



# The Woman from Leuk (Switzerland)—Discovery, Conservation, and Interdisciplinary Investigations of a Seventeenth-Century Mummy

Amelie Alterauge  · Annette Kniep ·  
Marquita Volken · Sandra Lösch

Accepted: 10 July 2018 / Published online: 13 August 2019  
© Society for Historical Archaeology 2019

**Abstract** During the excavation of St. Stephan’s Church in Leuk (Switzerland) in the 1980s, a well-preserved mummy with clothing and shoes was found in a wooden coffin. Subsequently, the mummy underwent restoration, but the observations have never been published. Therefore, an interdisciplinary investigation was recently organized that included a thorough archaeological and anthropological documentation in collaboration with specialists in costume history and leatherworking. The aim was to gather evidence for the dating and preservation mechanism, as well as to determine the biological profile of the individual. The investigation was accompanied by a noninvasive examination with a mobile x-ray device, which enabled identification of sex, age, body height, and pathologies. The clothing (cape, blouse, skirt, drawers) and the shoes were subjected to a detailed stylistic and technological examination. The individual is female, aged 45–60 years, with foot deformities that might be related to constricting footwear. Stylistic details of the shoes

indicate that the burial dates from the first half of the 17th century, more precisely to the 1630s. Despite her simple clothing, the burial location attests to her respected position in society.

**Extracto** Durante la excavación de la Iglesia de San Esteban en Leuk (Suiza) en la década de los 1980, se encontró en un ataúd de madera una momia bien conservada con ropa y zapatos. La momia fue sucesivamente restaurada, pero su estudio nunca fue publicado. Por lo tanto, recién se organizó una investigación interdisciplinaria que incluyó una completa documentación arqueológica y antropológica en colaboración con especialistas en historia del vestuario y peletería. El objetivo era el de reunir evidencias para su datación y preservación, así como la determinación de su perfil biológico. La investigación fue respaldada por un examen no invasivo con un dispositivo móvil de rayos X, que permitió la identificación del sexo, la edad, la estatura y las patologías. La ropa (capa, blusa, falda, bragas) y los zapatos fueron sometidos a un detallado examen estilístico y tecnológico. El individuo es de sexo femenino, de 45 a 60 años de edad, presenta deformidades en los pies que pueden estar relacionadas con el calzado de constricción. Los detalles estilísticos de los zapatos indican que el enterramiento se fecha en la primera mitad del siglo XVII, más precisamente en la década del 1630. A pesar de su vestimenta simple, la ubicación del enterramiento sugiere una reconocida posición social en la sociedad del tiempo.

---

A. Alterauge (✉) · S. Lösch  
Department of Physical Anthropology, Institute of Forensic  
Medicine, University of Bern, Sulgenauweg 40, 3007 Bern,  
Switzerland  
e-mail: amelie.alterauge@irm.unibe.ch

A. Kniep  
Bernisches Historisches Museum, Helvetiaplatz 5, 3005 Bern,  
Switzerland

M. Volken  
Gentle Craft—Shoe Museum, Rue du Rôtillon 10,  
1002 Lausanne, Switzerland

**Résumé** Pendant les fouilles de l'Église Saint Étienne à Loèche (Suisse) dans les années 1980, une momie bien préservée portant des vêtements et des chaussures a été découverte dans un cercueil en bois. La momie a par la suite fait l'objet d'une restauration mais les observations n'ont jamais été publiées. Par conséquent, une étude interdisciplinaire a récemment été organisée incluant une documentation archéologique et anthropologique approfondie en collaboration avec des spécialistes de l'histoire des costumes et du travail du cuir. L'objectif était de identifier la datation et la manière de conservation, ainsi que pour déterminer le profil biologique de l'individu. L'étude s'est accompagnée d'un examen non-invasif avec un appareil portable de radiographie, ayant permis l'identification du sexe, de l'âge, de la taille et des pathologies. Les vêtements (cape, blouse, jupe, culottes) et les chaussures ont fait l'objet d'un examen détaillé stylistique et technologique. L'individu est une femme, âgée de 45 à 60 ans, montrant des déformations des pieds pouvant être liées au port de chaussures serrées. Les détails stylistiques des chaussures indiquent que la sépulture date de la première moitié du 17<sup>ème</sup> siècle, plus précisément vers 1630. En dépit de la simplicité des vêtements, le site de la sépulture atteste de sa position respectée dans la société.

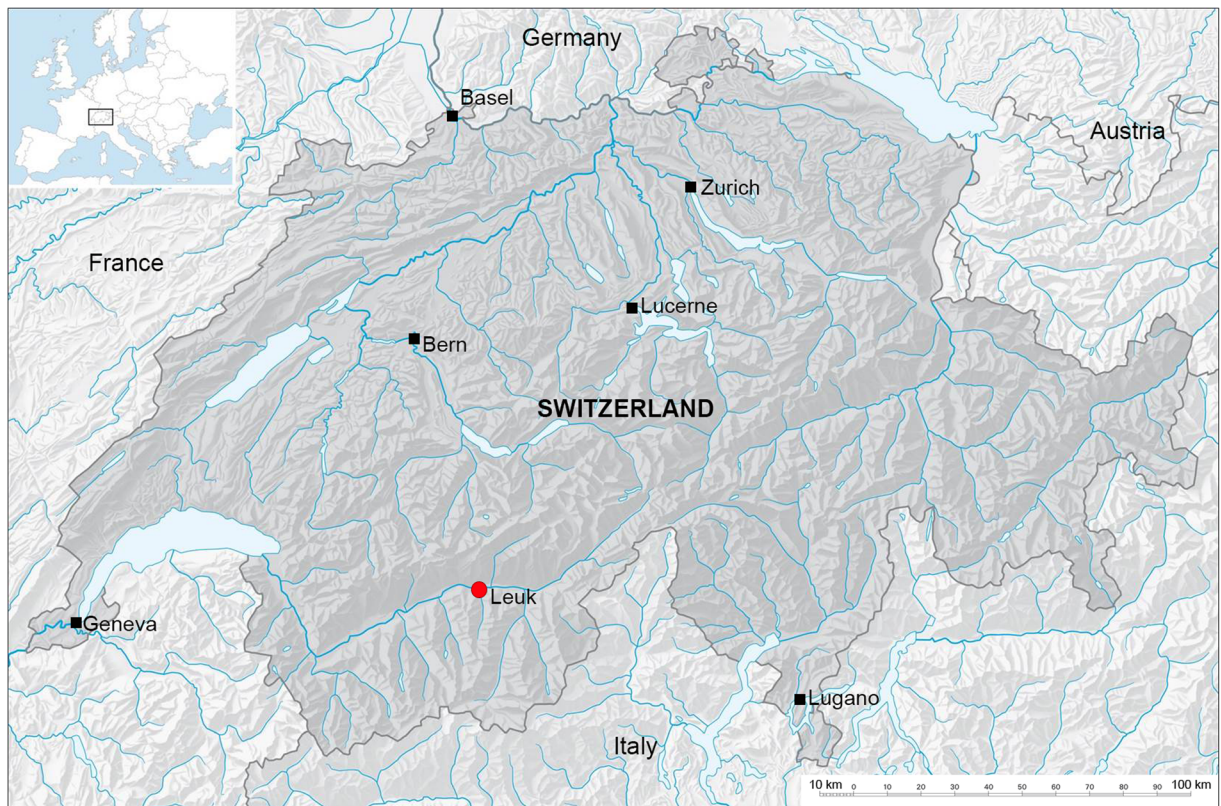
**Keywords** mummy · 17th century · shoes · clothing

## Introduction

On the Bernese side of the Swiss Alps, the village of Leuk is situated approximately 100 m above the base of the Rhône Valley at an elevation of 731 m (Fig. 1). The surrounding mountain slopes are covered in vineyards and coniferous forests due to the continental climate. During Roman and medieval times, Leuk was part of the transportation network linking Lake Geneva, Bern, and Milan (Kunsthistorisches Institut der Universität Zürich 2008). Within the district, Leuk was the municipal center for the administrative, secular, and ecclesiastical powers. The church of St. Stephan, first constructed during the 6th or 7th centuries A.D. on the foundations of a Roman road station, was transformed several times between the 9th and 15th centuries. The present configuration of the church was achieved in 1514 with the construction of the clocktower, three aisles, and a polygonal choir (Bellwald 2015:67).

Renovations of the interior of the church in 1982 led to the discovery of a wooden coffin containing a well-preserved mummified individual. The practice of burying inside churches was very common in Switzerland since the early Middle Ages, but was a custom reserved for distinct social groups, such as the church founders, the clergy, and the local nobility or patricians (Eggenberger, Ulrich-Bochsler et al. 1983; Meier and Schwarz 2013; Descoedres 2014:389–498). All these groups maintained a close relation to the local parish as employees and/or political and financial supporters. As a result, those groups gained the privilege of (and possibly also paid for) being buried in the interior of the church, while the common people were buried in the surrounding cemetery. Most of the interior inhumations were placed directly into the soil, sometimes in a wooden container (Eggenberger, Kehrlı et al. 2012:70–74,131–214); only in few cases a masonry tomb or small crypt was erected (Ochsner 2013:51–59). In Switzerland, larger crypts installed for the burial of several persons were reserved for monastic communities (e.g., Hotz [2007:149–150]) and noble families (e.g., Hochstrasser [2001:13]). The practice of burying inside churches continued until the 18th/19th century when secularization and hygienic concerns—originating in the expanding responsibilities of the municipality—and practical needs, for instance, a lack of space, led to a prohibition of inhumations within churches and a displacement of the cemeteries to areas outside the cities (Hauser 1994). This prohibition was regulated by different cantonal-legislature burial acts.

Though the Leuk mummy is one of the rare medieval or postmedieval mummies in Switzerland, little research has been conducted and less has been published (Kaufmann 1996b:237; Kaufmann et al. 2009:99). An interdisciplinary research project was organized in 2017 to examine this individual: the mummification mechanism, biological profile, clothing, historical dating, and burial type. An archaeologist, two physical anthropologists, a costume and textile historian, as well as a calceologist were involved in the investigation. In order to preserve the physical integrity of the mummy and to respect the wishes of its proprietor, the Roman Catholic parish of Leuk, only noninvasive examination techniques were employed. For this reason, a mobile x-ray device was used for onsite examination. Even though more advanced methods are available for investigating mummies (Jackowski et al. 2008; Gostner et al. 2013; Alterauge, Kellinghaus et al. 2017), x-ray imaging is



**Fig. 1** Topographical map of Switzerland and neighboring countries with the major cities and the location of Leuk. (Map by Amelie Alterauge, 2018; base map courtesy of Swisstopo.)

advantageous in terms of expense and allows the object to be studied in place, thus avoiding displacement or transportation of the object. It also permits the imaging of multiple types of materials and layers (Beckett and Conlogue 2010), and provides an overview of the potential range of discoverable information.

## Discovery

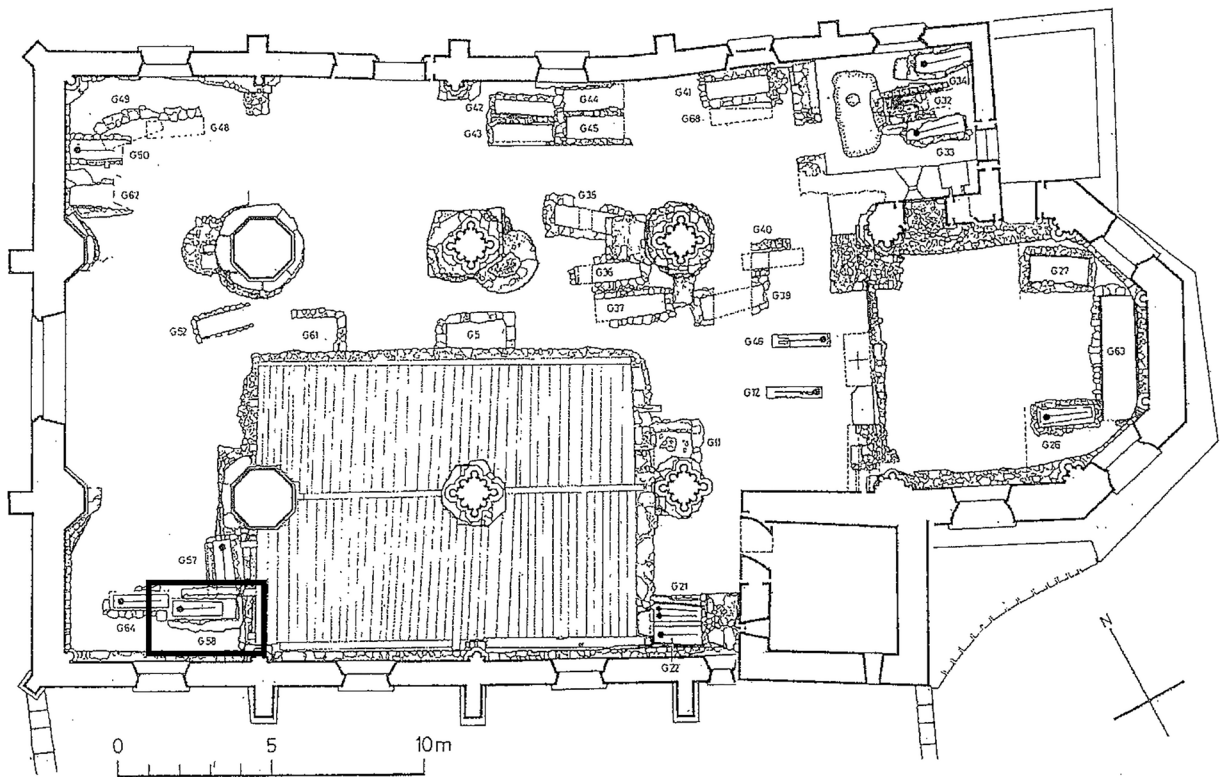
In 1982, the installation of a new central-heating system in the parish church of St. Stephan was preceded by an archaeological excavation, conducted by the Atelier d'archéologie médiévale in Moudon under the supervision of Werner Stöckli (Descoedres and Sarott 1984). Under severe financial and temporal limitations, the excavation focus was on the medieval building structures instead of the numerous burials. For that reason there is no detailed photographic or graphic documentation of the mummy's discovery. Known as Grave No. 58, the wooden coffin, containing a mummified body in clothing and shoes, was found in the first bay of the

southern aisle (Fig. 2). The coffin was located in an older masonry grave oriented northwest to southeast. It is assumed that the burial was part of the most recent graves within the church, dating to the early modern period. The coffin with the mummy was temporarily placed in the church's ossuary, while the other skeletal remains from the excavation were reburied in the nearby cemetery.

## Conservation

In 1993, the Leuk mummy was presented in an exhibition at the Museum Kultorama in Zurich, Switzerland. Afterwards, it was transported to the Anthropological Research Institute in Aesch for investigation and conservation. This included gamma-ray radiation to stop microbial infestation, superficial cleaning, sampling, conservation, and re-positioning of textiles (Kaufmann et al. 2009:94–95). Conservation and restoration of the textiles were conducted by Sabine Sille in 1995. An anthropological examination was performed, but,





**Fig. 2** Excavation plan of St. Stephan's Church with the current outline of the building and the baroque-period graves. Grave 58 (within black rectangle, lower left) contained the mummy in the southwestern corner of the church (Descoedres and Sarott 1984:figure 29).

despite the uniqueness of the find, had never been published.

At that time, the mummy was lying on a layer of sandy soil that covered the floor of the coffin. Puparia were found on the body in large numbers, as well as underneath it and within the layers of clothing. Puparia are empty shells from which adult flies have successfully hatched. They could be attributed to the families Muscidae (genus *Hydrotaea*), Fanniidae (genus *Fannia*), and Calliphoridae (genus *Lucilia*). The body was lifted from the coffin for the investigations (Fig. 3). The garments, which had disintegrated into fragments, were removed from the body, cleaned of dirt and puparia, and analyzed and examined to reconstruct the original cut and look of the clothing. Analyses of the weave structure, the fibers, and the dyes were performed through microscopy; unfortunately, it is not known whether other methods have also been applied. The definitions of fibers and colors throughout this article rely on the information given in the 1995 documentation (Sille 1995), as no repeated analyses were executed. Afterwards the fragments

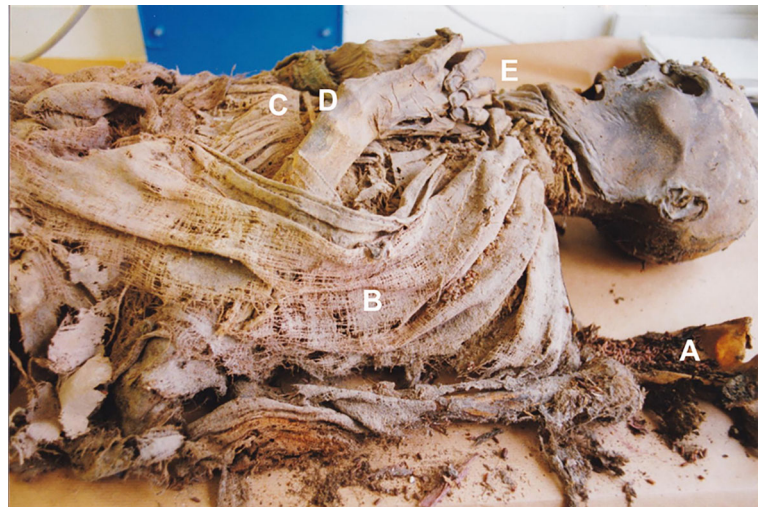
were placed on modern linen fabric, according to the fabric grain-line direction, that had been dyed and cut to give an impression of the original appearance of the garments. A silk crepe fabric was placed on top of the fragments and held in place by stitching through to the linen base (Sille 1995). By this method the fragments are kept in place on the supporting fabric and are also protected by the crepe fabric.

The shoes were also removed from the feet in 1995 for conservation reasons. The exteriors and interiors of the shoes were cleaned mechanically without the use of any liquids. Some of the sole threads on the left shoe appear to have been broken after burial, resulting in the tread sole and midsole falling off; these were subsequently glued back in place, but inverted.

The mummy was then dressed again in the restored clothing and shoes, and placed back in the cleaned coffin (Fig. 4). The mummy was in this state when examined in 2017. Currently, the mummy is housed in its original wooden coffin in the crypt of St. Stephan's Church. The crypt cannot be accessed by the public, but the coffin is visible through a trellised gate.



**Fig. 3** The mummy during conservation in 1995. The body was covered in dirt and puparia, and the garments had disintegrated into fragments. The scapulae and humeri had been disarticulated (A). The cape (B) and the waistband of the skirt (C) and blouse (D) can be seen in this photograph. Underneath the chin there is a part of the pleated collar visible (E). (Photo by Sabine Sille, 1995.)



### Current Investigation and Methods

The top of the open coffin is protected by a glass case that was removed for the examinations (Fig. 4). A photographic record and description, including measurements, were made of the wooden coffin. A date was established for the shape of the coffin through typochronological comparisons (Descœudres et al. 1995:64–67; Hess 2013).

During the examination, the mummy was left in its current position in the coffin and was photographically documented. For the morphological investigation, areas such as the head and the legs could be accessed; the restored clothing covers the remaining body parts. The dentition was observed through the open mouth and recorded after Hillson (1996:6–12,254–287). Accessible bones were measured, following Martin (1914:891–953), in order to estimate body height. To ensure comparability with other Swiss and European skeletal series, body height was calculated using the methods of Bach (1965) and Pearson (1899). The mummy was then x-rayed with a mobile x-ray device (x-ray generator: Examion® PX-20 BT Plus, Examion® X-DR portable detector) in anteroposterior and lateral projection. The best imaging results were obtained at an energy level of 70 kV and 1 mAs. The detector was at a distance of 67–83 cm from the x-ray generator for anteroposterior images, and at 58 cm for lateral projections of the head. Sex and age of the individual were determined from the x-ray images using standard anthropological criteria (Sjøvold 1988; Szilvássy 1988; Buikstra and Ubelaker 1994).

Visual observations of the textiles and shoes were carried out in their restored condition and compared to the results of the conservation procedure in 1995. Information on the restoration and the previous condition was taken from the restoration report and the attached—though incomplete—photographic documentation (Sille 1995).

The garments were examined and compared to clothing styles of the early modern period. The shoes were examined for stylistic and technical features, and in regard to historical examples and iconographical sources within a comparative analysis in order to determine a date for their manufacture (Goubitz et al. 2001; Swann 2001).

### Results

#### The Coffin

The trapezoidal-shaped coffin is 166 cm long, with a width of 42 cm at the head and of 36 cm at the feet. The coffin has straight side plates and is made from coniferous wood planks, most probably pine. The joinery consists of wooden dowels, and traces of a hand plane are still visible on the surfaces. The base and sides are formed of joined planks, while the latter are fixed onto the base and at the corners. According to eyewitnesses at the time of its discovery in 1982, the coffin lid was flat (it was disposed of afterwards). Inside the coffin was a round, straw-filled cushion; otherwise, it lacked linings, decorations, or metal handles.



**Fig. 4** Post-restoration photograph of the mummy, with clothing and shoes, in the wooden coffin in 2017. (Photo by Amelie Alterauge, 2017.)

### The Mummy

The mummy lies in an extended supine position and has a length of 138 cm from head to heel. The body is mostly intact, except for some taphonomic damage on the back. The skin is of leathery appearance and desiccated. No traces of excerebration, evisceration, or embalming were observed. There is no hair present on the scalp, and damage can be seen on the back of the head, which lay on the coffin's floor. The eyes and nose have sunken in (Fig. 3). The folded, clasped hands are currently placed above the pelvis (Figs. 4, 5). During conservation in 1995, however, photographs show the hands placed in a prayer position on the chest (Fig. 3). As a result of the changed position of the arms, the lower arms are no longer articulated with the humeri, but instead were moved toward the feet (Fig. 5). Additional evidence shows signs of positioning alterations that must have occurred during post-excavation handling of the body: the scapulae were separated from the body and have been concealed beneath the skirt between the knees.

Sex estimation for the mummy was performed on both morphognostically and radiographically evaluable criteria. The skull exhibits a vertical, rounded forehead and a pronounced lower jaw. The pelvis shows a wide greater sciatic notch and pubic angle (Fig. 5). These characteristic traits indicate the mummy is female. This corresponds with the previous examinations (Kaufmann et al. 2009:99).

The complete fusion of all assessable epiphyses suggests an adult age, while the state of the dentition might be indicative of an advanced age. In addition, the costal cartilage shows increasing calcification at all sternal rib ends (Fig. 6). Costae 4–7 especially show bony projections arising from the inferior and superior borders of

the sternal rib ends of approximately phase 6 or higher (İşcan et al. 1985). The fusion of the first ribs and the manubrium through calcified cartilage is complete. The upper and lower jaws show intravital tooth loss with atrophy of the maxillary bone (Fig. 7a, b). Two teeth (Nos. 23 and 44) were still in their sockets, while the others have either fallen out intravital or postmortem. All molars were lost intravital. Two single-rooted teeth were found at the back of the oral cavity. While tooth No. 23 exhibits caries on the medial side, a periodontal destructive process is observed at the position of the lower first right molar (Fig. 7b).

A maximum age at death is given by the skull sutures, particularly the nonfused lambdoid suture, whereupon the individual probably did not reach an age of more than 60 years. All in all, the individual's age at death is estimated at 45–60 years.

Body height could be calculated from the medial lengths of the right and left tibiae, and resulted in an estimated body height of  $151.6 \pm 3.9$  cm (Bach 1965) or  $151.0 \pm 3.4$  cm, respectively, using the maximum tibial lengths (Pearson 1899).

The individual shows several degenerative and pathological alterations. Both scapulae exhibit signs of arthritis in the glenoid fossa, while the left side is more strongly affected than the right one. The hand phalanges show enthesal changes on the palmar side. Both acetabuli show beginning arthritis of the hip joint with subchondral sclerosis of the acetabular rim. The spine shows minor degenerative changes in the form of osteophytes on lumbar vertebrae L1–L3 and a compression of the L5. Osteophytes can also be observed on the ventral rim of the sacral promontory. In addition, a bony protrusion of the palate, a so-called torus palatinus, was



**Fig. 5** Anteroposterior x-ray image of the pelvic area. The hands are folded over the pelvis; however, this arm position is not the original one. Note the wide greater sciatic notch and pubic angle, which indicate female sex. The hooks and eyes that close the

blouse at the cuffs and at the waist are also visible. (X ray courtesy of the Department of Physical Anthropology, Institute of Forensic Medicine, University of Bern, 2017.)

observed as an anatomical variant of the upper jaw. Two rounded calcifications on the right medial lobe of the lung are seen in the x-ray projection (Fig. 6). The x-ray analysis showed no Harris lines, which are growth-arrest lines running parallel to the epiphyseal plate in the metaphysis. It cannot be distinguished whether the individual suffered any periods of stress or malnutrition during adolescence, or, if these lines—if once present—have been remodeled.

The feet have fallen to both sides, creating difficulties for evaluating the radiological images that were taken in anteroposterior projection oriented toward the main axis of the mummy (Fig. 8). On both feet severe clawing of the second to fifth toe can be observed; while the

proximal phalanges are flexed dorsally, the intermediate phalanges are bent plantarly, thus resulting in an angle of nearly 90° in the metatarsophalangeal and the proximal interphalangeal joints. The head of the first metatarsal seems to exhibit a bony prominence on the medial side, known in medical literature as a bunion. The left foot exhibits a medial deviation of the first metatarsal and lateral deviation of the great toe, a condition better known as *hallux valgus*.

#### Clothing and Footwear

The overall appearance of the mummy's clothing is based on the restoration work done in 1995. Visible





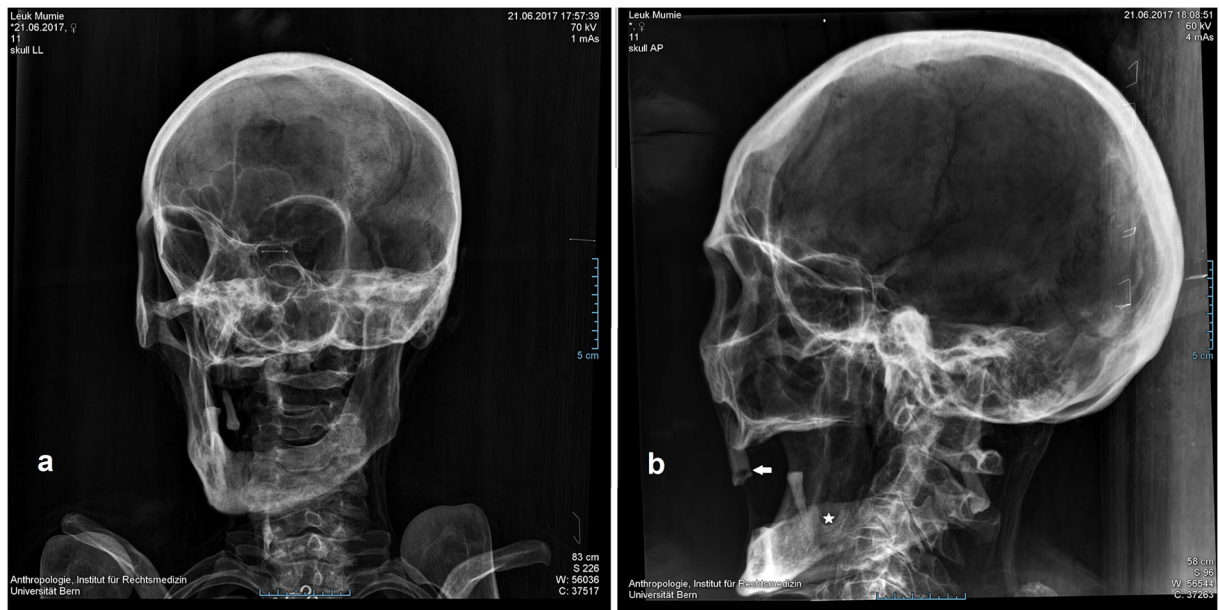
**Fig. 6** Anteroposterior x-ray image of the chest. The metal closures closing the blouse (small closures) and the cape (larger closure) are well visible. Age at death could be estimated from the calcified rib cartilage. The spine shows only minor degenerative changes (white arrow). Note the absence of the shoulder

blades and the calcification in the right medial lobe of the lung (white rectangle). (X ray courtesy of the Department of Physical Anthropology, Institute of Forensic Medicine, University of Bern, 2017.)

garments include an ankle-length skirt, a short blouse, and a simple cape reaching down to midcalf. According to the restoration documentation, an additional piece of clothing was found, linen drawers, which could not be examined during the current investigation. Stockings are not present on the mummy in its current state, but some fiber structure can be seen on the shoe and around the ankle in a preconservation photograph, though this is not mentioned as “stockings” in the restoration report; neither was any kind of headgear found or mentioned. The absence of headgear and stockings might hint at a complete disappearance of animal fibers, thus biasing

the present perception of the clothing worn by the individual, who may have worn other elements of clothing not preserved.

The skirt is made of a reddish brown linen tabby and reaches down to the ankles (Fig. 4). Neither the hem nor the waistband can be seen in the current state, and neither item was described during the restoration. The remaining fabric fragments show no signs of pattern or decoration apart from the overall dye. According to the restoration documentation, the skirt consists of two horizontal rectangles, measuring  $76 \times 96$  cm, tightly gathered in the waist.



**Fig. 7** (a) Anteroposterior x-ray image of the skull. With two exceptions the teeth were lost antemortem, and the maxilla shows severe atrophy; and (b) lateral x-ray image of the skull. The upper left canine exhibits profound caries (white arrow), and a periodontal destructive process can be observed at the position of the lower

first right molar (white asterisk). The lambdoid suture is still well visible. (X ray courtesy of the Department of Physical Anthropology, Institute of Forensic Medicine, University of Bern, 2017.)

The blouse is made of a light, originally white, bleached linen in a tabby weave. The fabric fits loosely around the chest and has been closely gathered to shape and fit the blouse around the neckline and the waist. The blouse is closed at the center front with two hooks and eyes on the neckline and one hook and eye on the waist, the total length of the center front being 33 cm (Figs. 6, 9). The sleeves are long and cover the arms down to the wrists; the ends are gathered as well and end in 5–6 cm wide cuffs that are closed with hooks and eyes. The fabric of the cuffs has been embroidered in white cross-stitch. Due to the deterioration of the fabric the pattern could not be reconstructed, but it appears to have shown simple ornaments or floral shapes. The fabric of the blouse is best preserved around the hems and closures, where metal corrosion from the closures has conserved the material and multiple layers of fabric and seams are present.

On the prerestoration photographs a piece of regularly pleated fabric is distinguishable below the chin, fabric that is supposed to be a part of a pleated collar, fitting tightly around the neck and attached to the blouse by several stitches (Fig. 3). Another photo shows the two front parts of the blouse before the restoration, the

remains of a pleated collar attached to the neckline of the blouse clearly visible. Today, however, the neckline appears without a collar and does not lie closely around the neck.

The body is covered in a cape made of undyed and unbleached linen tabby (Fig. 3), reaching from the neck down to a few centimeters above the skirt's hemline (Fig. 4). The neckline is gathered, and the cape is kept in place by an hook-and-eye closure, larger than those used on the blouse (Fig. 6). According to the restoration documentation, the cape was constructed of rectangles to form the front and the back, connected at the side seams. While the back consists of one single linen rectangle, measuring 113 cm in length and 94 cm in width, the fronts have been assembled from multiple rectangles.

In addition, under the skirt, the mummy wore undergarments made from fine, bleached linen (Fig. 10). According to the restoration documentation, these were drawers with a total length of 33 cm, which would place the hem around mid-thigh level (Sille 1995:2). The hem is decorated in two fine rows of simply drawn threadwork. The fabric is gathered at the waist; no kind of closure is described.



**Fig. 8** Anteroposterior x-ray image of the feet stuffed into the shoes. The toes show severe clawing and probably a hallux valgus of the great toe. (X ray courtesy of the Department of Physical Anthropology, Institute of Forensic Medicine, University of Bern, 2017.)

The style of footwear is an open-sided latchet shoe fastened with ties at the instep, with a welted construction including an insole, a midsole, and a tread sole (Fig. 11). The tread sole lacks a sewing channel for enclosing the threads from the welted seam, meaning the threads lay on the surface of the grain side of the leather. The stacked wedge heel is composed of four lifts and a single short lift or “jump,” and is placed between the midsole and the tread sole, making a smooth-bottomed tread-sole surface without a heel breast (Fig. 12). The soles are cut with a slight right/left orientation with an oval toe shape. The soles are 21 cm long. Taking into account possible shrinking of the leather, the modern size is estimated at 34/35 Paris point.

The uppers have a vamp with an integral extended tongue, plus two quarters with pointed-end latches. The latches and the extended vamp form

a circular side opening (Fig. 11). The quarters are sewn to the vamp with an internal flesh edge seam (side seams). The center back seam has an external butted seam. Inside the shoe the heel lining extends over the side seams and is whipstitched into place. A slight shadow in the X ray of the shoes hints at the presence of a toe puff, i.e., a lining for the toe section (Fig. 8). A strengthening cord is sewn around the circular opening with a whipstitch, starting from the laceholes on the tongue and ending in a loop around the lacehole at the end of the latchet. The shoes are fastened with a leather lace through the latches to laceholes at the middle of the extended tongue.

The leather for the uppers is cow/calf and varies in thickness from 1.2 to 1.8 mm. The heel lining is of 1.0 mm calf leather. The current color of the





**Fig. 9** Detail of the upper body with the clothing in restored condition. The old position of the blouse's collar and the cape directly underneath the chin is still visible due to the discoloration

caused by corrosion of the metal hooks (white asterisk). The blouse's hem has been placed on top of the skirt's waistband. (Photo by Amelie Alterauge, 2017.)

upper leather is faded dark brown to black; the original color appears to have been black. The lining is beige to light brown, indicating it was probably natural, uncolored leather. The soles are of 2.5 mm cow leather, with the lifts varying in thickness from 1.0 to 2.5 mm. The welt strip is of 1.8 to 2.0 mm thick calf leather. Only the sole edge appears to have been blackened, the tread area is natural color.

## Discussion

### Dating of the Coffin

Wood coffins regularly appear in the archaeological record from medieval times, but only became standard in Switzerland in the 19th century (Descœudres et al. 1995:64–67; Ochsner 2013:60–61; Alterauge and Lösch 2018). For instance, in Brig (Valais), coffins or wooden boards appeared in up to 75% of the late-medieval and early modern

burials inside and outside the church (Descœudres and Sarott 1986:416–417,428). The coffin shapes vary from rectangular chests during the Middle Ages to trapezoidal coffins with fluted side plates and elevated lids in the 18th and 19th centuries (Ochsner 2013:60; Ströbl 2014:44–56,66–68). Due to its simple construction, the dating of the Leuk coffin is rather difficult. The flat coffin lid, the trapezoidal shape, the use of wooden dowels, and the composition of the planks all point toward a manufacture date during the 15th–18th centuries (Descœudres et al. 1995:64–67; Ochsner 2013:60). A dendrochronological analysis might have helped to determine the exact date of the woodcutting, but due to the noninvasive approach this idea was not pursued. Nonetheless, coffin burials were quite common in St. Stephan's Church during the baroque period, and they were often placed one on top of another, creating several stacks in the grave space (Descœudres and Sarott 1984:198).

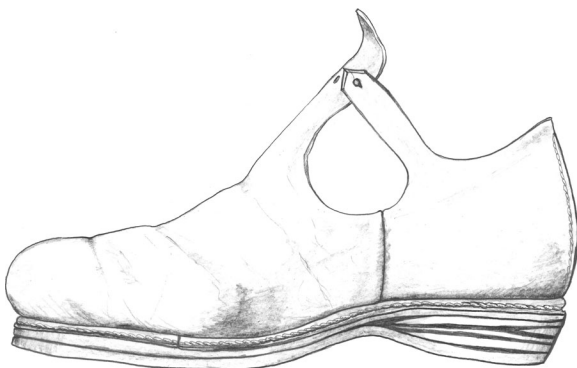


**Fig. 10** Pair of drawers worn underneath the skirt, after restoration. (Photo by Sabine Sille, 1995.)

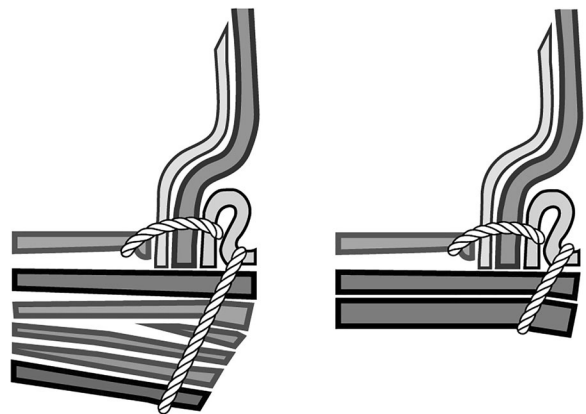
### Dating of the Shoes

Historical shoes of the same construction and style as those worn by the mummy include specimens from Porte de Romont (Fribourg, Switzerland), notably a child's shoe and a man's sized shoe that have similar

upper features (M. Volken and S. Volken 2007:165, figure 23). They are dated to between 1620 and 1640, with the site at Porte de Romont having a cut-off date of 1656. Shoes recovered from the *Vasa*, a Swedish ship that sank in 1628, also show strong similarities to the Leuk shoes (Swann 2001:104,108, figures 108,114).



**Fig. 11** Reconstruction profile drawing of the right shoe from Leuk, view of the medial side. At the place of the first metatarsal head there is an outward bulge in the side of the shoe (shaded gray), indicating a hallux valgus. (Drawing by Marquita Volken, 2017.)



**Fig. 12** Profile of the stacked heel with four lifts and one jump, colored medium gray (*left*), and welted-sole upper construction (*right*). (Drawing by Marquita Volken, 2017.)

The development of fashion elements can be contrasted with technological changes. The open-sided latchet shoe first appears in the archaeological record around 1600 (Goubitz et al. 2001:283). The shoe style, named “Weesp-Vq,” has a vamp with a short added tongue and quarters, small open sides, and fastens with latches (M. Volken 2014:177,179,309). This style is a precursor to the Leuk shoe. The oval-shaped toe is replaced by a squared-toed majority by 1630 (Swallow 1987; Swann 2001:106). Single lift heels and the channel for concealing the threads on the tread sole appear by 1580–1590, as seen on the footwear from the Wadden Sea SO1 shipwreck, though not found on all shoes there (Goubitz et al. 2001:81,89, figure 38). The stacked wedge heel with lifts and jumps was invented at the end of the 16th century and used during the first part of the 17th century, disappearing completely around 1640, when tall stacked heels with a straight breast became the standard fashion (Swann 2001:107–108). The general fashion of open-sided latchet shoes covers the first half of the 17th century, with subtle variations of the size of the open sides and latchet shapes, as well as great variations in the height of the heel and shape of the toe. An important style change occurs around the middle of this century, when transferable-buckle shoes appeared, introducing a new fastening method and new shoe styles (Swann 2001:127).

Accordingly, the open-sided latchet style of the Leuk shoes, in combination with the lack of a tread-sole thread channel, the stacked wedge heel included between the tread sole and midsole, and the oval-shaped toe, indicate a date of manufacture in the first half of the 17th century, probably between 1620 and 1630.

### Dating of the Clothing

Due to the fragmentary preservation of the textiles, the dating of the clothing is challenging. Additionally, the reconstruction work done during the restoration helps to identify the original shape of the garments, but may also bias their interpretation. As a further difficulty, comparisons on a local level can only be made with less well-preserved burials where hooks and eyes are often the only witnesses that the individuals were buried in clothing (Descoedres and Sarott 1984). Remnants of shoes, however, are found more often, e.g., in Leuk, Grave 24, and Brig, Grave 34 (Descoedres and Sarott 1984:203, 1986:430), and attest that individuals during the 16th and 17th centuries were interred in full, wearable attire.

The general appearance of the mummy’s attire—a straight blouse fitted around the neck and the waist, and paired with a round, ankle-length skirt—corresponds to the overall silhouette worn all over Europe in the late 16th and early 17th centuries. At courts and in the upper levels of society, the Spanish fashion, with regional differences and influences, was omnipresent (Stolleis 2008:22). The bodices were stiffened with boning or worn with stays, and the skirts were shaped into a cone with the help of hoops sewn into the skirts. “Fashion” was the constantly changing luxurious attire worn mostly at courts and, at varying degrees of opulence, by the bourgeoisie in the cities, while the clothing of the majority of the population merely followed the slowly changing lines and shapes of overall body appearance, but did not necessarily include highly fashionable details. Depictions of women on Swiss stained-glass windows wear the same waist-accentuating style with soft falling skirts and fitted, but not necessarily boned, bodices; e.g., Hasler et al. (2016). It has to be mentioned that most depictions show doublets or jackets worn on top of the blouse, leaving only the collar or a small part of the blouse visible. The clothing preserved on the Leuk mummy can still be compared to this style: The blouse sits tightly around the neck and covers the body in a straight line before being gathered again in the waist, resulting in a straight or very slightly rounded shape. The tight, regular gathers of the skirt would have accentuated the waist and shaped a soft curve over the hips, from which it would have hung loosely, reaching down to the ankles.

Underneath the skirt, the mummy wore drawers reaching down mid-thigh (Fig. 10). As stated earlier, the drawers could not be examined by the authors, but are only mentioned in the restoration documentation from 1995. As only a photo of the reconstructed drawers exists, the original condition in which they were found remains unknown. In addition, it is also not known what lead the conservator to the conclusion that the fragments found under the skirt were originally drawers, in contrast to the more common and likely underskirt. Whether drawers were a common form of women’s undergarments in the 16th and 17th centuries is still debated. Most (of the very few) extant drawers from the late 16th century are richly decorated and Italian, though it is not clear whether all of them were actually women’s drawers (Arnold 1988:209). Due to the lack of written sources and extant garments, it is not known how widespread drawers were in Europe, or whether they were



worn only in certain regions or levels of society. There is proof of women's drawers at the Medici court in Florence, but, on the other hand, they are said to have been connected to prostitution in France (Orsi Landini 2010:199). At least this proves that they were known in different countries and worn by women of very different backgrounds. If the fragments worn by the mummy were indeed drawers, they would be a very rare example of 17th-century women's drawers and proof that their use was not only more widespread than known, but also common in rural regions.

The blouse and the cape closed much tighter around the individual's neck than is currently visible on the mummy and reached up to her chin, framing the face with a pleated collar like a small ruff. Neck ruffs were fashionable in different shapes and sizes for both sexes from the late 16th to the mid-17th centuries, but originated from earlier collar shapes. While neck ruffs were not normally attached to the garments, but were worked as separate items due to their sizes and need for starching, a collar could be sewn directly onto a garment's neckline (Tiramani 2012:93). The collar on the blouse of the mummy shows that, as a more economical and practical alternative, pleated collars remained in use at the same time as the wide and elaborate ruffs that developed from them.

The only visible decoration is the subtle cross-stitch ornamentation on the blouse's cuffs. The earliest-known pattern books including patterns for similar cross-stitch borders date to the 1520s, but they may have already been popular before this and surely remained common until the 18th century without changing much in style and even being copied centuries later (Abegg 1998:15–16,22). This makes it hard to date them and indicates that the cross-stitch ornaments on the mummy's blouse are not a fashionable, but merely a timeless decoration.

No single element of the clothing indicates any level of distinction or particular wealth. In contrast to other burial sites in which lay individuals were buried in complete silk patterned attire (Ochsner 2013:122–130), or woolen glacial finds from the postmedieval period (Alterauge, Providoli et al. 2015; Reitmaier et al. 2015), the woman from Leuk was dressed in simple linen; however, the preservation of silk is better in ground burials, while less information is available on historical linen clothing. Despite the geographical position of Leuk and its role in the local trade, the mummy's clothing could have been produced locally. Flax grew in the vicinity, and the simple weave indicates that the fabrics

could have been woven in the village itself or nearby. Simple looms were widespread and differed profoundly from the complex looms that were used to create complex and patterned weaves. Only the skirt was dyed, in a brownish red, a color achieved with a variety of local plant dyes. Barks, different herbs, and galls have been used in Europe since prehistoric times to produce brown dye colors and galium to dye red, to name only a few (Hofmann-de Keijzer 2010:144,149–155). Linen can easily be bleached by exposing it to bright sunlight, though different treatments can support the process and enhance the effect.

In contrast to the fine, bleached linen of the blouse and the colored skirt, the mummy's cape was made from comparatively coarse and untreated linen. The single layer of linen does not seem to be capable of giving any sort of protection, be it against rainfall or low temperature. Still, the closure around the neck proves that it was made to be worn on the body and is not something that was added for the funeral, like a shroud. The cut differs from the majority of capes known from this era (Ellinger-Gebhardt 2015:248–251), not cut as a circle, but assembled from rectangles and gathered around the neck. Due to their merely practical use and the large amounts of reusable fabric, however, simple capes and other outer garments from the early modern period have rarely been depicted and are hardly ever preserved. As neither an explanation for a practical nor for a fashionable use can be found, it might have also had a completely different purpose, e.g., possibly representing a connection to a religious or other special group, serving a purpose in the village's society or during the burial ceremony.

The assumption that some details of the garments date more to the late 16th than to the first half of the 17th century does not contradict the dating of the shoes. The clothing worn by common people did not closely follow fashion. In rural areas especially, aspects like durability, comfort, and warmth were more important than fashion; also, fashion might not have been affordable. None of the garments shows signs of wear that would indicate use before becoming burial gowns, e.g., darned spots, tears, or stains, although the poor conservation of the textiles might have obscured them. However, there are no signs that would indicate the garments were made specifically for burial, as they do not differ from garments worn at that time (in contrast to a shroud, which is clearly identifiable as a burial gown). Considering the style of the skirt and blouse, the mummy of

Leuk was most likely buried in clothes she had already worn before her death. Taking into consideration her advanced age, she may even have worn clothes that had been fashionable when she was younger.

### Footwear and Related Pathologies

The marks found on the shoes' leather are not the result of taphonomic alterations, but are signs of wear during the "lifetime" of the footwear. Surface wrinkles created by wear indicate a hallux valgus (bunion) at the medial front of both feet. At the placement of the first metatarsal head is an outward bulge in the side of the shoe (Fig. 11); the adjacent toe area is noticeably flatter due to the displacement of the big toe toward the center. Below the bulge the sole is worn and compressed as a result of the extra pressure made by the concentrated weight of the deformed joint from walking. Hallux valgus is commonly associated with a deviated position of the big toe toward the second toe, and the deviation in the angle between the first and second metatarsal bones of the foot. Therefore, the distal part of the hallux, especially when it exhibits a bunion, pushes the medial shoe's side outwards, creating a specific pattern of wrinkles on the leather. This corresponds to the deformities seen on the x-ray images of the feet (Fig. 8) and supports the hypothesis that the individual wore the shoes before death. The signs of wear on the uppers and the sole are minimal, indicating the shoes were worn, but not for long enough to significantly wear down the front and back of the soles or to require mending. Thus, the individual was probably buried shortly after the manufacture of the shoes, in the 1630s at the latest.

The radiological observations indicate that the individual suffered from a foot deformity during life, including hallux valgus and claw toes. In regard to other examples of mummified feet (Isidro et al. 2015), the clawing was unlikely due to postmortem changes during mummification, but occurred during life; see also Piombino-Mascalì, Kozakaite et al. (2014). In natural mummies, outstretched fingers or toes are both observed, depending on the position in which they were placed before burial, as in cases of folded hands or feet in footwear.

The observed claw toes are often found together with other foot complaints. In contemporary populations of Western industrialized countries, hallux valgus is most often present among women. It is a

multifactorial disorder related to both anatomical factors, which may be genetic, and to biomechanical constraints, such as constricting footwear. However, studies have shown that hallux valgus was present in the past, but that prevalence by age, sex, and chronological period has changed over time (Mays 2005; Mafart 2007; Trujillo-Mederos et al. 2014). In both France and England, prevalence increased after the Middle Ages, specifically during the 16th and 17th centuries. It is related to a significant change in footwear, involving both shoe shape and material (Swann 1987; Mays 2005; Mafart 2007). In a group of 18th-century burials from a church on Tenerife, Canary Islands, those of different social status showed varying prevalence of hallux valgus, probably due to different footwear (Trujillo-Mederos et al. 2014).

In medieval Europe, shoes had flat, thin soles (lacking heels), a natural shape for the right and left toes, and the uppers made of thin flexible leather. After the invention of welted shoe construction in the beginning of the 16th century, footwear became increasingly inflexible due to the multiple layers of sole leather (M. Volken and S. Volken 2009). The invention of the masculine fashion of high heels around the beginning of the 17th century necessitated, for economic reasons, the use of straight lasts; resulting narrow footwear placed mechanical constraints on the foot (Swann 1983; Goubitz et al. 2001). Interestingly, studies have found inconclusive the correlation of hallux valgus with age and sex. While in French series the prevalence in males increased in the 17th century (Mafart 2007), in British series no evidence for sex differences was detected (Mays 2005). Even though hallux valgus is associated with advanced age, changes in bone structure have already been observed in some young adults, suggesting that constrictive footwear was worn prior to adulthood.

The woman from Leuk proves that foot complaints were also present in postmedieval Swiss alpine populations. In this particular case, the female aged between 45 and 60 years most likely suffered from hallux valgus and claw toes. While it is difficult to distinguish whether this disorder was caused by genetic, adapted constitutional, or biomechanical factors, the narrow, straight sole shapes of the footwear common during her lifetime may have caused or intensified this condition.

## Burial and Identity

Since there are no inscriptions on the coffin or embroidered monograms on the clothing, the attempt to identify the mummy is a challenging task. The fact that the individual was buried in the southwestern corner of the church in an older masonry grave attests to a certain status of the woman within the society. It was a privilege and sign of social distinction to be buried within the church rather than outside in the cemetery, with the most coveted places close to the altar or in the choir. Those areas were mainly reserved for the clergy, while nobles and patricians would have been buried in the nave. During the 16th and 17th centuries, the noble families of Leuk were replaced by emerging townsmen, who determined the village's fate as merchants, notaries and attorneys, officers, magistrates, and politicians (Bellwald 2015:71). Little is known about how social status—especially of newly rising civilians—might have been represented in small societies and rural areas, such as in a village like Leuk. Additionally, a respected position in society does not necessarily correspond to wealth or the display of wealth, especially in religious settings. While the clothes in which the woman was buried show no distinct signs that she was a particularly wealthy member of village society, her burial site indicated that she was, however, a respected member, holding a certain status in her environment, though a more detailed conclusion cannot be made due to the lack of further sources.

The pool of potential candidates for the mummy's identity might have been even larger when considering that the parish of Leuk comprised a vast region with several villages, with St. Stephan being the main burial church. Most unfortunate for this study, however, it turned out that the death register of Leuk only starts in 1658, which makes it virtually impossible to compare the results of this study to any historical documentation. In similar studies, multiple lines of evidence regarding physical anthropology and costume history were also followed, but, in the end, the name and precise date of birth and death were gained from written documentation, such as cemetery plans or church-register entries (Fingerlin 1992; Owsley et al. 2006; Lösch et al. 2011; Alterauge, Kellinghaus et al. 2017). In contrast, our mummy is from a period in which standardized registration had only just begun, and, due to a lack thereof, the individual remains unidentified. An identification would have made it possible to evaluate the position of

the individual in the society in more detail, while currently our hypotheses on clothing and status remain speculative because of the uniqueness of the find in Switzerland.

The folded hands on the chest can be found in Switzerland in graves dating from the late Middle Ages onward until the 18th century (Eggenberger, Ulrich-Bochsler et al. 1983:233; Windler 1993:70–71; Alterauge and Lösch 2018). Together with crossed lower arms on the chest, these gestures are believed to represent a position of prayer, as seen in contemporary depictions of praying (Illi 1992:18–19). Their occurrence is seen in Catholic and Protestant burials, and sometimes, but not always, connected with religious paraphernalia, namely a rosary placed in or wrapped around the hands of the deceased (Kälin-Gisler 2018:432). Even though Leuk was one of the centers of the Reformation in the Valais, St. Stephan's Church has always remained Roman Catholic (von Roten 1991), thus, it can be assumed that the woman was of this faith.

Regarding the individual itself, she was a woman of advanced, probably postmenopausal, age and slender figure. With an estimated shoe size of 34/35 Paris point and a body height of approximately 151 cm, she was of rather small stature, as compared to the burials in the cemetery of St. Peter's Church in Leuk, with an average female body height of 153 cm (early medieval, Descoedres and Sarott [1984:217]), of 155.4 cm at Saint-Prex in the canton of Vaud (13th–14th and 18th centuries, Simon and Simon [1992:257]), and of 159.7 cm at several sites in the canton of Bern (11th–20th centuries, Alterauge and Lösch [2018]). The discrepancy between the calculated body height and body length in situ, 13 cm, is quite notable; however, an average of 10 cm divergence is normally observed in excavations, with the measurement in situ being less than the estimated stature. The reasons can be manifold: shrinkage due to disappearance of intervertebral discs and dislocation of skeletal elements, e.g., skull and cervical spine. The coffin's length was obviously adapted to the individual's body height.

Calcifications are seen in the x-ray projection of the right medial lobe of the lung, but due to a lack of lateral X rays we are not able to determine their exact location or etiology. The radiological examination has proven useful for assessing age, sex, and presence of bone pathologies, but as X rays are only two-dimensional images of a three-dimensional object, there are clear



limitations when it comes to the evaluation of soft-tissue pathologies, especially in mummified remains. Therefore, the absence of severe skeletal pathologies (e.g., fractures, chronic infectious diseases) does not automatically correspond to good health during life. The degenerative changes at the hips, shoulders, and spine indicate, at least, that the individual was an active member of the community.

### Mummification

Switzerland is well known for preserved human remains from glaciers (Kaufmann 1996a; Alterauge, Providoli et al. 2015; Reitmaier et al. 2015), but it has also yielded several mummies dating to the medieval or early modern period that have survived in churches or monasteries (Kaufmann 1996b; Aufderheide 2003:172). Among these are the putative Baron of Sennwald, Johann Philipp von Hohensax (died in 1596), and the female mummy from the Franciscan church in Basel (died in 1787) (Hotz, Lecoq et al. 2011; Hotz, Augsburg et al. 2018).

While all church mummies have in common the fact that they were buried within a wooden container inside a building, the circumstances of their mummification are still under debate. Although Kaufmann (1996b) was convinced that Swiss mummies were cases of intended artificial mummification, he could not detect any incisions, organ removal, or stuffing of the corpses. Nowadays, we suggest that favorable climatic conditions, such as good ventilation and dry environment, can lead to natural mummification as a result of water removal from the body, slowing down or even ceasing the decomposition process (Aufderheide 2003; Piombino-Mascali, Kozakaite et al. 2014; Petrella et al. 2016; Alterauge, Kellinghaus et al. 2017; Piombino-Mascali, Gill-Frerking et al. 2017). In natural mummification, the process of natural body-water loss occurs more rapidly than does the advance of enzymatic activity responsible for the decomposition (Piombino-Mascali, Gill-Frerking et al. 2017). At the current state of research it seems unclear whether or to what extent such preservative conditions were intentionally induced as an intended or unintended (though accepted) consequence of crypt burial.

The mummification in Leuk was probably caused by the dry climate of the region. Leuk's climate is characterized by moderate average precipitation of about 600–700 mm per year and high solar radiation (Werner 1994:12–16). Additionally, the church was erected on

a limestone slope, which made it necessary to fill in the terrain with loose sediments, resulting in efficient drainage and ventilation of the soil. The terracing also led to a natural protection from groundwater and humidity. Two other inhumations in St. Stephan's Church were found to be partially mummified, but were reburied after their discovery.

The good state of preservation is somehow surprising, given the amount of fly puparia found within the coffin. As a precondition for the flies' colonization of the body and subsequent pupation of the maggots, certain minimum temperatures are necessary for the attested genera *Hydrotaea*, *Fannia*, and *Lucilia* (Cherix et al. 2012; Wyss and Cherix 2013). The lower the temperatures are, the longer the life cycle of fly colonization, oviposition, larvae development and growth, pupation, and emergence of the new adult insect will take (Amendt 2007:225–227; Vanin and Huchet 2017:176–179). The presence of empty puparia suggests that the complete cycle took place before burial. The coffin must have been closed soon after the flies' pupation, since the attested species do not usually pupate on a decomposing body. Remains of adult flies or other insects were not found in the analyzed samples, so they might have escaped the coffin via small gaps. However, the adult flies might have also simply decomposed in the coffin, since their remains are not as durable as the puparia. Furthermore, the mummification through desiccation must have occurred quickly after burial so that the next generation of insects could not consume the corpse any further. Therefore, the placement of the coffin in the grave must have happened soon after death of the individual.

Given the quantity of puparia in the coffin, temperatures must have been quite favorable for the insects' development, probably indicating a burial in spring, summer, or autumn. Since we do not know the exact species, we are currently unable to give a precise threshold, but, while the genera *Lucilia* and *Hydrotaea* are more "heat loving," needing at least 10°C to finish their metamorphoses, flies belonging to *Fannia* can also adapt to low temperatures, e.g., lower thresholds between 1°C and 5°C.

### Conclusion

This study aimed at compiling the available fragmentary information on the mummy from Leuk and comparing it

to current observations in order to date the individual, but also to reconstruct the mummy's history since its discovery in the 1980s. Since our investigation was noninvasive and comprised observing the mummy in its current restored condition, the difficulty was to distinguish between its pre- and postconservation state and, nonetheless, to interpret the remains and clothing according to their original appearance. The shoes date the burial to the first half of the 17th century, more precisely to the 1630s, and the garments are in accordance with this dating. Both provide unique insight into the clothing style at that time period. Even though the identity of the mummy is still unknown, the burial place in St. Stephan's Church points toward the woman being a relevant member of society in Leuk. Further interpretations were hampered by the limited knowledge on late-medieval and postmedieval burials in the region, and we hope that our study will be an incentive for further research on this time period.

**Acknowledgments:** We would like to thank the local authorities, especially Roger Mathieu and his colleagues from Leuk parish, for their support. We further thank the excavator Georges Descouedres from the University of Zurich and the conservator Sabine Sille for providing their documentation; Jens Amendt from the Institute of Forensic Medicine at the University of Frankfurt for the entomological analysis of the puparia; and the Service des Monuments, Bâtiments et Archéologie in Sion for the archaeological documentation.

#### Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

#### References

- Abegg, Margaret  
1998 *Apropos Patterns: For Embroidery Lace and Woven Textiles*. Schriften der Abegg-Stiftung, Riggisberg, Switzerland.
- Alterauge, Amelie, and Sandra Lösch  
2018 Die Friedhöfe im Kanton Bern im Wandel der Zeit—Interdisziplinäre Betrachtungen zu den Gräbern und Bestatteten (The cemeteries in the canton of Bern over the course of time—interdisciplinary thoughts on the graves and burials). In *Die Schweiz von 1350 bis 1850 im Spiegel archäologischer Quellen. Akten des Kolloquiums, Bern, 25.–26.1.2018*, Archäologie Schweiz, Schweizerische Arbeitsgemeinschaft für die Archäologie des Mittelalters und der Neuzeit, and Schweizerischer Burgenverein, editors, pp. 441–456. Verlag Archäologie Schweiz, Basel, Switzerland.
- Alterauge, Amelie, Manuel Kellinghaus, Christian Jackowski, Natallia Shved, Frank Rühli, Frank Maixner, Albert Zink, Wilfried Rosendahl, and Sandra Lösch  
2017 The Sommersdorf Mummies—An Interdisciplinary Investigation on Human Remains from a 17th–19th Century Aristocratic Crypt in Southern Germany. *PLoS ONE* 12(8). PLOS ONE <<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0183588>>. Accessed 20 May 2019.
- Alterauge, Amelie, Sophie Providoli, Negahnaz Moghaddam, and Sandra Lösch  
2015 Death in the Ice—Re-Investigations of the Remains from the Theodul Glacier (Switzerland). *Journal of Glacial Archaeology* 2(1):35–50.
- Amendt, Jens  
2007 Forensische Entomologie (Forensic entomology). In *Biologische Spurenkunde: Band 1: Kriminalbiologie*, Bernd Herrmann and Klaus-Steffen Saternus, editors, pp. 221–244. Springer, Berlin, Germany.
- Arnold, Janet  
1988 *Queen Elizabeth's Wardrobe Unlock'd*. Maney, Leeds, UK.
- Aufderheide, Arthur C.  
2003 *The Scientific Study of Mummies*. Cambridge University Press, Cambridge, UK.
- Bach, Herbert  
1965 Zur Berechnung der Körperhöhe aus den langen Gliedmaßenknochen weiblicher Skelette (To calculate body height from the long limb bones of female skeletons). *Anthropologischer Anzeiger* 29:12–21.
- Beckett, Ronald G., and Gerald J. Conlogue  
2010 *Paleoimaging: Field Applications for Cultural Remains and Artifacts*. CRC Press, Boca Raton, FL.
- Bellwald, Werner  
2015 Leuk—von der Urgeschichte bis zur Französischen Revolution (Leuk—from ancient history until the French Revolution). In *Blickpunkt Leuk 515-2015*, Vol. 1, Walliser Vereinigung für kulturhistorische Forschungen, editor, pp. 29–76. Rotten, Visp, Switzerland.
- Buikstra, Jane E., and Douglas H. Ubelaker  
1994 *Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at the Field Museum of Natural History, Organized by Jonathan Haas*. Arkansas Archeological Survey, Fayetteville.
- Cherix, Daniel, Claude Wyss, and Thomas Pape  
2012 Occurrences of Flesh Flies (Diptera: Sarcophagidae) on Human Cadavers in Switzerland, and Their Importance as Forensic Indicators. *Forensic Science International* 220(1–3):158–163.
- Descouedres, Georges  
2014 Religiosität und Bestattungen (Religiosity and burials). In *SPM VII: Archäologie der Zeit von*

- 800 bis 1350, Urs Niffeler, editor, pp. 389–409. Verlag Archäologie Schweiz, Basel, Switzerland.
- Descoedres, Georges, Andreas Cueni, Christian Hesse, and Gabriele Keck  
1995 *Sterben in Schwyz: Beharrung und Wandlung im Totenbrauchtum einer ländlichen Siedlung vom Spätmittelalter bis in die Neuzeit* (Death in Schwyz: Persistence and change in the funeral traditions of a rural settlement from the late Middle Ages to modern times). Schwyzer Zeitung AG, Basel, Switzerland.
- Descoedres, Georges, and Jachen Sarott  
1984 Materialien zur Pfarrei- und Siedlungsgeschichte von Leuk: Drei archäologische Untersuchungen: Pfarrkirche St. Stephan, ehemalige St. Peterskirche und Mageranhaus (Material on the parish and settlement history of Leuk: Three archaeological investigations: parish church of St. Stephen, former St. Peter's Church and Mageranhaus). *Vallesia* 39: 139–238.
- Descoedres, Georges, and Jachen Sarott  
1986 Eine frühchristliche Taufkirche im Oberwallis: Die Ausgrabungen in der Pfarr- und Wallfahrtskirche Unsere Liebe Frau auf dem Glisacker (Gemeinde Brig-Glis) (An early Christian baptistery in the Upper Valais: The excavations in the parish and pilgrimage church of Our Lady on the Glisacker [municipality Brig-Glis]). *Vallesia* 41:349–448.
- Eggenberger, Peter, Manuel Kehrl, Murielle Schlup, and Susi Ulrich-Bochsler  
2012 *Worb, Pfarrkirche: Die Ergebnisse der Bauforschungen von 1983* (Worb, parish church: The results of historical building research from 1983). Archäologischer Dienst des Kantons Bern, Bern, Switzerland.
- Eggenberger, Peter, Susi Ulrich-Bochsler, and Elisabeth Schäublin  
1983 Beobachtungen an Bestattungen in und um Kirchen im Kanton Bern aus archäologischer und anthropologischer Sicht (Observations on burials in and around churches in the canton of Bern from an archaeological and anthropological perspective). *Zeitschrift für Schweizerische Archäologie und Kunstgeschichte* 40(4):221–240.
- Ellinger-Gebhardt, Maria  
2015 Mantelschnitte—nicht immer eine runde Sache (Cape cuts—not always a round thing). In *In Mode: Kleider und Bilder aus Renaissance und Frühbarock*, Jutta Zander-Seidel, editor, pp. 248–251. Verlag des Germanischen Nationalmuseums, Nuremberg, Germany.
- Fingerlin, Ilse  
1992 *Die Grafen von Sulz und ihr Begräbnis in Tiengen am Hochrhein* (The Counts of Sulz and their funeral in Tiengen, Upper Rhine). Konrad Theiss, Stuttgart, Germany.
- Gostner, Paul, Marco Bonelli, Patrizia Perntner, Angela Graefen, and Albert Zink  
2013 New Radiological Approach for Analysis and Identification of Foreign Objects in Ancient and Historic Mummies. *Journal of Archaeological Science* 40(2):1003–1011.
- Goubitz, Olaf, Carol van Driel-Murray, and Willy Groenman-van Waateringe  
2001 *Stepping through Time: Archaeological Footwear from Prehistoric Times until 1800*. Stichting Promotie Archeologie, Zwolle, the Netherlands.
- Hasler, Rolf, Sarah Keller, and Uta Bergmann  
2016 Willkommsscheibe Deus (Matthäus) Lehmann und Anna Beret (Welcome disc Deus [Matthäus] Lehmann and Anna Beret). Vitrosearch <<https://vitrosearch.ch/de/objects/2468555>>. Accessed 10 December 2018.
- Hauser, Albert  
1994 *Von den letzten Dingen: Tod, Begräbnis und Friedhöfe in der Schweiz 1700–1990* (The last things: Death, burial and cemeteries in Switzerland 1700–1990). Verlag NZZ, Zurich, Switzerland.
- Hess, Stefan  
2013 Der sogenannte Pestsarg von Mandach: Ein aufschlussreiches Zeugnis frühneuzeitlicher Sepulkalkultur (The so-called plague coffin of Mandach: A revealing testimony on early modern sepulchral culture). *Argovia: Jahresschrift der Historischen Gesellschaft des Kantons Aargau* 125:124–133.
- Hillson, Simon  
1996 *Dental Anthropology*. Cambridge University Press, Cambridge, UK.
- Hochstrasser, Markus  
2001 Solothurn, ehemaliger Franziskanerkirche: Bericht zu den bauhistorischen Untersuchungen (Solothurn, former Franciscan church: Report on historical building research). *Archäologie und Denkmalpflege im Kanton Solothurn* 6:7–33.
- Hofmann-de Keijzser, Regina  
2010 Färben (Dyeing). In *Prähistorische Textilkunst in Mitteleuropa. Geschichte des Handwerks und Kleidung vor der Römern*, Karina Grömer, editor, pp. 143–157. Naturhistorisches Museum Wien, Vienna, Austria.
- Hotz, Gerhard  
2007 Die Bestattungen im Kloster St. Johann in Müstair: Anthropologische Auswertung (The burials in the monastery of St. Johann in Müstair: Anthropological evaluation). In *Müstair Kloster St. Johann 4. Naturwissenschaftliche und technische Beiträge*, Hans Rudolf Sennhauser, editor, pp. 117–182. Vdf Hochschulverlag AG, Zurich, Switzerland.
- Hotz, Gerhard, Marc Augsburg, T. Briellmann, A. Bircher, V. Castella, R. Fiechter, H.-U. Friedrich, M. L. Gamma, D. Gysin, O. Haas, F. Häslar, D. Herber, U. Hirter, L. Huber, J. C. Jacob, S. Janner, J. P. Kleitz, L. Meyer, V. Müller, J. Rauber, M. Ribbert, B. Rietsch, W. Rosendahl, A. Spycher, T. Westphal, P. Urban, H. Wittig, U. Wittwer-Backofen, A. Zink, and M. Zulauf-Semmler  
2018 Der rätselhafte Mumienfund aus der Barfüsserkirche in Basel. Ein aussergewöhnliches Beispiel interdisziplinärer Familienforschung (The enigmatic mummy find from the Franciscan church



- in Basel. An exceptional example of interdisciplinary family research). *Jahrbuch der Schweizerischen Gesellschaft für Familienforschung* 45:1–30.
- Hotz, Gerhard, Catherine Lecoq, Lucia Bürl, Jürgen Mischke, Thomas Böni, Roger Seiler, and Frank Rühl  
2011 Die Dame aus der Barfüsserkirche Basel: Paläopathologische Untersuchungen der weiblichen Mumie aus der Barfüsserkirche unter Berücksichtigung der historischen Quellen (The lady from the Franciscan church Basel: Paleopathological investigations of the female mummy from the Franciscan church in consideration of the historical sources). In *Geschichte und Tradition der Mumifizierung in Europa. Beiträge zu einer Tagung im Museum für Sepulkralkultur 2010*, Arbeitsgemeinschaft Friedhof und Denkmal e.V., editor, pp. 121–138. Arbeitsgemeinschaft Friedhof und Denkmal e.V., Kassel, Germany.
- Illi, Martin  
1992 *Wohin die Toten gingen: Begräbnis und Kirchhof in der vorindustriellen Stadt* (Where the dead went: Burial and churchyard in the pre-industrial city). Chronos Verlag, Zurich, Switzerland.
- Işcan, Mehmet Y., Susan R. Loth, and Ronald K. Wright  
1985 Age Estimation from the Rib by Phase Analysis: White Females. *Journal of Forensic Sciences* 30(3):853–863.
- Isidro, Albert, Beatrice Huber, Aamer Malik, and Assumpció Malgosa  
2015 Pathological Variations in Mummified Feet between Two Near-Distance/Long-Time Populations in Ancient Egypt. *Journal of Foot and Ankle Research* 8(1):58.
- Jackowski, Christian, Stephan Bolliger, and Michael J. Thali  
2008 Common and Unexpected Findings in Mummies from Ancient Egypt and South America as Revealed by CT. *RadioGraphics* 28(5):1477–1492.
- Kälin-Gisler, Martina  
2018 Grabbeigaben im Gebiet der Deutschschweiz (Grave goods in the German-speaking region of Switzerland). In *Die Schweiz von 1350 bis 1850 im Spiegel archäologischer Quellen: Akten des Kolloquiums, Bern, 25.–26.1.2018*, Archäologie Schweiz, Schweizerische Arbeitsgemeinschaft für die Archäologie des Mittelalters und der Neuzeit, and Schweizerischer Burgenverein, editors, pp. 431–440. Verlag Archäologie Schweiz, Basel, Switzerland.
- Kaufmann, Bruno  
1996a The Corpse from the Porchabella-Glacier in the Grisons, Switzerland (Community of Bergün). In *Human Mummies: A Global Survey of their Status and the Techniques of Conservation*, Konrad Spindler, Harald Wilfing, Elisabeth Rastbichler-Zissernig, Dieter zur Nedden, and Hans Nothdurfter, editors, pp. 239–246. Springer, Vienna, Austria.
- Kaufmann, Bruno  
1996b Mummification in the Middle Ages. In *Human Mummies: A Global Survey of their Status and the Techniques of Conservation*, Konrad Spindler, Harald Wilfing, Elisabeth Rastbichler-Zissernig, Dieter zur Nedden, and Hans Nothdurfter, editors, pp. 231–238. Springer, Vienna, Austria.
- Kaufmann, Bruno, Siegfried Scheidegger, and Catherine De Herdt  
2009 Anthropologische und paläopathologische Untersuchungen an Schweizerischen und ausländischen Mumien von 1975 bis 2008, durchgeführt im Anthropologischen Forschungsinstitut Aesch (Anthropological and palaeopathological studies on Swiss and foreign mummies from 1975 to 2008, conducted at the Anthropological Research Institute Aesch). In *Mumien und Museen: Kolloquium zur Ausstellung MUMIEN—Der Traum vom ewigen Leben*, Alfred Wiczorek, Wilfried Rosendahl, and Hermann Wiegand, editors, pp. 93–104. Verlag Regionalkultur, Heidelberg, Germany.
- Kunsthistorisches Institut der Universität Zürich  
2008 *Die Stadt Leuk* (The city of Leuk). Gesellschaft für Schweizerische Kunstgeschichte, Bern, Switzerland.
- Lösch, Sandra, Martin Bunzel, Christine Lehn, Ulrich Struck, Oliver Peschel, and Matthias Graw  
2011 Die Wolfstein-Mumien (16.–18. Jahrhundert)—Untersuchungen an mumifizierten Körpern einer Gruft in Süddeutschland (The Wolfstein mummies [16th–18th century]—studies on the mummified bodies from a crypt in southern Germany). In *Geschichte und Tradition der Mumifizierung in Europa: Beiträge zu einer Tagung im Museum für Sepulkralkultur 2010*, Wolfgang Neumann, editor, pp. 113–119. Arbeitsgemeinschaft Friedhof und Denkmal e.V., Kassel, Germany.
- Mafart, Bertrand  
2007 Hallux Valgus in a Historical French Population: Paleopathological Study of 605 First Metatarsal Bones. *Joint Bone Spine* 74(2):66–170.
- Martin, Rudolf  
1914 *Lehrbuch der Anthropologie in systematischer Darstellung mit besonderer Berücksichtigung der anthropologischen Methoden* (Textbook of anthropology in systematic presentation with special consideration of anthropological methods). Gustav Fischer, Jena, Germany.
- Mays, Simon A.  
2005 Paleopathological Study of Hallux Valgus. *American Journal of Physical Anthropology* 126(2):139–149.
- Meier, Hans-Rudolf, and Peter-Andrew Schwarz  
2013 *Die Grabfunde des 12. bis 19. Jahrhunderts aus dem Basler Münster: Repräsentation im Tod und kultureller Wandel im Spiegel der materiellen Kultur* (The grave finds of the 12th to 19th centuries from the Basel Minster: Representation in death and cultural change in the mirror of

- material culture). Archäologische Bodenforschung des Kantons Basel-Stadt, Basel, Switzerland.
- Ochsner, Christine  
2013 Auswertung der Grabfunde des 12. bis 19. Jahrhunderts aus dem Basler Münster (Evaluation of the grave finds of the 12th to 19th centuries from the Basel Minster). In *Die Grabfunde des 12. bis 19. Jahrhunderts aus dem Basler Münster: Repräsentation im Tod und kultureller Wandel im Spiegel der materiellen Kultur*, Hans-Rudolf Meier and Peter-Andrew Schwarz, editors, pp. 19–134. Archäologische Bodenforschung des Kantons Basel-Stadt, Basel, Switzerland.
- Orsi Landini, Roberta  
2010 The Influence of the Medici Style on European Fashion. In *Fashion and Clothing in Late Medieval Europe*, Regula Schorta and Rainer C. Schwinges, editors, pp. 193–209. Abegg-Stiftung, Riggisberg, Switzerland.
- Owsley, Douglas W., Karin S. Bruwelheide, Larry W. Cartmell, Laurie E. Burgess, Shelly J. Foote, Skye M. Chang, and Nick Fielder  
2006 The Man in the Iron Coffin: An Interdisciplinary Effort to Name the Past. *Historical Archaeology* 40(3):89–108.
- Pearson, Karl  
1899 Mathematical Contributions to the Theory of Evolution: V. On the Reconstruction of the Stature of Prehistoric Races. *Philosophical Transactions of the Royal Society of London, Series A, containing Papers of a Mathematical or Physical Character* 192:169–245.
- Petrella, Enrico, Sara Piciucchi, Francesco Feletti, Domenico Barone, Antonella Piraccini, Caterina Minghetti, Giorgio Gruppioni, Venerino Poletti, Mauro Bertocco, and Mirko Traversari  
2016 CT Scan of Thirteen Natural Mummies Dating back to the XVI–XVIII Centuries: An Emerging Tool to Investigate Living Conditions and Diseases in History. *PLoS ONE* 11(6). PLOS ONE <<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154349>>. Accessed 20 May 2019.
- Piombino-Mascalì, Dario, Heather Gill-Frerkling, and Ronald G. Beckett  
2017 The Taphonomy of Natural Mummies. In *Taphonomy of Human Remains: Forensic Analysis of the Dead and the Depositional Environment*, Eline M. Schotsmans, Nicholas Márquez-Grant, and Shari L. Forbes, editors, pp. 101–119. Wiley & Sons, Chichester, UK.
- Piombino-Mascalì, Dario, Justina Kozakaite, Algirdas Tamošiūnas, Ramunas Valančius, Stephanie Panzer, and Rimantas Jankausas  
2014 Skeletal Pathological Conditions of Lithuanian Mummies. *Papers on Anthropology* 23(1):118–126.
- Reitmaier, Thomas, Manuela Camichel, Nakita Frater, Sabrina Meyer, Roger Seiler, Martin Häusler, Frank Rühli, Marquita Volken, and Serge Volken  
2015 Eine weibliche Gletscherleiche aus der Zeit um 1690 aus Graubünden (A female glacier corpse from around 1690 from Grisons). *Archäologie Graubünden* 2:13–21.
- Sille, Sabine  
1995 Restaurierung/Konservierung der Kleidungsstücke der Mumie von Leuk (Resoration/conservation of the clothing items of the mummy of Leuk). Manuscript, Sabine Sille, Salavaux, Switzerland.
- Simon, Françoise, and Christian Simon  
1992 Etude anthropologique des squelettes de l'église de Saint-Prex (Anthropological study of the skeletons of the Saint-Prex church). In *L'église de Saint-Prex: Histoire et archéologie*, Peter Eggenberger, Philippe Jatton, Catherine Santschi, Françoise Simon, and Christian Simon, editors, pp. 251–262. Presses centrales, Lausanne, Switzerland.
- Sjøvold, Torstein  
1988 Geschlechtsdiagnose am Skelett (Sex diagnosis on the skeleton). In *Anthropologie: Handbuch der vergleichenden Biologie des Menschen*, Rainer Knussmann, editor, pp. 444–480. Gustav Fischer, Stuttgart, Germany.
- Stolleis, Karen  
2008 Kölner Patrizier- und Bürgerkleidung in der Frühen Neuzeit (Cologne patrician and burgher clothing in the early modern period). In *Kölner Patrizier- und Bürgerkleidung des 17. Jahrhunderts: Die Kostümsammlung Hüpsch im Hessischen Landesmuseum Darmstadt*, Karen Stolleis and Johannes Pietsch, editors, pp. 19–57. Abegg-Stiftung, Riggisberg, Switzerland.
- Ströbl, Andreas  
2014 *Entwicklung des Holzсарges von der Hochrenaissance bis zum Historismus im nördlichen und mittleren Deutschland* (Development of the wooden coffin from the high renaissance to historicism in northern and central Germany). Fachverlag des Deutschen Bestattungsgewerbes, Düsseldorf, Germany.
- Swallow, A.  
1987 The History of Shoes. *Baillière's Clinical Rheumatology* 1(2):413–429.
- Swann, June  
1983 *Shoes*. Batsford, London, UK.
- Swann, June  
2001 *History of Footwear in Norway, Sweden and Finland*. Kungl. Vitterhets Historie och Antikvitets Akademien, Stockholm, Sweden.
- Szilvássy, Johann  
1988 Altersdiagnose am Skelett (Age diagnosis of the skeleton). In *Anthropologie: Handbuch der vergleichenden Biologie des Menschen*, Rainer Knussmann, editor, pp. 421–435. Gustav Fischer, Stuttgart, Germany.

- Tiramani, Jenny  
2012 Three Multilayered Ruffs in the Historisches Museum Basel. In *Netherlandish Fashion in the Seventeenth Century*, Johannes Pietsch and Anna Jolly, editors, pp. 93–106. Abegg-Stiftung, Riggisberg, Switzerland.
- Trujillo-Mederos, Aioze, Matilde Arny-de-la-Rosa, Emilio González-Reimers, and Alejandra Ordóñez  
2014 Hallux Valgus among an 18th Century Population of the Canary Islands. *International Journal of Osteoarchaeology* 24(5):590–601.
- Vanin, Stefano, and Jean-Bernard Huchet  
2017 Forensic Entomology and Funerary Archaeoentomology. In *Taphonomy of Human Remains: Forensic Analysis of the Dead and the Depositional Environment*, Eline M. Schotsmans, Nicholas Márquez-Grant, and Shari L. Forbes, editors, pp. 167–186. Wiley & Sons, Chichester, UK.
- Volken, Marquita  
2014 *Archaeological Footwear; Development of Shoe Patterns and Styles from Prehistory till the 1600's*. SPA Uitgevers, Zwolle, the Netherlands.
- Volken, Marquita, and Serge Volken  
2007 Les chaussures de la porte de Romont à Fribourg du XIV<sup>e</sup> au XVII<sup>e</sup> siècle (The shoes of the Romont gate in Fribourg from the 14th to the 17th centuries). *Cahiers d'archéologie fribourgeoise* 9:154–191.
- Volken, Marquita, and Serge Volken  
2009 Der schuhtechnologische “Big Bang” der Wendezeit (The shoe technology “Big Bang” of the early modern period). In *Zwischen Tradition und Wandel, Archäologie des 15. und 16. Jahrhunderts*, Barbara Scholkmann, Sören Frommer, Christina Vössler, and Markus Wolf, editors, pp. 205–215. Dr. Faustus, Büchenbach, Germany.
- von Roten, Hans Anton  
1991 Zur Geschichte der reformierten Gemeinde Leuk 1560–1651 (History of the Reformed parish of Leuk). *Vallesia* 46:39–66.
- Windler, Renata  
1993 Die Gräber (The burials). In *Die Stadtkirche St. Laurentius in Winterthur: Ergebnisse der archäologischen und historischen Forschungen*, Carola Jäggi, Hans-Rudolf Meier, Renata Windler, and Martin Illi, editors, pp. 56–78. Fototar AG, Zurich, Switzerland.
- Werner, Philippe  
1994 *Erkenne die Natur im Wallis: Die Flora* (Discovering nature in Valais: The flora). Pillet, Martigny, Switzerland.
- Wyss, Claude, and Daniel Cherix  
2013 *Traité d'entomologie forensique: Les insectes sur la scène de crime* (Paper on forensic entomology: Insects at the scene of the crime). PPUR, Lausanne, Switzerland.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.