzw. *sodium*

hypochlorite). Werkzeuge in Bleiche eintauchen oder damit besprühen und/oder mit Bleiche-feuchtem Küchenpapier abwischen. Wichtig ist, dass die Bleiche die gesamte Oberfläche bedeckt und dort wirken kann. Diese Dekontamination kann am besten in bzw. über einer Plastikschiene erfolgen (s. Abb. 5).

Regel 3: Gesichts- und Haarmaske tragen (Abb. 6). Trotzdem nicht unnötigerweise über die Probe beugen. Haare von Anfang an gut unter der Haarmaske verpacken und nicht mit Handschuhen zurückschieben. Ein Haartuch unter der Haarmaske hilft hier.

Regel 4: Langärmeliges Hemd und lange Hosen tragen.

Regel 5: Alleine arbeiten. Turbulenzen und Gegenwart anderer Menschen vermeiden.



Abb. 4: Folgende Gegenstände sind zusätzlich zum Grabungsbesteck zur Beprobung mitzuführen: 1) mehrere Liter stilles Mineralwasser, 2) Spülmittel bzw. Flüssigseife aus der Flasche, 3) verpacktes Küchenpapier, 4) Haushaltsreiniger auf Chlorbasis, 5) Becher bzw. Gläser zum Abspülen, 6) Zange, 7) Pinzetten. Nicht notwendig aber hilfreich: Enghalslaborflasche.



Abb. 5: Werkzeuge und Utensilien sollen zweimal mit Küchenpapier mechanisch gereinigt werden Küchenpapier beim ersten Mal mit Seifenwasser und beim zweiten Mal mit Chlorreiniger tränken. Danach sollen sie über einem Gefäß mit Chlorbleiche abgespült werden.

Regel 6: Ganzes zu beprobendes Skelettelement möglichst sofort, zügig und mit Erdreich bedeckt entnehmen. Nicht säubern. Gleich verpacken, nicht waschen, trocken und kühl lagern. Es sollten möglichst intakte Knochen bzw. Zähne entnommen werden. Die eigentliche Probenentnahme mit der Säge kann später im Labor durchgeführt werden. Stark fragmentierte Knochen vermeiden. Geschlossene Zahnwurzeln bevorzugen. Das verbleibende Skelett kann nach Entnahme des zu beprobenden Skelettelements anschließend ohne spezielle Dekontaminationsmaßnahmen, also ganz „normal“ geborgen werden.

Sowohl bei Mensch- als auch bei Tierproben sollten pro Grabungsabschnitt eine Knochenprobe einer anderen Spezies genommen werden, um eine Kontamination durch das Liegemilieu überprüfen zu können.

Nach der Bergung

Niedrige Temperaturen und geringe Feuchtigkeit sind dem DNA-Erhalt über längere Zeiträume zuträglich. Die archäologische Bergung eines Skeletts stellt eine kritische Phase für den DNA-Erhalt dar, denn wechselnde Umweltfaktoren sind noch schlechter für das Molekül als moderat schlechte Erhaltungsbedingungen (Alley 2007). Deswegen sollte das entnommene Skelettelement nun nicht einer Reihe von

Umgebungswechseln ausgesetzt, sondern möglichst direkt in die eine oder andere Form der Archivierung überführt werden. Folgende Richtlinien sind dabei zu beachten:

Regel 7: Skelette nicht waschen oder mit Wasser besprühen

Regel 8: Zu beprobende Skelettelemente auf der Grabung solange wie möglich im Schatten und möglichst in einer Kühlbox halten. Zu vermeiden sind Lagerräume, die sich durch Sonneneinstrahlung aufheizen. Falls es vor Ort keine Möglichkeit zur Kühlung gibt, können die verpackten Skelettelemente notfalls auch wieder vergraben werden, um sie an heißen Tagen kühl zu halten.

Regel 9: nach der Bergung die verpackten Skelettelemente bzw. Proben möglichst schnell in eine kühle, trockene Umgebung bringen. Am besten in einen Kühlschrank. Feuchte Skelettelemente sollten dort aber nur für einige Tage gelagert werden, da sonst vermehrt Degradierung durch Bakterien und Schimmelpilze droht.

Regel 10: Feuchte Skelettelemente: kurzfristige Lagerung im Kühlschrank, ansonsten kühl halten, in Papier einwickeln und langsam in einem Karton austrocknen lassen. „Schwitzen“ in geschlossenen Plastiktüten vermeiden. Knochen oder Zähne niemals zum Trocknen in direktes Sonnenlicht oder auf eine Wärmequelle legen.

Regel 11: Mittelfristig sollte eine DNA Probe bei +4 °C aufbewahrt werden. Plant man, einen Knochen oder Zahn langfristig zu archivieren, so geschieht dies idealerweise bei -20°C in einer dichten Plastiktüte. Eine handelsübliche Gefriertruhe ist hierfür ausreichend. Wiederholtes Auf- und Einfrieren vermeiden. Für Konstanz sorgen!

Wahl des Probenmaterials

Folgende Vorschläge müssen im Einzelfall stets nach kuratorischen, musealen bzw. archäozoologischen oder anthropologischen Gesichtspunkten abgewogen werden. Es sollten nicht unnötigerweise Skelettelemente zerstört werden. Die folgenden Vorschläge gelten nicht für wertvolles Fossilmaterial wie etwa jungpaläolithischen Hominine oder ausgestorbene Spezies. Es müssen die Bedürfnisse der klassischen morphologischen Methoden abgewogen werden, um gegebenenfalls Messpunkte oder diagnostisch relevante Merkmale zu bewahren. Die Entnahme sollte von geschultem Personal vorgenommen werden, um morphologische Messpunkte, Bearbeitungsspuren etc. zu verschonen. Die genetische Beprobung sollte zuerst erfolgen, anschließend kann der Knochen für eine morphologische Untersuchung gesäubert werden. Proben sollten nicht gehärtet oder anderweitig behandelt, sondern das ganze, ungewaschene Skelettelement an ein palaeogenetisches Labor überführt werden.

Knochen können auch innerhalb eines Skeletts sehr unterschiedlich erhalten sein. Als Material eignen sich jede Art von Knochenkompakta (insbesondere Diaphysen von Langknochen, Abb. 7) und Zähne mit geschlossenen Zahnwurzeln (v.a. Molaren). Spongiöse Strukturen (Wirbel, Becken etc.) sind nicht geeignet. Gut erhaltene Proben zeichnen sich dadurch aus, dass sie schwer und hart sind. Weiche, leichte und poröse Proben sind in der Regel nicht geeignet. Eine helle Färbung ist tendenziell einer dunklen vorzuziehen, die Härte des Materials ist jedoch ausschlaggebend (die Oberfläche sollte man z.B. nicht leicht einritzen können). Kalk- bzw. Sinterablagerungen sind nicht störend, im Gegenteil, sie fördern die Erhaltung der DNA. Bereiche, die stark von Mikroorganismen zersetzt sind, sind zu vermeiden. Morphologisch vollständige Knochen sind auch molekular besser erhalten als fragmentierte. Knochen und Zähne von Kindern sind wenn möglich zu vermeiden, da die Zähne häufig nicht geschlossen sind und die Kompakta weniger ausgeprägt ist.

Eine unbemerkte mehrfache Beprobung des gleichen Individuums sollte strikt vermieden werden. Dies kann



Abb. 6: Bei der Beprobung Kopfhaut, Gesichtsmaske, langärmeliges Hemd und zwei Paar Einmalhandschuhe übereinander tragen.

durch die Auswahl gleicher Skelettelemente (z.B. nur linke Femora), bzw. durch Beachtung von Größen- und Robustizitätsunterschieden oder der Unterschiedlichkeit von Fundschichten erreicht werden.

Die Proben sollten aus möglichst ungestörten Befunden stammen. Sind weitere Beprobungen für Radiokarbondatierungen und Isotopenanalysen geplant sein, bietet es sich an, eine einzige größere Probe für alle Analysen zu nehmen. In diesem Fall werden die Isotopenproben in den palaeogenetischen Labors abgetrennt und weitergeleitet. Nicht umgekehrt!

Tier

Generell sollte man Knochen mit dichter und nicht gebrochener Kompakta nehmen, also Langknochen, Phalangen, Metacarpalia und -tarsalia. Bei größeren Tieren (Rind, Pferd) eignen sich – wenn nicht vermeidbar – auch die Wirbel. Becken, Schädel oder Hornzapfen sind noch weniger geeignet. Für die gängigen Haustiere bestehen außerdem folgende Erfahrungen:

Rind: Optimal sind Zahnwurzeln, Phalangen (Fingerknochen), Metapodien (Mittelhand- bzw. Mittelfußknochen) und Talus (Sprungbein). Gut sind die Stellen an Langknochen mit starker Kompakta. Weniger gut: Schädel, scapula (Schulterblatt) und costae (Rippen).

Schwein: Gut sind ganze Zähne, Phalangen, Metapodien und Talus – soweit nicht zu klein. Der Schaft der Langknochen ist besser als die Epiphysen.



Abb. 7: Optimale Probenentnahmestellen an einem Langknochen sind die biomechanisch stark beanspruchten Stellen der Dia- und Metaphysen, also dort, wo die Kompakta des Knochens am dicksten ist. Hier sind die vier besten Entnahmestellen markiert.

Schaf/Ziege: bevorzugt sind Langknochen, ansonsten Zähne. Metapodien soweit ausgewachsen und vollständig. Nicht gut sind Hörner.

Mensch

Alternative 1: Zwei Molaren bzw. Prämolaren

- Bei Zähnen wird der ganze Zahn benötigt. Alternativ kann nur die Wurzel verwendet werden, so daß die Krone mithilfe einer Säge abgetrennt und zurückgeführt werden kann. Zahnzement enthält viel DNA (Adler *et al.* 2010) ist aber auch kontaminationsgefährdet.
- Zerbrochene, abasierte oder stark kariöse Zähne eignen sich nicht.

Alternative 2: Ein Molar bzw. Prämolare und ein Knochenstück aus einem Langknochen in folgender Reihenfolge i) vier Stellen am *Femur* (Oberschenkel) wie in Abb. 7 dargestellt ii) ebenso an der *Tibia* (Schienbein) iii) ebenso am *Humerus* (Oberarm) iv) Felsenbein (*pars petrosa ossis temporalis*)

- Es sollten immer Knochenstücke mit dicker Kompakta genommen werden. Die spongiöse Struktur des Knochens ist ungeeignet.
- Größe des Knochenstücks: etwa 1 cm × 3 cm (Abb. 7).

Alternative 3: ein längeres oder zwei kleinere Knochenstücke

- Wenn möglich, dann entfernt von *post-mortem* Bruchstellen beproben, da hier Wasser und Mikroorganismen vermehrt die Degradierung der DNA vorangetrieben haben.

Probenentnahme mit Säge

Sollten Proben im Feld oder Archiv mit einer Säge entnommen werden, so sind abgesehen von der Säge selbst und evtl. Diamanttrennblättern folgende Artikel bereitzuhalten (s. Abb. 4 und 6).

- Schutzkleidung (siehe „Generelle Regeln zur Kontaminationsvermeidung“)
- Haushaltsbleiche, Küchenpapier, stilles Mineralwasser, Spülmittel in der Flasche, zwei Becher oder Gläser, eine Zange, zwei Pinzetten.

Es ist darauf zu achten, dass Arbeitsplatz und Geräte nach jedem Sägevorgang gründlich erst mit Seifenwasser und dann mit Bleiche (Sägeblätter müssen mindestens 5 min in Bleiche einwirken) gereinigt werden. Ein Erhitzen des Materials durch zu langes kontinuierliches Sägen sollte vermieden werden. Anthropologisches Material sollte wenn möglich von palaeogenetisch geschultem Personal gesägt werden.

Bemerkungen zur Probenmenge

Bei tierlichen Proben sind insgesamt 2 Gramm Probe ausreichend, um weitreichende genomische Analysen durchzuführen. Größere Probenmengen erleichtern das Prozedere bereits bei der Probenahme und vor allem im Labor, sind aber bei durchschnittlich erhaltenem Material nicht notwendig. Bei schlechteren Erhaltungsbedingungen (Jahresdurchschnittstemperatur des Fundplatzes >12°C) können größere Probenmengen die Erfolgsaussichten steigern. Bei menschlichen Knochen sinkt die Kontaminationsgefahr mit der zunehmenden Größe der Probe. Von größeren Knochenstücken können Oberflächen nämlich großzügiger abgenommen und verworfen werden, wodurch die Wahrscheinlichkeit steigt, dass die verbleibenden Stücke unkontaminiert sind.

Mit neuen DNA-Sequenzierungsmethoden können bereits jetzt ganze Genome aus einzelnen Knochen- und Zahnproben sequenziert werden. Zu kleine Proben können den Erfolg solcher aufwendigen Untersuchungen gefährden. Insofern gilt derzeit die Empfehlung, immer so viel Probenmaterial zu entnehmen, wie kuratorisch zu vertreten ist. In der Regel handelt es sich bei holozänen Skeletten ohne den Charakter der Seltenheit bzw. Einmaligkeit derzeit um Gewichte zwischen 2 und 6 Gramm bzw. eine Menge von maximal zwei Molaren. Es ist allerdings zu erwarten, daß methodische Fortschritte in naher Zukunft diese Mengenangaben weiter verringern werden.

Bergungsstufe 1: höchste Sicherheitsstufe für humane Skelette

1. Zwei Paar Handschuhe, regelmäßig wechseln
2. Gesichts- und Haarschutz
3. Nur 1 Bearbeiter am Skelett
4. Gewaschenes Grabungsbesteck (Bleiche und Mineralwasser)
5. Probe darf nicht mit Wasser oder starkem Sonnenlicht in Berührung kommen
6. Skelettelement (Zähne, Langknochen oder Felsenbein) vor Ort ohne Reinigung entnehmen und umgehend, einzeln verpackt kühl und trocken lagern

Lagerung:

☐ bei Raumtemperatur
☐ bei 4°C
☐ bei -20°C

Bergungsstufe 2: mittlere Sicherheitsstufe für menschliches Material; sehr gut für Tiere

1. Zwei Paar Handschuhe, regelmäßig wechseln
2. Wenn möglich Gesichts- und Haarschutz, ansonsten nicht über Probe beugen
3. Skelettelemente nicht waschen und am Tag der Bergung einzeln archivieren

Lagerung:

☐ bei Raumtemperatur
☐ bei 4°C
☐ bei -20°C

Bergungsstufe 3:

Skelettelemente wurden traditionell ohne entsprechende Maßnahmen geborgen.

Folgende Angaben können gemacht werden:

☐ gewaschen
☐ nicht gewaschen
☐ unsicher

☐ Lagerung kühl
☐ Lagerung trocken
☐ Unsicher
☐ behandelt mit (Klebstoffe etc.):
☐ Skelette wurden bereits anthropologisch untersucht durch:

Abb. 8: Die drei verschiedenen Bergungsstufen spiegeln unterschiedliche Grade der Reinheit wieder. Sie dienen der Orientierung im Feld und der Kommunikation zwischen Archäologe und Palaeogenetiker. Die Beschreibungen der Bergungsstufen können ausgedruckt und mitgeführt werden. Mit Probenamen versehen und Kommentaren ergänzt kann je eine zur Probe in die Tüte gelegt zu werden.

Bergungsstufen

Zweifellos wird die tatsächliche Situation im Feld oder Archiv/Museum eine optimale Bergung nicht in jedem Fall zulassen. Für den Palaeogenetiker ist es jedoch wichtig die Bergungs- und Archivierungshistorie der Funde so gut wie möglich zu kennen. In diesem Sinne und als Zusammenfassung der obigen Regeln werden hier drei „Bergungsstufen“ unterschieden, nach denen Funde entnommen werden können (Abb. 8). Dabei stellt Bergungsstufe 1 den optimalen und wünschenswerten Fall, vor allem für humanes Material,

dar. Bergungsstufe 2 ist die am ehesten realisierbare und sollte in Zukunft die Mindestanforderung darstellen, wenn weitere palaeogenetische Arbeiten geplant sind. Bergungsstufe 2 sollte auch Standard für archäozoologische Beprobungen sein. Auch wenn *ad hoc* keine Analysen geplant sind, empfiehlt es sich für zukünftige Forschungsvorhaben gemäß Bergungsstufe 2 ein Archiv zu generieren.

Bergungsstufe 3 stellt den üblichen Fall einer Altgrabung dar. Hier ist lediglich anzugeben, ob die Skelette gewaschen oder ungewaschen sind und wie sie archiviert wurden. Die in den Bergungsstufen ent-

haltenen Richtlinien sind jederzeit online unter <http://www.uni-mainz.de/FB/Biologie/Anthropologie/MoLA/Deutsch/Home/Home.html> (google-Suche: „*Palaeogenetik Mainz*“) abzurufen und werden dort kontinuierlich den neuesten methodischen Entwicklungen angepasst.

Die Beschreibung der Bergungsstufen kann auf Grabungen mitgeführt und durch eigene Angaben entsprechend ergänzt werden und dient auch der Kommunikation zwischen Archäologen und Palaeogenetikern.

Adresse:

Joachim Burger
AG Palaeogenetik
Institut für Anthropologie
Johannes Gutenberg-Universität Mainz
Saarstraße 21
55099 Mainz
Deutschland
Tel.: +49 613 139 209 81
E-mail: jburger@uni-mainz.de

Danksagung

Wir danken Amelie Scheu und Christina Georg für wertvolle Kommentare.

Literatur

- Alley J 2007. *Entwicklung einer GIS-Datenbank zur Untersuchung der Einflüsse geographischer und klimatischer Faktoren auf den Erhaltungszustand alter DNA*. Masterarbeit, Mainz.
- Bollongino R, Tresset A, Vigne J-D 2008. *Environment and excavation: pre-lab impacts on ancient DNA analyses*. *Comptes Rendus Palevol*. 7(2–3): 91–98.
- Burger J, Hummel S, Herrmann B, Henke W 1999. *DNA preservation: A microsatellite-DNA study on ancient skeletal remains*. *Electrophoresis* 20(8): 1722–1728.
- Burger J 2006. *Zwischen Kontamination und Authentizität. Der Nachweis menschlicher DNA aus archäologischen Skeletten*. In: Niemitz C (ed.). *Brennpunkte und Perspektiven der aktuellen Anthropologie*. Mitteilungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte, Beiheft 1. Berlin, 53–59.
- Adler CJ, Haak W, Donlon D, Cooper A, The Genographic Consortium 2011. *Survival and recovery of DNA from ancient teeth and bones*. *Journal of Archaeological Science*, in press.

The revival of creationism in contemporary societies: a short survey

KALLY SIMITOPOULOU¹, NIKOLAOS I. XIROTIRIS¹

¹*Laboratory of Anthropology DUTH, Komotini, Greece*

Summary

The ideas of Darwin on evolution, described about 150 years ago, are nowadays recognised as the cornerstone for the development of “evolutionary thinking” in several disciplines as they have revolutionized their concept and methodologies. During these years aggressive attacks against evolution have arisen, originating mainly from religious groups. In this paper we briefly survey the attitudes of certain religious dogmas towards evolution and the impact of creationism at social level in the Christian and Islamic world. We discuss the involvement of religions in the educational status of western and eastern secular states, as well as the implication of politics in the debate between religion and science. The role of scientists and educators is also commented.

Keywords: Evolution, religion, education, Darwin

Zusammenfassung

Darwins Gedanken über die Evolution, die vor ca. 150 Jahren beschrieben wurden, gelten heute als Eckstein für das “evolutionäre Denken” in verschiedenen Disziplinen, deren Konzepte und Methodologien sie revolutioniert haben. Während all dieser Jahre haben aggressive Attacken gegen die Evolution stattgefunden, die meistens von religiösen Gruppen ausgehen. In dieser Arbeit werden wir die Charakteristika von einigen religiösen Dogmen gegen die Evolution und den sozialen Einfluss des Kreationismus auf die christlichen, islamischen u.a. Welten untersuchen. Wir werden die Einmischung der Religion in die Bildung der westlichen und östlichen säkularen Staaten diskutieren wie auch die Implikationen der Politik in der Debatte zwischen Religion und Wissenschaft. Die Rolle der Wissenschaftler und Lehrer wird ebenfalls kommentiert.

Schlüsselwörter: Evolution, Religion, Bildung, Darwin

Introduction

...“No educated person any longer questions the validity of the so called theory of evolution, which we now know to be a simple fact. Likewise, most of Darwin’s particular theses have been fully confirmed, such as that of common descent, the gradualism of evolution, and his explanatory theory of natural selection”...

...“Great minds shape the thinking of successive historical periods. Luther and Calvin inspired the reformation; Locke, Leibniz, Voltaire and Rousseau, the enlightenment. Modern thought is most dependent on the influence of Charles Darwin”...

...“clearly, our conception of the world and our place in it is, at the beginning of the 21st century, drastically different from the zeitgeist at the beginning of the 19th century”...

Ernst Mayr (2000)

The aforementioned thoughts were communicated to the wide public through the issue of *Scientific American* in July 2000, by one of the most eminent evolutionists of our times. By the end of his fruitful life dedicated to biology and genetics research, Ernst Mayr described in a simple, undeniable way the universality of evolution, and the great impact of Darwinian ideas in any cognitive field.

In the year 2009 Darwin’s birthday and his contribution to science and society were celebrated all over the world with a plethora of events in the honor of this great mind that changed the way of scientific thinking. Indeed, evolution has revolutionized numerous scientific disciplines apart from biology. Embryology, developmental and behavioral sciences, neurosciences, epidemiology, immunology, ecology, geology, paleontology and socioeconomic sciences, philosophy, bioethics, archaeology as well, are some of the disciplines which have been integrated in the Darwinian

way of thinking. During these two centuries, the dynamics of evolutionary ideas have replaced the descriptive inertia of the classic (scientific and non-scientific) approaches, thus documenting the power of evolution as a general explanatory tool of nature.

At the same time the debate on the relationships between science and religion, reformed and updated, was on the scene again. The theories of „Intelligent Design“ are intensified as creationists improved their weapons against rationalism and expanded their propagandistic influence to the wide public and, most importantly, to the field of education. Any rationalist therefore would wonder why Darwin is still prosecuted for just expressing scientific aspects. After the ecclesiastic trials of Giordano Bruno and Galileo, nobody brought to the court Newton, Freud, Einstein, or other pioneer thinkers, who with their brilliant scientific contributions ruined the medieval world of prejudices. Since the Victorian period, the Darwinian ideas have been satisfactorily developed and documented, especially due to the undisputable progress of molecular genetics and other related disciplines. In spite of this, evolutionists still face threats of various types today, biology teachers are brought in front of justice because they teach evolution in their classes, school boards in the USA demand reforms of the biology curricula in favor of creationism, conservative politicians support creationism instead of true science and the mass media increasingly promote pseudoscientific aspects. Darwinian ideas still scandalize a lot of people. A whole pseudoscience has been invented to combat Darwinism. Creationism and its modern expression, masked behind the „Intelligent Design“ theory, influences thousands of followers, reserves numerous scholars and disseminates extended bibliography.

The revolution of evolution

The direct attacks against evolution from Darwin's ideological enemies were anticipated in their times. Upon their publication the books „On the Origin of Species“ and later on „On the Origin of Man“ undermined the foundations of the Victorian world, as they challenged the place of earth as the centre of universe and the position of man on the top of living creatures' scale. The whole ideological framework of the epoch's society based on the biblical beliefs began collapsing and the important influence (political, economic, social) of church and state was in danger. The innovative ideas so clearly expressed by Darwin concerned:

- The evolutionary process itself. The world was no longer stable, nor chronologically recent. In the contrary, it is a continuously transformed world, within which the species arise, develop, change and disappear from the life scene through time.
- The common origin of all life forms, without any rating in their „life value“. This is indeed the „dangerous idea“ that sophisticated living structures and complex organisms can arise from simpler ones, following evolutionary transformations in millions of years. No superficial powers, no Gods and no intelligent designers are needed to justify the existence of the contemporary amazing variability, since this is the product of continuously acting evolution.
- The „blind“ mechanism of natural selection functions as a selective filter favoring the survival of organisms with the best fitness, adaptability and reproductive ability. The individuals of each species are adapted to their contemporary environments; however the populations as totals evolve, infinitely adding new branches in the life tree, without any metaphysical interference or teleonomy towards the amelioration of living creatures. Populations evolve gradually under the influence of the „evolutionary forces“ (mutation, migration, random genetic drift, natural selection) and there is no possibility for the sudden emergence of new species from nowhere. The intra- and inter-species variability keeps changing through time as they keep reproducing under various environmental conditions and geographical barriers.

Evolution therefore offers a global interpretative scheme within which the living world dynamically changes in a huge scene of time and space without hierarchy, teleonomy, or determinism. Consequently, man is no longer the crown of creation; it is just another species, with a certain place in the life tree, following its own evolutionary path, neither better nor worse than that of other species. Actually, by replacing the – at the epoch generally accepted – unchangeable and divine character of life, evolution lays the bases for the development of contemporary science.

Actually the Darwinian theory clearly highlighted the long lasting – although not always clear – conflict between ideas based on blind faith and those related to scientific trial and evidence, thus shaping the borderline among modern science and the scientific tradition of the 16th–17th centuries.

Reactions then and now

The fierce reaction of the religious establishment was therefore expected. Christianity leaders immediately realized the loss of their ideological power and influence. Besides, the interests of the political and economic status linked to those of the church dictated the worst attacks against Darwin and his followers to the mass media. Darwinism and evolution were condemned in the public opinion. They still are after two centuries of scientific progress and despite the unquestionable value of science today, as it can be concluded through several public opinion researches. For instance, in a US public opinion survey performed in 2005 (Harris poll, 2005), 54% of adults do not think human beings developed from earlier species (up from 46% in 1994), 45% do not believe that plants and animals have evolved from some other species, 47% do not believe apes and humans have a common ancestry, 48% disagree that Darwin's theory of evolution is proven by fossil discoveries.

It should be noted however, that the reactions of clergy towards evolution through time have not been uniform. They covered a wide range of attitudes, from extreme fundamentalism to more tolerant declarations, trying to combine theological doctrines with scientific evolutionary aspects, in an effort to disorient the public in favour of church. The moderate statement of Pope John Paul II (1996) that *"new findings lead us toward the recognition of evolution as more than a hypothesis"*, but *"...if the origin of the human body comes through living matter which existed previously, the spiritual soul is created directly by God..."* is indicative of this bivalent attitude.

It is also a fact that several types of speculations, justified through Darwinian and neo-Darwinian aspects, arose from different frontiers and have generated misleading – if not monstrous – ideologies. On the one hand obsessions with the hierarchy of human races established by misuse of the Darwinian term "survival of the fittest" fed the development of various eugenic movements during the 19th century in many European countries and the USA which culminated in the Nazis' brutalities. At the opposite "humanistic" side a distorted version of Lamarckian theories, i.e. the rejection of genetic factors and the exclusive acceptance of environmental parameters in the evolutionary process, was generally imposed to the former communist countries. The ideology of a "socialistic" science which was dictated in the USSR by Lysenko (1948) during the '30s caused the extinction of brilliant geneticists and resulted in a delay of biological sciences in the eastern

world for half a century. Lysenko's activity still remains a notorious paradigm of the ideological misuse of science for political purposes (Ryan 2002).

Contemporary ideological implications – Creationism today

Both the aforementioned cases constitute dark intervals in the history of science having left behind thousands of innocent victims. They clearly show the potentially catastrophic results caused by the ideological implications in science and by the adoption of antiscientific propagandas either by the decision makers or by the wide public. In spite however of this bitter humankind's experience, pseudoscience and promotion of irrational aspects are more than ever present nowadays, with creationism constituting their glamorous facade. The term "creationism" covers a range of relevant beliefs referring to the origin and the function of life as a whole due to a supernatural divine power. "Scientific creationism" (no reliance on biblical revelation, utilizing only scientific data), "biblical creationism" (no reliance on scientific data, using only the bible), and "scientific biblical creationism" (full reliance on bible, but also using science) are some alternative approaches of contemporary creationism. Its roots are traced in the religious doctrine that humanity, life, the earth and the universe has been created by god(s). The "science" of creationism includes, among others, "scientific evidence" showing: A sudden creation of the universe and its constitutional entities (matter and energy), the inadequacy of mutation and natural selection to explain the life tree of living creatures, clearly distinct genealogy between humans and primates, relatively recent creation of earth and life, interpretation of the earth's geology through catastrophism, including the biblical event of flood.

Indeed, all monotheistic religions, Judaism, Christianity, Islam and their various branches, refer to God as the ultimate creator, whereas other dogmas (Hinduism, Buddhism, Taoism etc.) are based on different perceptions about the concept of nature, hence they are less amenable to fundamentalist arguments of this type. Creationism therefore, although not a religion itself, is closely linked to the different monotheistic religions, their clergy and consequently to the related conservative socio-economic and political powers.

Creationism in the USA

By the dawn of Darwin's theory all those whose views opposed to evolution were referred as anti-evolutionists. Since 1929 in the USA the term "creationist" became equal to christian fundamentalist, though its usage was contested by other groups who believed in various concepts of creation. Since the '20s however, creationism in America has contested scientific theories, such as that of evolution, which derive from observations of the universe and life. At earlier stages creationists just disdained or refused the scientific evidence on evolution. But recently they have invented a whole pseudoscience, the „Intelligent Design“ theory, promoted as a new science through a fuzzy documentation.

Although an extended survey of the history of creationism exceeds the aims of the present paper, some recent developments in the field of "Intelligent Design" should be mentioned in order to show the upgrade of the ideological and political pressure forced by creationists today, all deriving mainly from the USA where several creationistic establishments flourish.

A key person in the new creationistic movements is Walt Brown (2008), a mechanical engineer from the Massachusetts Institute of Technology and officer in the US military until his retirement 1980. In 1980 he became director of the "Center for Scientific Creation" which promotes the "Young Earth Creationist Movement".

The aforementioned center, in a trial dubbed the „Monkey Trial Replay“ (1981), claimed that teaching evolution as the sole theory violated the rights of children who believed in biblical creation, thus presenting its arguments as an issue of religious freedom under the U. S. constitution. The "Times" of 7 March 1981, however, noticed the dangers of the rising ideas reporting that some people faced the case as *"a signal of things to come, with more and more fundamentalist groups trying to flex their not inconsiderable influence in schools across the country"*.

At the same time Frank D. White, the governor of Arkansas signed a bill requiring that creation science and the theory of evolution should be given equal weight in schools (McLean v. Arkansas Documentation Project).

In 1986 another creationist organisation called „Reasons to Believe“ was established, supporting the "Old Earth Creationism". In 1989 the "Foundation for Thought and Ethics" published the book "Of Pandas and People. The Central Question of Biological Origin" by Davis and Kenyon (1989). The "Foundation for Thought and Ethics" (FTE) is a Christian non-profit organization

based in Richardson, Texas. It publishes textbooks and articles promoting „Intelligent Design“ and christian nationalism. The FTE has close associations with the "Discovery Institute", hub of the „Intelligent Design“ movement and other religious christian groups. In the aforementioned book, the definition of „Intelligent Design“ is given as follows: "Intelligent Design means that various forms of life began abruptly through an intelligent agency, with their distinctive features already intact". The publisher, in collaboration with religious groups supported a wide campaign for state textbook approval, with a relevant petition in Alabama urging that „Intelligent Design“ should be presented as an alternative to evolution. Efforts to motivate local school boards, teacher's groups and parents accordingly are continuously made. In its second edition (1993) the school textbook was enriched with a new chapter promoting the idea of irreducible complexity i.e. the argument that many biological systems are too complex to have evolved from simpler ancestor forms through natural selection.

The year 1990 could be considered as a cornerstone of „Intelligent Design“ theory, defined as an approach assuming that intelligent intervention was necessary for evolution, an approach which actually diminishes the validity of evolution and falsifies the scientific methodology as it leaves place for supernatural explanations.

In 1996, the "Discovery Institute's Center for Science and Culture" (CSC), formerly known as the "Center for Renewal of Science and Culture", was founded to promote „Intelligent Design“. Soon it started a public discourse with the publication of "Darwin's Black Box" by Michael Behe (1998), arguing for evidence of irreducible complexity.

The institute works systematically for the promotion of the so called "wedge strategy" since 1992. It is a work plan aiming to exploit all available means like mass media, academic institutions, political influence etc. in order to combat the "contemporary materialistic point of view" and re-introduce the christian values (actually the evangelical protestant values) in the body of science and its public understanding. Obviously the mass development of creationist museums all over the country should be considered as part of this strategy.

Creation museums, i.e. museums using the profile of a regular museum of natural sciences in order to present the aspect that the origins of the universe, life, mankind, and man's early history follow the Book of Genesis, have been established in many states. Although strongly criticized by the scientific community as institutes promoting fallacies instead of knowledge, they are really influential as they are lavishly sponsored by

religious centers and attract millions of visitors. A short catalogue of such “museums” is listed below:

The “Museum of Earth History” in Eureka Springs, Arkansas; it was constructed as a joint venture of the “Creation Truth Foundation” and “Passion Play” outdoor biblical theme park. The “Guardian” has described it as “first dinosaur museum to take a creationist perspective”. Three museums are established in California: the “Museum of Creation and Earth History” in Santee, the “Cabazon Dinosaurs” and the “Creation Research of the North Coast Museum” in Bayside. The first one is part of the “Institute for Creation Research” and, having been attracting 15,000 visitors per year, was considered the world’s largest creationist museum by the “Northwest Creation Network” until the title was taken by Kentucky’s creation museum. Four similar museums are in Florida: the “A Key Encounter Theater” in Key West, the “Creation Adventures” museum in Arcadia, the “Creation Discovery” museum in Ft. Lauderdale, and the “Dinosaur Adventure Land” in Pensacola. Also the “Camp Sunrise Museum” in Fairmount in Georgia, the “Creation Museum” in Petersburg, Kentucky (actually one of the richest institutes of this type; it opened in 2007, its cost is estimated to 27 million dollars and according to its website it has been visited by one million visitors within its three years function), the “Glendive Dinosaur & Fossil Museum” in Montana, “The Lost World Museum” in Phoenix, New York, the “Creation Museum” and “Antique Tool Museum” in North Carolina, the “Akron Fossils & Science Center” in Ohio, the “Grand River Museum” in South Dakota, the “Ark Museum and Dinosaur Park” and the “Wyatt Museum” in Tennessee, the “Creation Evidence Museum” in Glen Rose, Texas, the “Mt. Blanco Fossil Museum”, and the “Museum of Earth History” in Dallas, Texas, the “Liberty University Museum” in Lynchburg, Virginia, the “7 Wonders Creation Museum” located in Silverlake, Washington near Mount St. Helens. This one uses the volcano’s 1980 eruption to claim that geologic change can happen rapidly and that changes believed by mainstream scientists to take millions of years can occur in as short a period of time as hours or days.

Similar museums can be found in Canada (“Big Valley Creation Science Museum”, and “Creation Truth Ministries”), in China (“Noah’s Ark” in Hong Kong), in Germany (“Lebendige Vorwelt Museum”), in Serbia (“DINO Creation Museum- Center for Natural Studies”, Belgrade), in UK (“Creation Science Movement Genesis Exhibition” Portsmouth, “AH Trust Christian Theme Park” Lancashire, “Noah’s Ark Zoo Farm” near

Bristol), and even in Turkey (“Noah’s Ark Museum”, Uzengeli Village).

The aforementioned sporadic references are indicative of the strategies and the investments dedicated to the promotion of “Intelligent Design” pseudoscience in the USA. It is worth mentioning, however, that several of these strategies have their origins in Australia. In the last 20 years Australian protestant creationists manage two out of the three main international creationist research organizations. “Answers in Genesis” was founded in the late 1970s; since then it has expanded its influence in the USA (1994), New Zealand, United Kingdom, Canada, and South Africa. Several well educated leaders, for instance Ken Ham, the geologist Dr. Andrew Snelling, the astrophysicist Dr. Jason Lisle, the chemical engineer Dr. Jonathan Sarfati and the geologist Dr. Tasman Bruce Walker have all had significant impact on the development of creationism in Australia, and then they have brought their teaching to the USA. On 29 May 2010 Queensland State Schools announced that creationism and “Intelligent Design” will be discussed in history classes as part of the new national curriculum.

Thinking about the impact of these organized strategies to the public opinion, as well as to the repetitive efforts for educational reforms towards irrational, antiscientific and conservative directions, one should be aware of their effectiveness.

A report surveying the teaching of evolution in the USA by Lawrens S. Lerner (2000) under the auspices of California State University describes the quality of science education as it is assumed after assessment of several countable criteria. The picture is very disappointing in 19 out of 50 States and actually reflects the range of the interfering efforts of creationists who benefit from the democratic procedures involved in the country’s educational system in order to: a) totally ban the teaching of evolution, b) impose the teaching of “Intelligent Design” theory as the exclusive scientific interpretation of life, c) demand equal teaching of both the Bible and evolution in schools.

It seems that the American notion of the early ‘60s, when under the threat of the technological superiority of the USSR, the USA promoted a radical reform of their educational system in favor of science education, has been gradually weakened under the pressure of christian fundamentalists.

As a response to this situation, several active pro-evolution movements arising from teachers associations, individual teachers, universities and centers for the promotion of science education do their best to defend the obvious necessity for the development of a real

scientific culture. For example the “National Center for Science Education” (<http://ncse.com>) provides information and advice as the premier institution dedicated to keeping evolution in the science classroom and creationism out. It is a non-profit organization with 4000 members who are scientists, teachers, clergy, and citizens with diverse religious affiliations. The “National Center for Science Education” provides information and resources to schools, parents and concerned citizens working to keep evolution in public school science education. It educates the press and public about the scientific, educational, and legal aspects of the creation and evolution controversy, and supplies needed information and advice to defend good science education at local, state, and national levels.

Since 1999 the “National Academy of Sciences” delivers an online book “Science and Creationism” covering all the main topics of the science-creationism conflict and providing pro-evolution arguments. A relevant informative website is also the “Talk Origins Archives”.

Creationism in Europe

The situation is different in Europe. Europe used to see creationism as an exclusively US American phenomenon until it realised that its ideas had been exported to the old continent, threatening the rationalistic thinking in its place of origin. Conservative protestant establishments are hidden behind the adoption of creationistic ideas in several European countries. Their influence expands gradually, despite strong opponent voices in some countries with long lasting scientific tradition like UK, like the one of Richard Dawkins. An informative survey on the appreciation of creationism in various European countries can be found in: http://en.wikipedia.org/wiki/History_of_creationism#cite_note-63.

Indicative of the recent tendencies in favor of creationistic ideas is the statement of the German education minister Karin Wolff in 2007 that she believed creation theory should be taught in biology class as a theory, like the theory of evolution: “*I think it makes sense to bring up multidisciplinary and interdisciplinary problems for discussion*”.

The ministry of education of Romania approved in 2002 the use of a biology book endorsing creationism entitled “Divine Mastery and Light in the Biosphere” in public high schools, although it was characterized as an accessory and not as a textbook after the strong protest of the Romanian Humanist Association.

On 7 September 2004 the Serbian minister of education Ljiljana Colic temporarily banned evolution from being taught, although she was forced to resign later on.

In Poland, the deputy minister of education Mirosław Orzechowski told the “Gazeta Wyborcza” (in October 2006) that “*The theory of evolution is a lie, an error that we have legalised as a common truth.*”

Moreover, the increasing presence of Islam in Europe and the rapidly augmenting penetration of creationism in Islamic beliefs makes Europeans especially concerned about the possible implications of this situation in the secular education status of Europe. Thus, on 4 October 2007, a liberal democrat member of the Luxembourg parliament, Anne Brasseur, presented to the parliamentary assembly of the Council of Europe a report on the issue, showing how creationists – most of whom are Christian or Muslim – are trying to infiltrate European schools. As a result, the assembly (626 members elected from each European member state) adopted the 1580 resolution to ban creationism from receiving any discussion in schools outside of religion classes, noticing that: “*The Parliamentary Assembly is worried about the possible ill-effects of the spread of creationist ideas within our education systems and about the consequences for our democracies... If we are not careful, creationism could become a threat to human rights which are a key concern of the Council of Europe...*”. The Council of Europe calls on all nations of Europe “*to firmly oppose the teaching of creationism as a scientific discipline on an equal footing with the theory of evolution and in general resist presentation of creationist ideas in any discipline other than religion*”.

Several trans-European networks work on the improvement of science and education promoting excellence in research and teaching of life sciences. Such networks are the “European Molecular Biology Organisation” (<http://www.embo.org>), the related “European Molecular Biology Laboratory” (<http://www.embl.org>), the “European Life Sciences Forum” (<http://www.elsf.org>), the “Initiative for Science in Europe” (<http://www.initiative-science-europe.org>) etc. A marvelous online journal addressed to teachers and secondary level students, the “Science in School” (<http://www.scienceinschool.org>), is monthly delivered in 29 languages, bringing the frontier scientific achievements to the educational community. Thus, Europe responds to the challenge of creationism with the promotion of free rationalistic spirit.

Creationism in Islam

The attitudes of the Islamic world towards evolution need special attention. The situation has been shown in a survey about the adherence of teachers to creation science conducted in 2008 during the XIII Symposium of the "International Organisation of Science and Technology Education" (IOSTE), under the title "The use of science and technology education for peace and sustainable development" held in Izmir, Turkey in September 2008 (<http://www.ioste2008.org>). 5700 teachers from 14 countries participated in this survey. Lebanon, Senegal, Tunisia, Morocco and Algeria had 62% to 81% of creationist teachers (with no difference between biologists and others). In Lebanon teaching evolution has been banned since mid '90s. In Turkey, theistic and scientific aspects are taught in parallel since 1985, after relevant governmental decision. Campaigns against teaching evolution in schools are often performed in Lebanon, Egypt, Indonesia and elsewhere. Pakistan sponsors international conferences on creation. The Muslim clergy (muftis) reprobate Darwin in their sermons. Surprisingly however, Iranian Ayatollahs hold a more compromising position closer to the „Intelligent Design“ theory, i.e. that evolution does not necessarily contradict to the Holy Scriptures. It is worth noticing however, that such an approach offers Iran the theoretical cover for the realization of a wide, publicly funded research program on stem cells, unique in Islamic world.

Turkey, although a secular state itself, holds the leadership of the creationistic movements in the Islamic world either in Asian countries or in Islamic communities settled in Europe. This is not irrelevant to the strong links of conservative Americans with Turkish intellectuals. In 2008 a magisterial decision banned the website of Richard Dawkins in Turkey after an appeal of a debatable person, the writer Adnan Oktar (mostly known as Harun Yahia). This odd personality, although lacking scientific or theological background (he has studied interior design) constitutes the most aggressive creationistic voice of Islam. He runs an Islamic organization which owns a publishing house with luxurious editions and a video production company. His book "The Atlas of Creation" (2007, 800 luxurious pages), has been translated to 13 languages, it is displayed in every bookstore of the Islamic countries and recently hundreds of copies were sent to schools and universities in Europe and the USA, without having been asked. Again creationism shows its "religious business" profile and its complex relationships with geopolitical interests.

It should be noted however, that whereas the western world is rather familiar to the debate among science and

creationism (actually based on the contradiction among rationalistic methodology and religious doctrines), the situation in Islam is more complex. On the one hand, according to several Koran scholars for instance, there are not clear incompatibilities between Mohamed's sayings and evolution. On the other hand numerous members of the Islamic intellectual elite actively work for the promotion of creationistic ideas. In some cases the controversy in Islam overcomes the dipole science-religion being transformed to ideological conflict between East and West, or, in practice, (functional) obedience versus (revolutionary) rationalism. The Oktar's propaganda for instance claims that "*Islam, on the occasion of evolution, faces a scientific dictatorship controlled by freemasonry aiming to its elimination!*"

Conclusion: the attitudes and the responsibility of Scientists

The old debate between religion and science has passed several phases since the beginning of human culture. Initially, in primitive societies religious leaders (samans) exclusively mastered the knowledge on the mystery of life. Later on the clergy in ancient civilizations was the body of connoisseurs of nature's secrets. Ionian philosophers and their spiritual offsprings introduced the free thinking (Æonian Renaissance) and put the bases for the contemporary science. After centuries of human progress the cognitive frameworks of clergy and scientists gradually diverged as the former remain stuck to undisputable dogmas, whereas the latter trusted only the empirical data, being aware however of the complexity of nature and of the limits of science. Obviously the power of science is found in its ability to doubt, reject unsuccessful theories, rethink and reform its aspects whenever new data support better explanations. science evolves, religion insists on its unchangeable patterns. Science continuously renews the content of the debate without feeling threatened by the new ideas, whereas religion defends its doctrines by attacking the – non compatible to them – scientific evidence. Whereas science has documented its contribution to the improvement of humankind, religion offers illusions and supernatural perspectives. It seems that the endless efforts of church(es) to depreciate the scientific achievements are directly linked to their desire for human manipulation and maintenance of power. Creationism develops as a political and socioeconomic movement trying to impose religious dogmatism on contemporary societies, promoting irrational and confusing views to the wide public, mainly through education and mass media,

actively supported by conservative political centers. This is not just an issue of ideological retroceding to the Dark Ages. It is a dangerous situation concerning the quality of our democracies as it influences the ability of people to make conscious decisions so crucially needed today in our rapidly developing technological societies.

For years scientists did not deal systematically with such issues being absorbed in their research areas. Neither had they linked their personal religious beliefs, which range between rational thinking, atheism, agnosticism and religious faith, to the functional framework of science. But nowadays, many well educated scholars with scientific background propagate creationism and „Intelligent Design“ theory. Therefore, more active reactions are needed worldwide to defend the human right for access to reliable scientific information, better science education and broader dissemination of public understanding of science. Consequently, it is an indispensable obligation of the scientific and educational community to uncover the real motives of relevant ideological conflicts, to show to the younger generations the enlightening pathways of science and to combat prejudices and pseudoscientific illusions.

References

- Anonymous. *Talk Origines Archives*. <http://www.talkorigins.org> (20.12.2010).
- Anonymous 1981. *Monkey Trial Replay*. http://creationwiki.org/History_of_creationism (20.12.2010).
- Anonymous 1986. *Reasons to Believe*. <http://www.reasons.org/about-us> (20.12.2010).
- Anonymous 1999. *Science and Creationism: A View from the National Academy of Sciences*. National Academy of Sciences (Second Edition), Washington.
- Anonymous 2002. *Divine Mastery and Light in the Biosphere 2002*. Romanian ministry of education. <http://www.evz.ro/detalii/stiri/carte-creationista-pentru-biologie-avizata-de-minister-844190.html> (20.12.2010).
- Behe M 1998. *Darwin's Black Box*. Free Press.
- Brown W 2008. *In the Beginning: Compelling Evidence for Creation and the Flood*. Center for Scientific Creation (8th Edition).
- Colic, L. 2004. <http://www.popsoci.com/taxonomy/term/30899/all> (20.12.2010).
- Harun Yahia 2007: *Atlas of Creation (Volume 2–3)*. Global Publishing (9th edition).
- Harris poll 2005. <http://www.pollingreport.com/science.htm> (20.12.2010).
- John Paul II, The Pope, 1996. http://www.newadvent.org/library/docs_jp02tc.htm (20.12.2010).
- Lerner L 2000. *Good Science, Bad Science: Teaching Evolution in the States*. Thomas B. Fordham Foundation. Washington.
- Lysenko TD 1948. <http://www.marxists.org/reference/archive/lysenko/works/1940s/report.htm> (20.12.2010).
- Mayr E 2000. *Darwin's Influence on Modern Thought*. Scientific American 59: 79–83.
- McLean v. Arkansas Documentation Project. http://www.antievolution.org/projects/mclean/new_site/index.htm (20.12.2010).
- Orzechowski M 2006. <http://newhumanist.org.uk/1783/western-front> (20.12.2010).
- Percival D, Kenyon DH 1993. *Of Pandas and People. The Central Question of Biological Origin*. The Foundation for Thought and Ethics (Second Edition).
- Ryan S 2002. *Trofim Denisovich Lysenko Reference Archive*. <http://www.marxists.org/reference/archive/lysenko/index.htm> (20.12.2010).
- Wolff K 2007. <http://fistfulofeuros.net/afoe/political-issues/funny-it-doesnt-look-like-kansas/> (20.12.2010).

Addresses:

Kally Simitopoulou, Nikolaos I. Xirotiris
Laboratory of Anthropology DUTH
P.O.Box 209
69100 Komotini
Greece
Tel.: +30 253 103 9999
E-mail: simit@he.duth.gr, xirot@he.duth.gr

RICHTLINIEN FÜR AUTOREN

Die vorliegenden Autoren-Richtlinien sind als spezifische Ergänzung / Anpassung an die gängigen „Uniform Requirements for Manuscripts Submitted to Biomedical Journals“ (siehe <http://www.icmje.org/icmje.pdf>) gedacht, welche als Grundlage für eine Manuskripteinreichung beim *Bulletin der Schweizerischen Gesellschaft für Anthropologie* gelten.

Allgemeines

Artikel-Kategorien

Folgende Artikel-Kategorien können publiziert werden:

- **Originalarbeiten:** In der Regel max. 30 A4-Seiten (einschliesslich Tabellen, Abbildungen und Literaturverzeichnis).
- **Zusammenfassungen von Abschlussarbeiten / Vorträgen:** In der Regel max. 30 A4-Seiten (einschliesslich Tabellen, Abbildungen und Literaturverzeichnis).
- **Technical Notes:** In der Regel max. 15 A4-Seiten, methodisch ausgerichtet.
- **Buchbesprechungen:** Max. 2 A4-Seiten, nur Text, bibliographische Details.
- **Berichte:** Max. 5 A4-Seiten, nur Text.
- **Mitteilungen:** Max. 1 A4-Seite, Hinweise auf Veranstaltungen usw.
- **Reviews / Diskussionsforum:** Generell nur auf Einladung des Redaktionskomitees, ungefragte Einsendungen können jedoch evtl. berücksichtigt werden.

Sprache

Die Manuskripte können in deutscher, französischer, italienischer oder englischer Sprache abgefasst sein.

Manuskriptabfassung (Originalarbeiten)

Gestaltung

Für das ganze Manuskript (inkl. Titel, Abbildungslegenden, Tabellen etc.) gilt:

- Schrift „Times New Roman“, Schriftgrösse 12, doppelter Zeilenabstand. Seitenränder allseitig 2.5 cm. Fortlaufende Seitennummerierung (beginnend mit Titelseite). Keine Worttrennungen. **Keine Formatierungen** (wie z.B. Tabulator, Textboxen, Blocksatz etc.), ausser lateinische Wörter resp. Speziesnamen *kursiv*.
- Keine Fussnoten, kein Inhaltsverzeichnis.

Aufbau

Hauptabschnitte, jeweils auf eigener Seite beginnend:

- **Titelseite:** Titel der Arbeit in Textsprache und in Englisch. Zusätzlich Kurztitel (max. 40 Zeichen) für Kopfzeile. Name und vollständige Anschrift des korrespondierenden Autors sowie Name, Institution und Ort weiterer Autoren. Angabe von allfälligen finanziellen Abhängigkeiten.
- **Zusammenfassung:** In der Textsprache und in Englisch mit jeweils max. 5 Schlüsselwörtern. Vollständige Sätze, Darstellung der wesentlichen Aspekte der Arbeit, max. 250 Wörter.
- **Text:** Überschrift 1: Fett markiert und zentriert.
Überschrift 2: Fett markiert und links ausgerichtet.
Überschrift 3: Normal markiert und links ausgerichtet.
- **Literaturverzeichnis.**
- **Abbildungsnachweis.**
- **Anschrift:** Name, Institution, Adresse, Land, Telefon, Fax, E-Mail. Korrespondierender Autor an erster Stelle, dann Autorenliste in alphabetischer Reihenfolge.
- **Liste der Tabellen- / Abbildungslegenden:** Nicht in den Text einfügen, sondern durchnummeriert als separate Liste in untenstehender Art hinten anfügen:
Abbildungslegenden: Abb. X: iii.
Tabellenlegenden: Tab. X: iii.

Abbildungen und Tabellen

- Abbildungen sollen möglichst als Original in Form von Dias, Schwarzweiss-Fotos oder Strichzeichnungen vorliegen. Für die Beschriftung gilt: Abbildungsnummer und Orientierung des Bildes auf dem Diarahmen resp. auf der Fotorückseite vermerken.
- Eingescannte Abbildungen: Scannen in Originalgrösse bei einer Minimalauflösung von 800 dpi im TIFF-Format (Schwarzweiss-Datei).
- Eingescannte Dias oder Negative müssen in einer Auflösung von 2400 dpi im TIFF-Format vorliegen.
- Digitalfotos müssen in höchstmöglicher Auflösung vorliegen (mindestens „fine“ oder „high“).
- Abbildungen, Diagramme, Zeichnungen und Tabellen sind mit den fortlaufenden Abbildungs- bzw. Tabellennummern zu kennzeichnen und mit einer kurzen Legende zu versehen. Alle Abbildungen und Tabellen erscheinen als fortlaufend nummerierte Hinweise im Text, z.B. (Abb. 1) bzw. (Tab. 1).
- Die Redaktion geht davon aus, dass der Autor / die Autoren im Besitz der Abdruckrechte der Abbildungen für die vorgesehenen Zwecke sind.

Bibliographie

Persönliche Mitteilungen (Meier *persönl. Mitteilung*) oder eingereichte und nicht akzeptierte Arbeiten (Meier *submitted*) sollten im Text nicht zitiert werden. Der Autor / die Autoren sind für die Richtigkeit der Bibliographiezitate verantwortlich.

- **Zitierweise im Text:**
Ein Autor: (Schultz 1992), (Schultz 1992; Maier 1978a, 1978b).
Falls Seitenzahlen angegeben werden sollen:
Eine Seite: (Schultz 1992, p 13; Maier 1978; p 245).
Zwei Seiten: (Schultz 1992, p 13f.).
Mehr als zwei Seiten: (Schultz 1992, p13ff.).
Zwei Autoren: (Acsádi und Nemeskéri 1970).
Drei und mehr Autoren: (Herrmann *et al.* 1990).
- **Zitierweise im zusammenhängenden Text:**
Ein Autor: Schultz (1992, p 4), Schultz (1992, p 13f.) oder Schultz (1992, p 13ff.) weist auf...
Zwei Autoren: Müller und Maier (1979) weisen...
Drei und mehr Autoren: Herrmann *et al.* (1990, p 35) weisen...
- **Zitierweise im Literaturverzeichnis:**
Das Literaturverzeichnis am Ende des Textes soll alphabetisch (und innerhalb des Autors chronologisch absteigend) geordnet sein. Arbeiten in press (Meier *in press*) sind mit vollständigen Angaben (inkl. Journal) im Literaturverzeichnis aufzuführen.

Artikel in Zeitschriften:
Die Namen der Zeitschriften sind auszuschreiben.
Ein Autor: Bach H 1965. Zur Berechnung der Körperhöhe aus den langen Gliedmassenknöchen weiblicher Skelette. Anthropologischer Anzeiger 29: 12-21.
Mehr als drei Autoren: Maier A, Müller HP, Schmidt C *et al.* 2000....
Falls mehrere Artikel vom gleichen Autor im selben Jahr erscheinen sind: mit a, b usw. bezeichnen (z.B. Meier 1999a, Meier 1999b).
Falls Jahrgang und Druckjahr unterschiedlich sind: Müller H 1906 (1907). Xyz...

Arbeiten in Büchern:
Arnold K 1986. Die Einstellung zum Kind im Mittelalter. In: Herrmann B (ed.). Mensch und Umwelt im Mittelalter. Springer. Stuttgart, 53-64.

Bücher:
Herrmann B, Grupe G, Hummel S, Piepenbrink H, Schutkowski H 1990. Prähistorische Anthropologie. Leitfaden der Feld- und Labormethoden. Springer. Berlin, Heidelberg, New York.

Hinweise auf Internetseiten:
Sind mit dem letzten Zugriffsdatum zu versehen: www.beispiel.de (14. 3. 2005).

Weitere Hinweise

- Kommende Veranstaltungen, auf welche im Bulletin hingewiesen werden sollen, bitte frühzeitig der Redaktion melden!
- Die Gesamtdauer des initialen externen Review-Prozesses ist auf maximal einen Monat veranschlagt.
- Der korrespondierende Autor erhält ein elektronisches „Gut zum Druck“.
- Grundsätzlich wird nur schwarzweiss gedruckt. Bei Übernahme der Kosten durch den Autor / die Autoren können einzelne Seiten farbig gedruckt werden.
- Die Autoren erhalten eine pdf-Version und pro Autor ein gedrucktes Freiexemplar (weitere gedruckte Exemplare nach Rücksprache mit der Redaktion). Eingesandtes Material (Text, Originalabbildungen) verbleibt im Besitz der Redaktion, kann auf ausdrücklichen Wunsch der Autoren jedoch zurückgeschickt werden.

Manuskripteinreichung

Form der Abgabe

Elektronische Version (bevorzugt Windows XP® / Word XP®, ganzes Manuskript als pdf-Dokument) via E-Mail und gleichzeitig Textdokument auf CD-Rom auf dem Postweg an Redaktionsadresse. Schreibmaschinenmanuskripte nur nach vorheriger Absprache mit der Redaktion. Text sowie die einzelnen Abbildungen als jeweils separate files.

Redaktion

Dr. Christine Cooper
E-mail: munkel@swissonline.ch
Tel.: +41 (0)76 404 80 63

Dr. Christina Papageorgopoulou
E-mail: papageor@uni-mainz.de
Tel.: +49 (0)6131 39 23472

INSTRUCTIONS TO AUTHORS

These guidelines are intended as specific supplement / adaptation to the “Uniform Requirements for Manuscripts Submitted to Biomedical Journals” (see <http://www.icmje.org/icmje.pdf>) which apply to manuscripts submitted to the *Bulletin der Schweizerischen Gesellschaft für Anthropologie*.

General information

Article categories

Articles of the following categories can be published:

- **Original articles:** Generally no more than 30 A4-pages (including tables, illustrations and reference list).
- **Summaries of theses / presentations:** Generally no more than 30 A4-pages (including tables, illustrations and reference list).
- **Technical notes:** Max. 15 A4-pages, focused on methodological aspects.
- **Book reviews:** Max. 2 A4-pages, only text, bibliographical details.
- **Reports:** Max. 5 A4-pages, only text.
- **Communications:** Max. 1 A4-page, information on events etc.
- **Reviews / Discussion forum:** Generally only at the invitation of the editors; unasked contributions may be accepted under certain circumstances.

Language

The manuscripts can be written in German, French, Italian or English.

Composition of manuscripts (original articles)

Design

The following rules apply to the entire manuscript (including titles, illustration legends, tables etc.):

- Font “Times New Roman” size 12. Double-spaced. Margins 2,5 cm on all sides. Consecutive page numbering starting on the title page. No word divisions. **No formatting** (like tabulators, text boxes etc.) except Latin words respectively species names *italic*.
- No footnotes, no table of contents.

Structure

Main sections, each beginning on a separate page:

- **Title page:** Title in text language and in English. Give an additional short title (max. 40 characters). Complete name and address of corresponding author. Names, institutions, and places of further authors. Declaration of any financial dependencies.
- **Abstract:** In the language of the text and in English with max. 5 key words each. Complete sentences, summary of the work's essential aspects, max. 250 words.
- **Text:** Title 1: Bold, centered.
Title 2: Bold, aligned left.
Title 3: Normal, aligned left.
- **Reference list.**
- **Proof of illustrations.**
- **Address:** Name, institution, address, country, telephone, fax, e-mail. Corresponding author first, followed by other authors in alphabetical order.
- **List of table and illustration legends:** Not to be inserted in the text, instead separate list of consecutively numbered legends at the end of the document in the following style:
Illustration legends: Fig. X: iii.
Table legends: Tab. X: iii.

Illustrations and tables

- Illustrations should be supplied as original black-and-white photographs, slides, or line drawings. Number and orientation of the figure are to be noted on the back of the photograph or on the slide frame.
- Scanned images: Scan in original size with a minimal resolution of 800 dpi in TIFF-format (black-and-white file).
- Scanned slides or negatives must have a resolution of 2400 dpi in TIFF-format.
- Digital photos in the highest resolution possible (at least „fine“ or „high“).
- Illustrations, diagrams, drawings and tables are to be marked with the consecutive figure / table number and a short legend. All illustrations and tables appear as consecutively numbered notes in the text, e.g. (Fig. 1) or (Tab. 1).
- The editors assume that the authors are in possession of the printing rights for all illustrations for the designated purpose.

Reference style

Personal communications (Meier *pers. comm.*) or submitted and not accepted work (Meier *submitted*) should not be quoted in the text. The authors are responsible for the accuracy of all references.

- **In the text:**

One author: (Schultz 1992), (Schultz 1992; Meier 1978a, 1978b).

When pages are mentioned:

One page: (Schultz 1992, p 13; Meier 1978, p 245).

Two pages: (Schultz 1992, p 13f.).

More than two pages: (Schultz 1992, p 13ff.).

Two authors: (Acsádi and Nemeskéri 1970).

Three and more authors: (Herrmann *et al.* 1990).

- **In the running text:**

One author: Schultz (1992, p 4) mentions...

Two authors: Müller and Meier (1979) mention...

Three or more authors: Herrmann *et al.* (1990, p 35ff.) mention...

- **In the reference list:**

The reference list should be in alphabetical order (and within one author in descending chronological order). Work in press (Meier *in press*) is to be listed with complete specifications (including journal).

Articles in journals:

The journals' names must be spelled out.

One author: Bach H 1965. Zur Berechnung der Körperhöhe aus den langen Gliedmassenknöchel weiblicher Skelette. *Anthropologischer Anzeiger* 29: 12-21.

More than three authors: Meier A, Müller HP, Schmidt C *et al.* 2000....

In case several articles by the same author were published in one year, indicate this with a, b etc.: (Meier1999a, Meier 1999b).

When year and year of printing are different: Müller H 1906 (1907). Xyz....

Contributions in books:

Arnold K 1986. Die Einstellung zum Kind im Mittelalter. In: Herrmann B (ed.). *Mensch und Umwelt im Mittelalter*. Springer. Stuttgart, 53-64.

Books:

Herrmann B, Grupe G, Hummel S, Piepenbrink H, Schutkowski H 1990. *Prähistorische Anthropologie. Leitfaden der Feld- und Labormethoden*. Springer. Berlin, Heidelberg, New York.

Internet sites:

Must be listed with the last date of access: www.example.de (14. 3. 2005).

Further information

- Future events that should be mentioned in the bulletin need to be communicated to the editors as early as possible!
- The entire duration of the initial review process is maximally one month.
- The corresponding author will receive an electronic proof for checking.
- Generally, printing is in black-and-white. It is possible to print single pages in color at the author's expense.
- The authors will receive a pdf-version and a free reprint each (further reprints can be obtained in agreement with the editors). Submitted material will not be returned to the author, unless specifically requested.

Submission of manuscript

Form of submission

Electronic version (preferably Windows XP® / Word XP®, entire manuscript as pdf-file) by e-mail and at the same time text document on CD-Rom by mail to the editorial address. Typewritten manuscripts only after arrangement with the editors. Text and illustrations as separate files.

Editors

Dr. Christine Cooper
E-mail: munkel@swissonline.ch
Tel.: +41 (0)76 404 80 63

Dr. Christina Papageorgopoulou
E-mail: papageor@uni-mainz.de
Tel.: +49 (0)6131 39 23472