

# Aegyptus et Pannonia VI.



Acta Symposií anno 2019

B U D A P E S T



# **Aegyptus et Pannonia VI.**

Acta Symposii anno 2019

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# AEGYPTUS ET PANNONIA VI.

Health and Life in Ancient Egypt. Mummies in Focus

Proceedings of the Conference held 27-29<sup>th</sup>

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## **INTRODUCTION TO THE “HEALTH AND LIFE IN ANCIENT EGYPT” CONFERENCE-VOLUME**

**Dr. Hedvig Győry PhD**

Earlier readers of *Aegyptus et Pannonia* will surely be surprised by this volume. It has been more than 10 years since we organised our last conference for the fifth volume, and the theme has changed completely. Therefore, as an introduction, we would like to briefly summarize the recent events and the activities we have carried out in the professional field. This is also the reason for the structural change: the conference presentations will be followed by detailed articles resulting from the work of our Society.

### **The Hungarian-Egyptian Friendship Society and the Ancient Egyptian Committee**

The Hungarian-Egyptian Friendship Society (HEFS) has been a non-governmental organization operating since 1995, which strives to acquaint and promote Egyptian culture; scientific activities and research are essential elements among its objectives. We discuss actual and earlier Egyptian topics from historical, artistic, literary, touristic or even economic points of view in our lectures. We also organize other programs according to the demand of situations and suggestions of our members. Thus, in the recent period our programs included Egyptian days and festivals, workshops, excursions, experience reports, public meetings and quizzes, as well as literary and photo competition. We also share other news and curiosities on our website and in our radio programs. Our activities are carried out partly in collaboration with other organizations, as was the conference organized in 2019 “Health and Life in ancient Egypt. Mummies in Focus”, presentations of which are published in this volume.

Particular emphasis is placed in our efforts to raise awareness of ancient Egyptian monuments, which is why an independent Committee (Ancient Egyptian Committee / AEC) has been set up to coordinate this. It plays a key role in the life of the Society and has done much work both in dissemination and research in recent years.

Part of our work is aimed at pupils who are taught ancient Egyptian knowledge through competitions in a playful way. There were also children’s classes and lectures in schools and community places (often called house of culture in the Hungarian language). Here, we primarily work through manual skills to develop on visual culture. We have been writing out fine art competitions (drawing/painting, puppet, digital

storytelling) for years. In the last two years, an adult category was also launched for the competition at the public's request, and we have organized some exhibitions with the paintings in Hungary, but had already a children's drawing/painting exhibition in Cairo. The committee has published a book on several occasions, most recently with children's drawings/paintings about the ancient Egyptian myth on the Eye of the Sun, and the next such volume is processed. Our radio programs belong also to this activity; there we present various faces of ancient Egypt and report on the latest news ("On the field of the Pharaohs"), resp. we draw attention to exhibitions in Hungary ("From Exhibition to Exhibition").

In the research field, the Ancient Egyptian Committee was initially involved in the excavation and reconstruction works of the Isis Temple in Szombathely (Savaria), focusing primarily on the religious, social, lifestyle, and artistic aspects of Egyptian religious cults. In co-operation with the archaeologists of the Savaria Museum in Szombathely and the Hungarian National Museum in Budapest, it also organized five international conferences. At that presentation, national results, discussion of controversial cases, and lectures on international professional results took place. A significant part of the lectures appeared in the form of articles in the volumes of *Aegyptus et Pannonia*, founded by AEC, representing the diversity of relevant scientific researches.

### **The medico-history research group**

Already in the early 1990s, we contacted the Semmelweis University II, Clinic for Internal Medicine. With the support of the then director, Professor János Fehér, we published several publications in the *Orvosi Hetilap* and other Hungarian medical / medico-historical periodicals. In 2003 under the auspices of the Kriterion Publishing House in Cluj-Napoca, the book "Health and Lifestyle in Ancient Egypt" was published with the assistance of a biochemical researcher at the University. Besides the articles, lectures were also given on request.

The medico-history research group in the AEC was established with such antecedents in 2010 to examine herbs of ancient Egyptian medicine that can still be used currently in today's life, in the knowledge that ancient Egyptian science has reached such a high standard that it has become an outstanding and exemplary professional skill for the surrounding peoples, and later became one of the cornerstones of modern medicine — through the mediation and further development of Greek and Roman and then Arabic medicine. A significant part of the substances used in prescriptions are of vegetal origin, so reviewing and examining their effects and the data on them may provide new uses for current pharmacology. In this field, we collaborated primarily with researchers from the Semmelweis University of Medicine, under the direction of Professor Anna Blázovics.

A few years ago, I was also invited to contribute to the work of the editorial staff of *Kaleidoscope, Journal of Culture, Science and Medical History* at the Semmelweis Uni-

versity. Last year a lecture was given with the staff of the University and the Hungarian Academy of Sciences on the occasion of the Science Day of the Hungarian Academy of Sciences. We thus also maintain an excellent relationship with Professor Judit Forrai, who headed the Institute of Public Health at Semmelweis University, and with the Life Sciences and History Working Committee of the Hungarian Academy of Sciences under her leadership.

Over time, we contacted the HNM Semmelweis Museum of the history of Medicine, which also houses some Egyptian medical material, and the mummy of Zoltán Arányi, whose mummification method raises questions concerning the afterlife of this practice. Documents on this topic were encrypted for the conference, published in this volume.

Initially, our goal was to present international results to Hungarian people, which is why we have given several lectures inside and outside the Society on herbs known and used in ancient Egypt, from the point of view of phytotherapy, aromatherapy, and other medico-historical topics, some of which are summarized in our *Egyiptomi Füzetek* (Egyptian Booklets). We aimed to make aware as many people as possible of the newly acquired pieces of knowledge; at the same time these lectures provided us opportunity for a kind of summary and systematization, for reviewing the still immature results, and for expanding the professional consultation.

After years actively pursued in-depth research on *materia medica*, we have found interesting, even currently valid discoveries in the case of figs, sycamore, Christ's thorns, or coniza. In doing so, we collaborated with the Institute of Pharmacognosy at the Semmelweis University and the Hungarian Free Radical Research Society (Magyar Szabadgyök-Kutató Társaság), also involving pharmacist students at the University, focusing on free radical researches. It has led to a significant change in attitudes and approaches. Our research has yielded results that are as valuable from a medico-historical point of view as from a medical point of view, because they may provide solutions to broaden boundaries in the field of pharmacognosy and to discover newer therapeutic indications. It has been proven that the use of the ingredients listed in ancient Egyptian recipes studied so far can be proven to be effective drugs even today. One of our articles<sup>1</sup> was awarded the Lajos Markusovszky Prize by the *Orvosi Hetilap* (Medical Weekly, May 2017). The student, we worked with, took also a 2<sup>nd</sup> place prize for her work made for the rector's competition in the frame of the Scientific Students Body (TDK).

Scientific publications were thus produced and the need for wider dissemination of the results arose again. The idea of a public meeting or dissemination conference

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1 Katona, Júlia – Győry, Hedvig – Blázovics, Anna: „Azon orvosságok kezdete, melyeket a májra adnak”. [The beginning of the medicaments given for the liver]. *Orvosi Hetilap* 157/48, 2016, 1926-1933.

was raised, where ancient Egyptian medicine could be approached from a historical, cultural, ethnographic and pharmaceutical historical point of view, while drawing attention to the diverse uses and health-preserving and improving roles of these plants. In the course of these researches, the study of the contemporary treatment of the liver came to the fore again, which is also reflected in the current volume, building on our previous results. In the course of this investigations, it was suggested that it would be worthwhile to follow the *jns.t* / anise identification more thoroughly. The results of the researches can be found in this volume, significantly expanded compared to what was presented at the conference. Another direction of research is the mineral analyses, which we recently launched with the participation of Dr. Klára Szentmihályi.

The year 2018 then gave our research team a new impetus and members. In addition to phytotherapy and pharmacognosy, there was an anthropological direction, as can be seen from our article in the volume, which is an expanded material for the 2019 conference presentation. At the same time, we have relaunched the series of *Aegyptus et Pannonia* scholarly symposia with a new direction: mummy research. That year namely, a PhD student Enikő Szvák, who has been investigating the Egyptian mummies of the Hungarian Natural History Museum, asked us to help with our expertise in ancient Egyptian culture by participating in the research of these mummies. We already made some insight into this field as we have continually monitoring the publications concerning ancient Egyptian mummies, but made some practical steps only in 1996, with the help of Ildikó Pap, the than director of the Anthropological Department, when a publication was issued for the 90<sup>th</sup> centenary of the Hungarian excavation at Gamhud, Middle Egypt. It included the human remains kept in the Hungarian Natural History Museum, taken out from the coffins published at that time.<sup>2</sup>

We have now embarked on a much wider range of activities, as indicated by our joining to the Nephthys Project. The new, exciting topic added new colour to the palette of our research team, and brought our earlier conference plan to the forefront. It was a natural consequence of organizing this conference together with the Hungarian Museum of Natural History. Still, since there are also ancient Egyptian monuments in the Hungarian National Museum's Semmelweis Museum of Medical History in Budapest, we wanted to draw attention to them as well. The fact that this conference remained not just a plan is due to the active participation of the two partner-institutions, and also to the National Cultural Fund (NKA), which not only made possible to organize the conference, but also contributed to the publication of this volume. We received further help from Ibisz Bt.

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<sup>2</sup> Győry, Hedvig, *Az első magyar ásatás Egyiptomban, 1907. Válogatás a gamhudi ásatás anyagából, 1997.* [The first Hungarian Excavation in Egypt, 1907. Selection from the material of the Gamhud excavation. 1997]. Budapest 1998.

## ***The Nephthys Project***

**Enikő Szvák**

The Nephthys Project was launched in the fall of 2018 as part of a PhD dissertation. The aim of the research is a comprehensive series of studies on Egyptian human and animal mummies and mummy remains kept in Hungary. A particularly important aspect is to implement a multidisciplinary investigations that involves the least invasive procedures possible.

The research began with the biological anthropological reconstruction of the Egyptian mummy collection preserved in the Anthropological Department of the Hungarian Museum of Natural History. Based on the preliminary results, the investigation of the pathologically most promising pieces continued with industrial CT examination, electron microscopy and 3D digital microscope analyses. Radiocarbon dating was also performed, aiming to get a more precise age-determination of the mummies. We wanted to learn the age of death, the possibility of diseases, general health conditions, and materials used in mummification for the deceased individuals, and the period from which the remains originate.

In the course of our research, we found that not only human remains, but also the organic and inorganic chemical analysis of the materials used for mummification can add a lot of new and exciting information to our knowledge about mummies. Thus, the identification of mummifying substances is also treated as a priority area during the project.

We are also experimenting with new procedures. Our goal is not only to realize a multidirectional research, but also to advance in the field of innovation in the future. Therefore, we also performed non-destructive ion beam studies on mummy remains with the help of ATOMKI employees in Debrecen. The preliminary results of the procedure are encouraging, and it is believed that the method may be suitable for a preliminary assessment of the bones at a later stage. This could make further chemical analysis on remains in future safer and easier.

The project resulted in several conference-presentations and professional posters at renowned national and international conferences. These successes gave us the chance to find new research partners and bring new mummy remains under investigation. Currently, the research material of the project includes the remains of the Egyptian human and animal mummies of the HNM's Semmelweis Museum of Medical History and the Török Aurél Collection in the Eötvös Lóránt University, Budapest, as well as the fish mummy of the Déri Museum, Debrecen.

Some of the test series have been completed, and other ones are still ongoing, as the evaluation of the results is. The first scientific publications were scheduled for 2020, which is unfortunately severely hampered by the limitations due to COVID-19.

With the scientific conference we organized, we want to create a tradition. We want to encourage renowned international researchers to participate in the mummy conferences held in Hungary every few years to become an integral part of the circulation of the Egyptian mummy research. In our opinion, it is essential to maintain old professional relationships and make new acquaintances also for the sake of research and to increase our professional knowledge. To maintain the research's smoothness, from time to time, the partial results available to us should be presented to the general public and the narrower profession in the framework of scientific lectures and professional posters. It makes it easier to clarify the issues before the publications appear, so we also organized a mummy workshop on one of the afternoons of the "Health and Life" conference. We presented our results in front of a forum of excellent researchers.

We are pleased to announce that there are currently more than twenty Hungarian and international institutions and more than thirty colleagues working free of charge for the success of the research. We hope that this number will get higher over time and that even more will join us.

At present, we hope that our relatively recent research will stand the test of time and enrich the positive image of Hungarian anthropologists and researchers abroad as a long-term project.

### **Health and Life in Ancient Egypt conference**

In 2012, our conference "Cultures and Therapies. Ethnography and Science" failed due to financial reasons, so it was a special pleasure for us to successfully apply in 2018/2019 for an international conference with the Hungarian Natural History Museum and the HNM's Semmelweis Museum of Medical History. The conference entitled "Health and Life in Ancient Egypt. Mummies in Focus" was held in August 2019. Its program could be followed on the conference's website to make it available to those interested.

The conference was preceded by a press reception organized by the Hungarian Natural History Museum, for which a separate promo spot was created. The participants of the conference were greeted by dr. Ildiko Pap PhD, the honorary director of the Department of Anthropology of the Hungarian Natural History Museum and dr. Gábor Tomka, the deputy general director of the Hungarian National Museum and the Egyptian Embassy. In the introductory speech the three organizing institutions presented their respective research and plans. During the lectures, we enjoyed the hospitality

of the two partner institutions for three days. An exhibition was also organized in the Semmelweis Museum of Medical History in honour of the conference, which was presented to the participants by the museum staff on the occasion of a reception. During the conference, lectures, a poster section and two workshops were held, which provided opportunities to get to know the new results more thoroughly, also on the situation of the research in ancient TB, and discuss the issues that arose during the research of the examined mummy material in the Museum. Many of the presentations were held as introduction to discussions and consultations, which provided an opportunity for exchanges of professional experience.

The program ended with a visit to the Egyptian exhibition in the Museum of Fine Arts and another one to the Holy Right preserved in St. Stephen's Basilica. It was also possible to visit the periodical exhibition "Gold of Mexico" and try out the "Escape Room" of the Hungarian Natural History Museum.

### **Acknowledgement**

The publisher of this volume would like to thank all the organizations and individuals, who made possible the conference and the publication of the volume, as well as the speakers and the volunteers involved in organizing and conducting it, who contributed to the success of the conference by their work.

We want to emphasize the work of Krisztina Scheffer and Enikő Szvák, who not only contributed to the lectures, but also took part in eliminating many of the pitfalls of the organization process.

We also say special thanks to the members of the Scientific Committee: Prof. dr. Rosalie David (University of Manchester), dr. Dina Faltings (Heidelberg Universität, Sammlung Ägyptologisches Institut), dr. Győry Hedvig PhD (HEFS), Prof.dr. Salima Ikram (American University of Cairo), habil. dr. György Pálfi (University Szeged, Anthropology Chair), dr. Ildikó Pap PhD (Hungarian Natural History Museum), Prof. dr. Wilfried Rosendahl (Reiss Engelhorn Museum), Stephanie Zesch (Reiss Engelhorn Museum), habil. dr. Albert Zink (Eurac Research), who took part in the scientific preparation of the conference.

We want again thank the authors of this volume for their professional contributions, and also for their patience and cooperation.

Also, special thanks for Hedvig Király for her assistance in editing work, and for Almamag Bt's work in graphic editing and for its understanding and flexibility during these times burdened with COVID-19.

We then are greatly indebted to Rosalie David in Manchester for her invaluable help by proofreading almost every article in the volume, despite her many other tasks and the situation in Manchester, severely affected by the virus.

We hope you will be as happy to read this volume as the AEC has released it.

## NEW LIPID BIOMARKER DATA CONFIRM THE DIAGNOSIS OF TUBERCULOSIS IN THE GRANVILLE MUMMY

David E. Minnikin<sup>1</sup>, Oona Y-C. Lee<sup>1</sup>, Houdini H. T. Wu<sup>1</sup>, Gurdial S. Besra<sup>1</sup>, Ian D. Bull<sup>2</sup>, John A. Taylor<sup>3</sup>, Mark Spigelman<sup>3</sup>, Helen D. Donoghue<sup>5</sup>

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### Abstract

Dating from c. 600 BC, the British Museum remnants of the mummified Lady Irtyersenu of Thebes remain from a thorough examination by Augustus Bozzi Granville almost 200 years ago. A previous investigation diagnosed the presence of tuberculosis in the remains, using biomarkers specific for tuberculosis. DNA fragments were amplified and lipids known as mycolic acids were profiled. The specificity of this diagnosis is now reinforced by the detection, in lung samples, of additional lipid biomarkers, namely mycolipenic and mycocerosic acids. A feasible scenario for the evolution of tuberculosis and its spread to the ancient Nile valley is outlined.

### Introduction

The so-called “Granville” mummy, from the necropolis of Thebes, was the Lady Irtyersenu, of the 27<sup>th</sup> Dynasty, dated to c. 600 BC.<sup>1</sup> The mummy was subjected to a detailed autopsy by Augustus Bozzi Granville, a Fellow of the Royal Society of Great Britain.<sup>2</sup> Granville was an eminent physician and obstetrician, and he observed that

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1 HEDGES ET ALII 1997.

2 GRANVILLE 1825.

the mummy was that of a woman aged around 50 years, who had been corpulent. She showed signs of what we now recognise as osteoporosis, but of particular interest was a mass around the right ovary, which Granville described as “ovarian dropsy” or cancer and led to his conclusion that this was the cause of death. However, more recent studies<sup>3</sup> suggest that this was a benign cystadenoma of the ovary, which would not have been fatal. The histological studies of the mummy tissues recorded a pulmonary exudate that could indicate a potentially fatal pathological condition, such as tuberculosis. Investigations into the Granville mummy are summarised elsewhere in this volume.<sup>4</sup>

Tuberculosis (TB) has long been recognised in Egyptian mummies by palaeopathological changes such as Pott’s Disease; and *Mycobacterium tuberculosis* complex (MTB) DNA has been detected and characterised from the pre-dynastic era,<sup>5</sup> the Old, Middle and New Kingdoms.<sup>6</sup> Amplification of characteristic TB DNA fragments, from a range of archaeological material, has been supported by the isolation of specific lipid biomarkers.<sup>7</sup> The particular lipids, employed for detection of the *M. tuberculosis* complex, are summarised in Figure 1.

- The high molecular weight C<sub>70</sub> to C<sub>90</sub> mycolic acids (Figure 1A) are conveniently profiled by fluorescence high performance liquid chromatography (HPLC) of pyrenebutyrate derivatives of pentafluorobenzyl (PFB) esters.<sup>8</sup>
- Profiles of the C<sub>27</sub> to C<sub>34</sub> mycolipenic and mycocerosic acids (Figure 1B) are recorded sensitively by negative ion-chemical ionisation (NI-CI) gas chromatography-mass spectrometry (GC-MS) of pentafluorobenzyl (PFB) esters.<sup>9</sup>

In the case of the Granville mummy, excellent mycolic acid profiles were recorded for lung and femur samples (Figure 2).<sup>10</sup> In this study, residual lung samples were analysed for the possible presence of mycolipenate and mycocerosate TB lipid biomarkers.

## Results And Discussion

The protocol developed for the detection of TB lipid biomarkers in ancient material<sup>11</sup> provides a fraction enriched in mycolipenic and mycocerosic acid PFB esters for analysis by NI-CI GC-MS. Employing a special technique, termed “selected ion monitoring”, it is possible to search for the TB specific signals labelled *m/z* 407, 409, 437, 451 and 479

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3 STROUHAL 1976; NUNN – TAPP 2000.

4 DONOGHUE 2020.

5 CRUBÉZY ET ALII 1998.

6 NERLICH ET ALII 1997; ZINK ET ALII 2003a, b.

7 HERSHKOVITZ ET ALII 2008; LEE ET ALII 2012; DONOGHUE ET ALII 2017.

8 HERSHKOVITZ ET ALII 2008; LEE ET ALII 2012.

9 LEE ET ALII 2012.

10 DONOGHUE ET ALII 2010.

11 LEE ET ALII 2012.

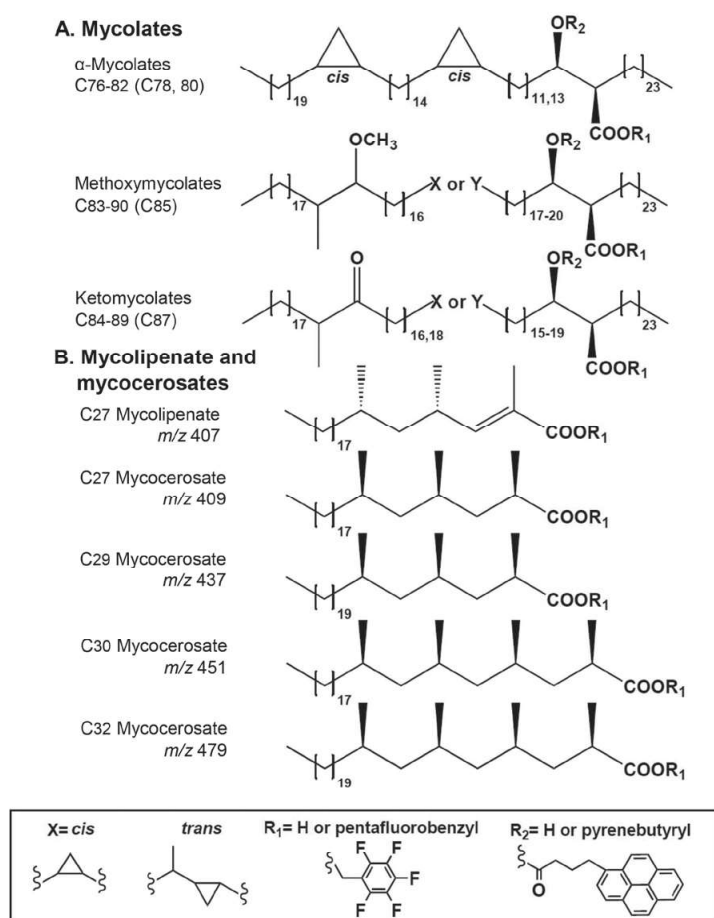


Figure 1. Structures of key biomarkers for tuberculosis.

(Figure 1B). The profiles for the two lung samples, examined previously,<sup>12</sup> are shown in Figure 3. In comparison with the *M. tuberculosis* (*M. tb*) standard (Figure 3C) the signals are rather weak, but key peaks are discernible. Lung 1 has principal C<sub>29</sub> and C<sub>32</sub> mycocerosates, accompanied by lesser C<sub>27</sub> and C<sub>30</sub> components (Figure 3A); a very weak signal at *m/z* 407 indicates the presence of C<sub>27</sub> mycolipenate. In contrast, Lung 2 provided only a minimal signal for C<sub>32</sub> mycocerosate (Figure 3B).

Considering the strength of the previously recorded mycolic acid profiles (Figure 2), the mycolipenate/mycocerosate signals for the lung samples are quite weak, but they are positive (Figure 3). It was not possible to examine the femur sample, studied previously (Figure 2).<sup>13</sup> In general, it has been previously found that ancient mycolic acids (Figure 1A) are often more degraded than mycolipenate and mycocerosates.<sup>14</sup> However, those studies were principally on bone-derived material, where the mycolipenate and mycocerosates may have been preferentially shielded within the bone. The observation of mycolipenate in Lung 1 is significant as this component is only expressed by strains of *M. tuberculosis*.<sup>15</sup> The present results reinforce the previous opinion<sup>16</sup> that the Lady Irtyersenu was heavily infected with tuberculosis and this could have been a significant contribution to her demise.

12 DONOGHUE ET ALII 2010.

13 DONOGHUE ET ALII 2010.

14 DONOGHUE ET ALII 2017.

15 DONOGHUE ET ALII 2017.

16 DONOGHUE ET ALII 2010.

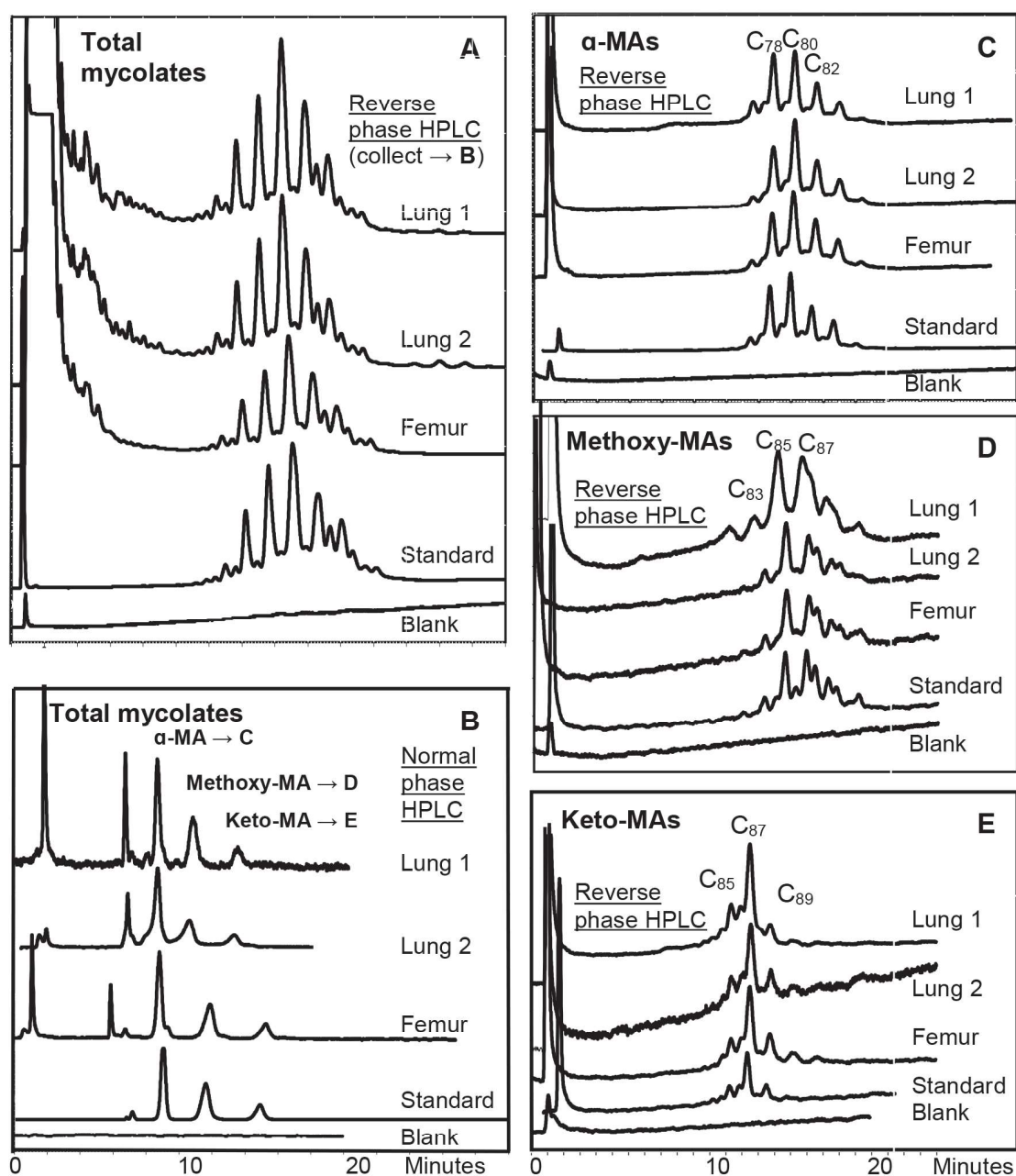
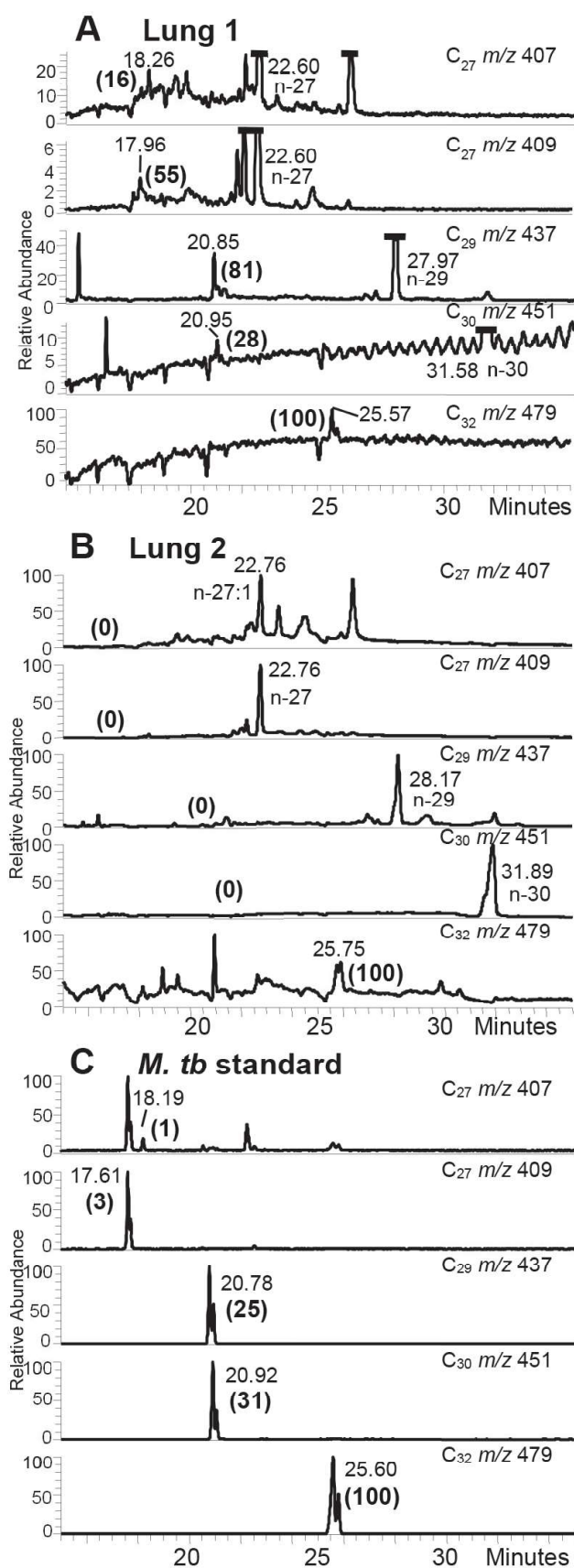


Figure 2. Fluorescence high performance liquid chromatography (HPLC) profiles of mycolic acid derivatives. A: Total mycolates by reverse phase HPLC, which selects according to overall size; B: Total mycolates, collected from A, are separated into three classes (Figure 1A) by normal phase HPLC and each type is collected and examined by reverse phase HPLC, as shown in C, D and D.

The presence of tuberculosis in ancient Egypt has been well-established in previous investigations.<sup>17</sup> The majority of the cases were general *M. tuberculosis* but some appeared to be *Mycobacterium africanum*, a member of the broad *M. tuberculosis* complex.<sup>18</sup> As suggested by the name, *M. africanum* is associated with the continent of Africa, particularly the more westerly locations.<sup>19</sup> In exploring how TB may have arrived in the Nile Valley, it is necessary to consider the deeper origins of tuberculosis back to the Pleistocene. A popular hypothesis is that TB had human evolutionary origins in Africa, as examples of all the current human and animal lineages are found there.<sup>20</sup> The problem with this opinion is that there is no human or animal skeletal evidence whatsoever for African TB before the Holocene. Also at that time, it is apparent the human population density in Africa was much too low to facilitate the evolution of a bacterium as complex as *M. tuberculosis*. Conversely, there is a large body of evidence for widespread TB, across the Northern Hemisphere, in a variety of megafauna who display characteristic bone lesions. The pivotal example is a 17,000 year old metacarpal from *Bison antiquus* that

Figure 3. Negative ion-chemical ionisation (NI-CI) gas chromatography-mass spectrometry (GC-MS) of mycolipenic and mycocerosic acid derivatives. A and B are extracts of samples Lung 1 and Lung 2 and C represents an *M. tuberculosis* standard. Relative proportions are indicated by normalisation to the major component (100).



17 NERLICH ET ALII 1997; ZINK ET ALII 2001, 2003a, b.

18 ZINK ET ALII 2003a.

19 WIRTH ET ALII 2008; GAGNEUX 2018.

20 WIRTH ET ALII 2008; GAGNEUX 2018.

yielded TB diagnostic amplified DNA fragments and lipid biomarkers.<sup>21</sup> An alternative hypothesis has been advanced, therefore, that TB evolved as a Pleistocene zoonosis in the Northern Hemisphere.<sup>22</sup> It is apparent that ancestral TB may have evolved *via* a semi-environmental agent related to current strains labelled as “*Mycobacterium canettii*” that have reduced transmissibility and pathogenicity.<sup>23</sup> Around 50,000 years ago, “*M. canettii*”-like strains may have evolved into virulent strains, with new-found aerosol transmissibility.<sup>24</sup> This may have led to pandemic TB with implications for the Late Pleistocene extinction of a range of megafauna.<sup>25</sup>

A speculative scenario (Figure 4) for the origins of TB in the Nile Valley is as follows. *Homo sapiens* evolved in Pleistocene Africa, but apparently made a series of trips out of Africa to the so-called Fertile Crescent at the Eastern Mediterranean.<sup>26</sup> During such forays, it is possible that humans may have encountered infected animals and contracted TB. In early times, it may have been a benign form of TB, some-

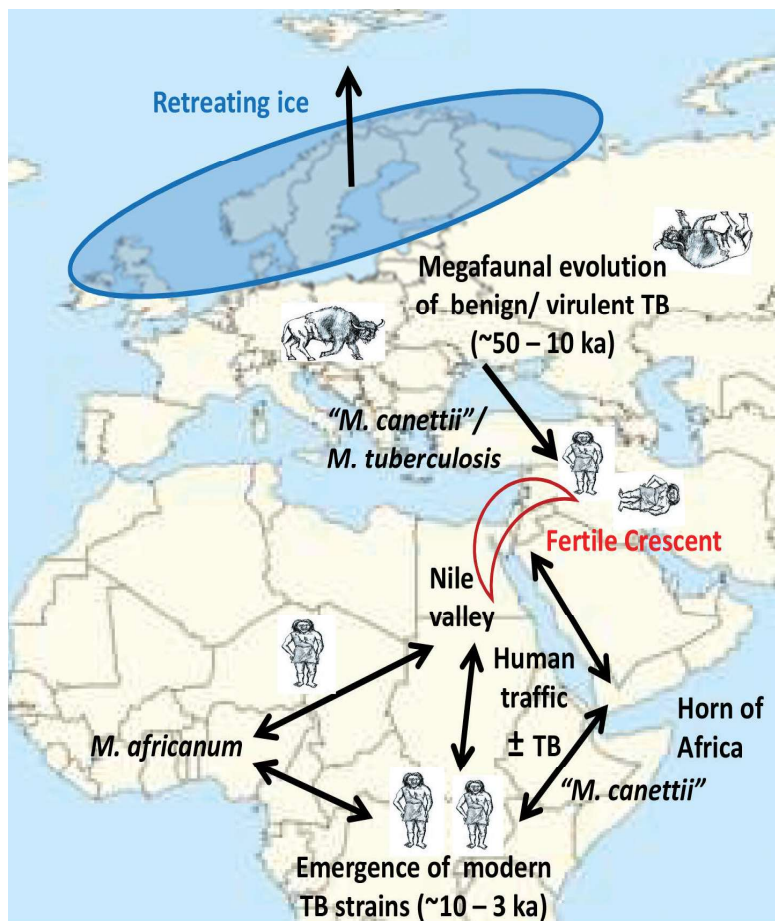


Figure 4. A possible overall scenario for tuberculosis evolution and distribution in the Late Pleistocene and Early Holocene. 1 ka = 1,000 years.

21 LEE ET ALII 2012.

22 LEE ET ALII 2012; DONOGHUE ET ALII 2017.

23 SUPPLY – BROSCH 2017.

24 JANKUTE ET ALII 2017.

25 JANKUTE ET ALII 2017; DONOGHUE ET ALII 2017.

26 STRINGER – GALWAY-WITHAM 2018.

thing similar to ancestral “*M. canettii*” and this could have been introduced into Africa. This could provide an explanation for the current presence of “*M. canettii*” in the “Horn of Africa”<sup>27</sup> as a crossing of the lower Red Sea was a prime route to the Arabian Peninsula and the Fertile Crescent.

At the start of the Holocene, 9,000 to 10,000 years ago, there are many clear cases of TB in the Eastern Mediterranean<sup>28</sup> that may have occurred due to naïve *H. sapiens* interacting with newly virulent *M. tuberculosis*, originally derived from infected megafauna. Increased population density and traffic would then establish TB as a disease in Africa, including the Nile Valley. The presence of West African *M. africanum* in cases from the Nile basin is not surprising as 6,000 to 7,000 years ago the Sahara was not such a formidable barrier. A possible overall evolutionary scenario is illustrated in Figure 4.

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27 SUPPLY – BROSCHE 2017.

28 HERSHKOVITZ ET ALII 2008; BAKER ET ALII 2015.

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