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An Annotated Bibliography of Archaeoentomology

Diana Gallagher

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Introduction

For my Master's Degree Project, I have undertaken to compile an annotated bibliography of a selection of the current literature on archaeoentomology. While not exhaustive by any means, it is designed to cover the main topics of interest to entomologists and archaeologists working in this odd, dark corner at the intersection of these two disciplines. I have found many obscure works but some publications are not available without a trip to the Royal Society's library in London or the expenditure of far more funds than I can justify. Still, the goal is to provide in one place, a list, as comprehensive as possible, of the scholarly literature available to a researcher in this area.

The main categories are broad but cover the most important subareas of the discipline. Full books are far out-numbered by book chapters and journal articles, although Harry Kenward, well represented here, will be publishing a book in June of 2020 on archaeoentomology. The information discovered through archaeoentomology is most easily used as one part of a larger group of archaeological techniques, all working toward the description of a site, person, or landscape.

This is not a large area of study and the same names come up in multiple works. Some topics are still quite new, such as Battlefield Archaeoentomology, and so have fewer entries than other topics.

What is Archaeoentomology and what is its place in Environmental Archaeology?

Archaeoenomology is the study of insect remains on sites of archaeological interest. Although a relatively recent addition to the archaeological tool kit, it can be helpful in assessing past environments, the biogeography of various arthropod species, and the funeral and burial customs of different groups through time. Paleoentomology is related to archaeoentomology but differs in the time depth encountered. Most archaeoentomological works relate to the ancient, medieval or early modern world, extending in more recent years to the first and second world wars, while paleoentomology reaches farther back in time to pre-human periods.

Insect remains in archaeological deposits provide a challenge for identification that is unique in entomology. The photograph below (Figure 1) shows insect pieces contained within a mass of plant and other debris. This is the starting point for extracting the head capsules, thoraxes, sclerites, and other parts that will go to make up the materials to be identified.

Figure 1. Insect remains in plant debris. Photo from the Encyclopedia of Global Archaeology (2014: 5746)

In the next photo (Figure 2), the remains and pieces have been separated from the debris and other material and await identification.

Figure 2. Insect parts after extraction. Photo from the Encyclopedia of Global Archaeology (2014:5746)

The above photographs give an excellent idea of the insect evidence being excavated, described, and interpreted in the following books, articles, and chapters.

Archaeoentomology: Books

N.B.: There are very few books entirely about archaeoentomology, with the literature largely consisting of articles in scholarly journals and chapters in specialty edited volumes. As noted above, mid-2020 will see the publishing of the first comprehensive book with archaeoentomology as the title subject.

Bain, A.L. (2001). Archaeoentomological and Archaeoparasitological Reconstructions at Ilot Hunt (CeEt-110): New Perspectives in Historical Archaeology (1850-1900). British Archaeological Reports S973. Oxford: Archaeopress. ISBN10:1841712604.

https://www.academia.edu/698735/Archaeoentomological_and_Archaeoparasitological_Reconstructions_at_%C3%8Elot_Hunt_CeEt-110_New_Perspectives_in_Historical_Archaeology_1850-1900.

Bain is an archaeoentomologist working at the Université de Laval in Montreal, Quebec. She and her students are responsible for quite a few of the more recent publications in this area. This publication is based on her doctoral dissertation and describes the excavation and analysis of the Ilot Hunt block in Quebec. It is an excellent resource for anyone who wishes to understand how a large scale urban excavation is run and includes the history of the site, documentary evidence, and a review of the material culture as well as archaeoentomological and archaeoparasitological analyses. Bain provides two excellent appendices, the first of which includes drawings, plans, and photographs of the site and the material culture, and the second includes large sharp photographs of many of the best insect specimens recovered from the different layers of the site. These are very helpful in understanding the complexities of Ilot Hunt and its time period of the latter half of the 19th-century.

The work is divided into sections, including an overview of urban life in 19th-century North America, a detailed history of the excavations and finds at the site, the results of the analyses of insect remains and parasite eggs, and a discussion and interpretation of all the evidence as a whole. Bain's hypothesis is twofold; the primary hypothesis and the secondary or null hypothesis. The primary hypothesis states that, if the textual, legal, and medical evidence is correct and there were major improvements in health, hygiene, and sanitation, then the researcher should see that reflected in the archaeology less evidence of insect infestation, human parasitic infection, and fewer medicine bottles. If the secondary or null hypothesis holds, however, and these new practices are not taking hold among people in the area, then the archaeology should show that these problems remain constant over this time period.

The growth and urban development of many cities in North America in the late 19th-century meant that these places faced challenges in housing their people as well as bringing in water and getting rid of waste. Privies were the norm in many places, even when some parts of a city had piped in water. Wealthier neighborhoods would have first access and, even there, the water and sewer systems were not always constructed in parallel, which created more problems. Quebec was in the same position as many other cities with periodic epidemics, issues with drinkable water, and problems coordinating waste disposal. Ilot Hunt was a block within the Lower Town of Quebec, with a mix of domestic and commercial buildings. It has been studied archaeological and historically since 1987 although Bain's work is based largely on the work done in 1995.

Both insect and parasite remains were found at levels for the 1850s through 1900. The parasites were round worm and whipworm, in a similar amounts to levels found on urban privy sites of this period. Insect remains included different families of beetles, with the largest percentage being Staphylinidae. Native species make up approximately 20% of the insects found with the rest being introduced species.

The groups of insects found include decomposers, such as Staphylinidae, Micropeplidae, and Hydrophilidae. Insects that eat fungus and dung were also present as were those, such as Silphid beetles that eat carrion. The synanthropic insects included grain pests, cockroaches, bedbugs, and lice, although levels of these are low. With these findings, Bain is able to show that sanitation and hygiene improved over the course of the last half of the 19th century. She accepts that her primary hypothesis is the correct one as the occupants of the site appeared to conform to the city laws that required cleaning of privies and removal of trash from around dwellings.

Buckland, P.C. (1979). Thorne Moors: A Paleoecological Study of a Bronze Age Site. Occasional Publication No. 8. University of Birmingham, Birmingham, UK. ISBN10:0704403595.

Ancient trackways, elevated paths of wooden logs used in marshy areas to allow human passage, are studied in British archaeology that focuses on the Bronze and Iron Ages. Along with the archaeological artifacts, pollen, plant, and insect remains were documented, providing a record of the ecology of this area. Thorne Moors, the area in which this study was carried out, is in the north of England and consists of 21 square kilometers of degraded sphagnum bog (Pg. 3).

In the early 1970s, a local naturalist reported that he had found charred timbers within the excavation of a new drain. Buckland investigated and ultimately found burnt timbers as well as an area of trackway built of split timbers. These timbers were found to have well preserved insect remains and Buckland took six samples for analysis. A 5-kilogram sample was taken from peat between the timbers of the trackway and a further 10 kilograms were taken from the horizon at the base of the sphagnum peat, which was approximately 10 centimeters above the trackway. Further samples were taken from the stump of one of the large trees at the base of the peat as well as from samples of the wood itself (Pg. 22). The samples were processed to recover insect remains. Radiocarbon dating puts at least one of the timbers at around 3000 years old.

The result of this analysis yielded a long list of insect species, comprising more than 850 specimens, of which sixteen taxa are no longer found in England. The change in insect species and abundance, studied in parallel with the pollen evidence, shows landscape change in the area around the trackway on Thorne Moors. Gradual climate deterioration with minor episodes of periodicity that influenced archaeological cultures is Buckland's conclusion on the basis of the insect evidence. This is by no means the total picture, however. Buckland notes "Several of the Thorne species may have become restricted as a result of the presumed culmination of the Sub-Boreal to sub-Atlantic deterioration about 700 B.C. but could equally have lasted until the post-medieval 'Little Ice Age' shortly before more detailed recording began." (Pg. 138). He also suggests that more mobile species could leave and then return to recolonize later once the climate improved. The majority of species whose range declined, which he puts at over 25% of the Thorne Moors taxa, are associated with woodland and, more specifically, with decaying timber, where many species in Britain find "their last refuge" (Pg. 139)

Elias, S.A. (1994). Quaternary Insects and Their Environments. Smithsonian Institution Press, Washington and London. ISBN10:1560983035.

This is truly a foundational publication in both paleoentomology and archaeoentomology. Elias in this volume outlined procedures that are still followed in recovering insect remains from archaeological and paleoecological soil.

Elias reviews the history of quaternary insect studies, including identifying prominent researchers in the field, as well as the value of such studies. He provides detailed instructions for sampling, concentrating, and preserving sediments containing insect remains. His highly useful chapter on important fossil insect groups and their identification provides guidance for archaeoentomologists trying to sort out different beetle elytra and insect head capsules.

His chapter on the use of insect fossils in archaeology ranges from sites in Europe and the Near East to North and South America. He addresses work going on in Siberia, Alaska, and the Eastern Beringia region (Pg. 177). His detailed accounts of each area cover many of the sites excavated through the mid-1990s when this volume was published. Any researcher on early insect fauna in Alaska or the Yukon would be well advised to read this book.

Having said that, however, anyone looking for information about insects on later sites will likely find more information elsewhere. Although he covers some medieval sites at York and the Norse sites in Greenland, most of his discussion centers around much older sites and landscapes. The volume is still of great use to archaeologists since it provides a thorough background in the beginnings of the recovery techniques now in use and an impressive overview of many important sites all over the world.

Kenward, H. (2007). Invertebrates in Archaeology in the North of England. Northern Regional Review of Environmental Archaeology. Research Department Report Series 12-2009. English Heritage.
https://www.researchgate.net/publication/266370711_Northern_Regional_Review_of_Environmental_Archaeology_Invertebrates_in_Archaeology_in_the_North_of_England.

Kenward has done an exceptional amount of archaeoentomological work in England on ancient and medieval sites, especially in York and the north of England more generally. I have included a representative sample of his work in this bibliography but more may be found stretching back into the 1970s. He will be publishing a book later in 2020 but I have included this work as it is book-length and covers archaeoentomology in the north of England. At over 500 pages, it includes a large number of sites of a variety of time periods, identified insects, and information about taphonomy and the depositional environment, as well as considerations of methodologies, problems, and directions for future research. With such an abundance of information, this will be only an overview.

Kenward begins by asking why we should study the past when it costs money, often considerable amounts of money, to do so. His brief answer is that well done archaeology is science and science contributes to the collective good of humanity. Environmental archaeology, of which insects are a part, can have value as a way to understand human interactions with the environment in the past, which can help address the future and the problems that will come. He provides a comprehensive review of the insects found on the sites within this work, ranging in time from before the Neolithic through Roman and Medieval sites to sites dated after 1350. He reviews all the orders of insects and includes as well annelid worms, crustaceans, helminth worms, and echinoderms, among others. Secondary or trace evidence for invertebrates is also considered, including burrows, frass, holes in grain, and the modification of bones and skin.

In his coverage of taphonomy, Kenward describes preservation issues, waterlogging, mineral replacement, charring, and other ways invertebrates might enter the archaeological record. His chronological organization of sites is helpful in placing them accurately in time. He discusses Roman and Medieval sites extensively. Some examples are the Roman military forts at York and Carlisle in which have been found filled wells containing insect remains that indicate the cleaning out of stables along with evidence of grain pests and insects that live in hay. Non-military sites, such as civilian settlements and sewers in York have yielded grain pests and human fleas. A dump deposit contained housefly pupal cases and eggs of a horse parasite indicating the presence of horses and of sometimes mucky conditions for humans. There are many more sites in Roman York than can be discussed here.

Medieval sites, defined as occurring after the Romans left but before the Black Death of 1350 arrived,

The two remaining sections are a thematic review and a discussion of techniques, problems, and the future of the field.

Much more could be said about this work and the detail it provides on all aspects of life in northern England at different periods that may be illuminated by studying archaeoentomology. While I have only skimmed the surface, a close reading of this book will repay anyone interested in this archaeological specialty.

Smith, D. (2016). Insects in the city: an archaeoentomological perspective on London's past. BAR British Series 561. BAR Publishing, Oxford, UK. ISBN10:1407309862.

Smith has delved deeply into the history of London using insects to reconstruct not only the human aspects of history but the environmental aspects as well. Beginning 350,000 years ago and stretching to the medieval and early modern period, Smith covers a total of 32 sites. Very few sites were found from the Paleolithic through the Neolithic. More are available for study from the Bronze Age, Roman period, Medieval and early modern periods.

Smith has a very interesting discussion on the interpretation of insect faunas from the archaeological record and some of the problems he sees. (Pg. 10) He cites Harry Kenward, well represented in this bibliography, whose research has become the foundation for much of the interpretation of insect remains in England. The use of these remains for the reconstruction of past landscapes and the development of insect assemblages as indicator groups is fundamental to archaeoentomology but is open to criticism in some areas. Smith notes the possibility of overemphasizing species with very restrictive stenotypes in reconstruction of the past while underplaying species that are more general in their habits. Using the modern ecology of a species can lead researchers away from the need to understand these species in terms of the past ecology of the site itself. (Pg. 10) The accidental inclusion of background fauna can also cause a researcher to place undue emphasis on their presence. Smith gives the example of dead dung beetles on a modern windowsill. They do not indicate the presence of livestock in the house but rather that these beetles can fly or be blown from considerable distances. (Pg. 11)

Having said that, there is still much to be gained, as Smith shows, from the appropriate analysis of insect evidence. His assessments of Roman, Medieval, and early modern sites are very helpful as part of the overall archaeology of London. One such is the Roman site known as Poultry in the center of the walled city and dates to the earliest occupation of London by the Romans, around 50 AD. Preservation on this waterlogged site was good and many species of powder post, death watch, and hide beetles as well as rove beetles and a few ectoparasites of humans and animals were found. Smith interprets the insects present to mean that there were timber framed buildings with earthen floors with accumulations both inside and out of food waste and decaying plant material. Smith notes that this grouping of insects, once common in houses, is no longer because of the rise of central heating and the vacuum cleaner. (Pg. 43)

An example of a medieval insect assemblage was found on the Priory of the Order of the Hospital of St. John in what is now Clerkenwell. Botanical and entomological analysis of a pit feature used for refuse showed that waste materials, animal bedding, and fodder from a hay meadow went into the pit, located near a medieval barn. Weevils associated with hay meadow plants were found as well as species associated with stable bedding, such as *Typhaea stercorea*, and species that live in materials that is so decayed that is it hot, such as *Anthicus* species. (Pg. 73) Granary and pea weevils confirmed that the stabled animals were fed on old grains and peas. Smith notes that the clearest indication of the use made of the material was the discovery of the goat louse, *Damalina caprae*.

A particularly helpful take away from this book is the caution Smith gives against falling into the "Pompeii premise", in which archaeologists assume that what is observed in the record is the last phase of action at a particular site (Pg.12) It is accurate in the case of Pompeii but in few other places. Sites continue to exist after their main phase of use and things can be added or removed or reused and redeposited. This must be kept in mind when using insect evidence to determine what was happening when and what that means for the occupation of the site in question.

Archaeoentomology: Articles

General Archaeoentomology

Aerts, S.E.I. (2016). Detecting Cultural Formation Processes Through Arthropod Assemblages. *Inter-Section: Innovative approaches by Junior Archaeological Researchers*. Leiden University. Vol II, 22-28. http://www.inter-section.nl/uploads/1/3/9/5/13953540/aerts_2016_inter-section.pdf.

This publication is put out by the University of Leiden in the Netherlands as a vehicle for articles by their students and faculty. This piece is written by a student and lays out a conceptual model for urban archaeological waste and cess pits. He shows that it is possible to trace formation processes using arthropod remains. Using the remains of synanthropic insects, he differentiates between natural and cultural processes as well as distinguishing local from non-local insect faunas. The sub-assemblages used are domestic, peridomestic, and natural environment. This model assists in assessing waste-management patters of a household as well as consumption patterns and personal hygiene (Pg. 22).

The author describes how separating insect species into communities allows for a clearer understanding of a deposit and assists in interpretation to determine if the deposit was subject to a natural or cultural selective process resulting in over- or underrepresentation of a species (Pg. 24). A useful example he provides is that of dumping some weevil-infested grain into a pit. Although the dumping is one event, it will result in an overrepresentation of one species and it is helpful to understand the domestic insect assemblage of a site, as opposed to the fauna of the natural environment, to identify the human caused imbalance.

Bain, A. (2004). Irritating intimates: the archaeoentomology of lice, fleas, and bedbugs. *Northeast Historical Archaeology*. Vol. 33(8), 81-101. doi10.22191/neha/vol33/iss1/8. https://orb.binghamton.edu/neha/vol33/iss1/8/.

Allison Bain, as indicated in the Books section, is a scholar well known in the discipline of archaeoentomology. She studies historical era sites and their insect fauna in the northern U.S., Canada, and Greenland. This article discusses insects, specifically ectoparasites, that have been problems for humans over the millennia.

Bain here looks at lice, fleas, and bedbugs on a variety of sites and asks what they can tell us about hygiene and sanitation in the past. She also warns us not to use modern ideas of hygiene and sanitation to judge the past since cultural perceptions can be problematic (Pg. 81). Still, she believes the study to be worthwhile. She provides a short natural history lesson for the three insects and notes the sites on which they have been found, ranging from Norse Greenland to 19th-century native sites in Wyoming to ancient Brazil, whence a human head louse egg was found dating from over 10,000 years ago (Pg. 83). The sites she lists for finds of human fleas include Tell el-Amarna in ancient Egpyt, medieval York, 18th-century London, and a 1000-year-old site from Southern Peru.

Much of Bain's own research has been carried out in the northeastern US and Canada and so she is able to supply detailed information about sites in these areas. Lice from the Îlot Hunt site in Quebec (see Bain 2001 in Books) were identified as were bedbugs. The Abiel School privy site in Boston, Massachusetts, dating from the mid-19th century, provided evidence of bedbugs as well. Bain ends by noting that, although these ectoparasites are becoming rarer, they were part of human history and so should not be overlooked.

Bain, A. (1998). A Seventeenth-Century Beetle Fauna from Colonial Boston. *Historical Archaeology*. 32,3 38-48. https://www.researchgate.net/publication/261135375_A_Seventeenth_-Century_Beetle_Fauna_from_Colonial_Boston.

This article provides a large scale archaeoentomological analysis of a seventeenth-century Colonial site, focusing on Coleopteran remains. The feature investigated was a privy discovered during the archaeological investigations preceding the Big Dig in Boston, Massachusetts. A total of 22 samples were taken for analysis from 8 subphases within the privy, producing over 2000 beetle specimens of which 64% were European or introduced species (Pg.38). Bain divided the beetles into groups according to their habitat requirements. The larger division into groups included three faunas: outdoor, privy, and house. On a smaller scale, Bain divides them into the pest fauna, the compost and dung fauna, the carrion fauna, the mold and fungus fauna, and the urban environmental fauna. In making these divisions, she is following the methods of British researchers Hall and Kenward (See elsewhere in this bibliography) who have attempted to identify groups of insects found in particular contexts both natural and human created.

The outdoor fauna contained some wood beetles, such as the scolytids, that indicate the presence of coniferous and deciduous trees. Bain believes some of the dung beetle species may belong to the outdoor group if there were herbivores on the site (Pg. 44). She finds the privy fauna harder to determine since many domestic sites might have provided suitable habitats for carrion feeders. For the privy, the three species Bain finds to be diagnostic are *Carpelimus obesus*, *Anytolus rugosus*, and *Cercyon terminatus*, which were found and are species that would have been attracted to fecal remains in the privy. She believes that, because of their placement in the privy, they could have overwintered and reproduced in the layer of fecal material (Pg. 44).

The house fauna includes ptinid beetles, as well as species that infest grain and vegetables. A pea weevil specimen indicates that garden peas were disposed of in the privy and two grain beetles, along with botanical evidence of cereal grain, indicate that spoiled grain was put there as well. Bain finds that the larger percentage of beetles were introduced species from England and Europe. Of the 24 species of introduced beetles, this privy is the earliest known record of 20 of them. (Pg. 45) Boston was a busy port with many ships going to and from Europe and other areas. As such, it was a central entry point for these biological invaders

Borojevic, K., Steiner Jr., W.E., Gerisch, R., Zazzaro, C.,Ward, C. (2010). Pests in an ancient Egyptian harbor. *Journal of Archaeological Science*. 37(10), 2449-2458. https://www.sciencedirect.com/science/article/pii/S030544031000155X.

On Egypt's Red Sea coast, the authors undertook a series of excavations spanning approximately a decade from 2001 to 2010. They worked on several rock cut caves at the site of Mersa/Wadi Gewasis, a site which had historically served as an area from which pharaohs of the Middle Kingdom has sent out ships on expeditions to the land of Punt in the early second millennium BC. (Pg. 2449). In one of these caves, Cave 3, was found plant and insect remains as well as wood and charcoal. The arid conditions of the site meant that preservation was exception and included such items as a piece of papyrus rope. This provides some very good information about this period and some of the challenges of transporting and storing grains. Wood and charcoal, including some complete deck planks reused in ancient times as ramps, had survived in sufficient shape to show evidence of woodworm.

In one section of Cave 3 was found an ancient spill of plaster that preserved what was under it at the time it occurred. Plant and insect remains were found under it along with a ceramic fragment that allowed the authors to date these remains securely to 3800 years ago. Spikelets from emmer wheat were among the plant remains found along with palm fruit and charred cereal grains. The plaster spill allowed the researchers to show that the insect remains were of the same age as the wheat pieces. The insects identified were several darkling beetles, *Trachyderma hispida*, and a grain pest *Tenebroides mauritanicus*. This is the first report of *T. hispida* from an archaeological food storage site in Egypt. (Pg. 2456) Some fly puparia and a mud wasp cocoon were also found but those could not be definitely dated to the same period as the beetles and wheat remains. The authors believe the stored grains had been meant for use by soldiers and mariners at the ancient harbor.

Buckland, P., Sadler, J.P. (1989). A biogeography of the Human Flea, *Pulex irritans* L. (Siphonaptera: Pulicidae). *Journal of Biogeography*. 16, 2, 115-120.

This article considers the human flea *Pulex irritans* and its presence on archaeological sites as well as its origins and the routes by which it reached Western Europe. While the travels of some ectoparasites are well known, for example the sheep louse *Damalinia ovis* came to Greenland with the Norse and their livestock, others are more speculative. (Pg. 115) Ectoparasites are linked to their hosts, which means that they can shed light on the archaeological record.

The authors note that although humans are from the Old World, the human flea seems to have come from the New World, more specifically Central and South America. They discuss various possibilities concerning the move from the New to the Old World and show that there were sufficient two way connections over the Bering land bridge and through Asia to allow the flea species to have moved after the Postglacial period. (Pg. 116) Another route, via the North Atlantic, is also postulated. This considers the possibility that the Norse brought the human flea to Europe, having contracted it from indigenous populations or through the fur trade. This would make it a late arrival in Europe.

The authors also discuss the animal host in the New World that allowed this flea to develop. While the peccary is suggested, the authors prefer the guinea pig as having the longest association with people in the New World and as an animal on which *Pulex irritans* thrives.

Chomko, S.A., Gilbert, B.M. (1991). Bone Refuse and Insect Remains: Their Potential for Temporal Resolution of the Archaeological Record. *American Antiquity*. 56(4), 680-686. https://www.jstor.org/stable/281545?seq=1.

The authors of this article describe the archaeological recovery of the contents of a pit from a site in north-central Wyoming, dating to the Late Prehistoric period, which ranges from approximately 1700 B.C. to 500 A.D. The irregularly shaped pit, sized 12.5 inches in diameter with a depth of 9 inches, was filled with fragmented bison bones. As this was a situation in which the pit was eroding out of a gully, speed was needed to save it and so the pit contents were encased in plaster and brought to the authors' lab for analysis.

The plaster was taken off with dental picks and the contents were studied. Based on the context and insect remains, the analysis revealed that a meal of bison had been cooked in a skin container, the remains of which were allowed to sit and congeal in the container for three weeks before being dumped upside down into the pit in which it was found. A stone slab was then used to seal it. This had occurred between the months of June and September.

This may seem a very specific scenario to be obtained from some insect remains but the authors do an excellent job of explaining each step of their analysis. The insect remains were composed of 200 fragments of Calliphorid pupal cases mixed with the lowest inch or so of bone at the base of the bone mass. These pupal casings are light and should be at the top if the bones had been left as they were found. Because the light cases, as well as some lighter fragments of bone, were at the bottom, the authors infer that the container had been dumped upside down into the pit. The pupal cases were all open and no adult flies or beetle remains were found, which, given the excellent preservation on the site, would have happened if they had been present. The open pupal cases provide the three-week time frame as well as the time of year. It also explains the absence of beetle remains if, as the authors suggest, the refuse had been buried and sealed before the material had become attractive to them. This reconstruction demonstrates the utility of entomological analysis in archaeology since the bone mass without insect remains would have provided much less information about the site usage.

Coope, G. R., & Osborne, P. J. (1968). Report on the coleopterous fauna of the Roman well at Barnsley Park, Gloucestershire. *Transactions of the Bristol and Gloucestershire Archaeological Society*, *86*(84), 7.

This article is included as one of the foundational works of archaeoentomology. Coope and Osborne developed a very workable method of processing archaeological soil samples for insect remains, one that is still used by archaeologists today. The technique involves water sieving followed by liquid paraffin (also called kerosene) flotation and sorting using a stereomicroscope and has yielded excellent results for many sites. These sites were rural and urban wells in Roman Britain and yielded large beetle assemblages.

King, G.A., Thomas, M., Gilbert, P., Willerslev, E., Collins, M.J., Kenward, H. (2009). Recovery of DNA from archaeological insect remains: first results, problems and potential. *Journal of Archaeological Science*. 36, 1179-1183. https://www.sciencedirect.com/science/article/pii/S0305440309000223.

This report covers the authors' efforts to recover useable ancient DNA from archaeological remains of the grain weevil, *Sitophilus granarius*, found on Roman and medieval sites. They also use modern grain weevils as a control group. They were able to extract and amplify mitochondrial DNA and hope to be able to do this on other sites.

There are three main reasons the authors feel that more DNA studies should be done. The first is that they wish to test the hypothesis that genetic consistency is similar to morphological consistency since the Quaternary period in insects. The second is to identify species and populations of insects in a greater degree of detail since many related species look very similar, especially when it is disarticulated remains that are found. The third reason is that DNA may indicate variation that provides clues to the past, such as migrations and recolonizations. The grain weevil was chosen because it is often found on British sites, especially waterlogged sites. The authors believe that this could be of use in a variety of other areas. Testing human head lice might show changes when populations moved, insects introduced at different times into settlements could indicate the intensity and location of trade, and even connections between insects and plants relocated by humans could be investigated.

Kislev, M.E., Hartmann, A., Galili, E. (2004). Archaeobotanical and archaeoentomological evidence from a well at Atlit-Yam indicates colder, more humid climate on the Israeli coast during the PPNC period. *Journal of Archaeological Science*. 31, 1301-1310. https://www.sciencedirect.com/science/article/pii/S0305440304000299.

Many very old archaeological sites may be found underwater. The rise of sea levels for about two thousand years after the beginning of the Holocene at around 10,000 years before the present means that Neolithic settlements around the Mediterranean were abandoned and new ones founded farther inland. The authors believe that Alit-Yam off the Israeli coast was flooded at that period from rising sea levels and, possibly, local tectonic movements. (Pg. 1301) The site, carbon dated to the first half of the 8th millennium before the present, is between 8 and 12 meters below sea level and may, at first glance, seem an unlikely place to find plant and insect remains.

The authors were fortunate to find a filled in well containing animal bones, flint tools, and pottery as well as plant and insect remains. The well seems to have been filled in with refuse by the inhabitants as the rising sea level made the water too salty to use. Marine archaeologists dredged the well and brought the material ashore in bags where it was sieved and the materials collected. The seeds of 90 different plant species were found and, being waterlogged, were well preserved. The insect remains consisted of 27 fragments of the granary weevil *Sitophilus granarius* that usually infests wheat and barley and is a very ancient stored products pest. This insect is no longer found in the area and, with the additional evidence of six plant species in the well that are also no longer in the area, the authors state that this indicates that the climate was colder and more humid when this settlement was in existence.

Osborne, P.J. (1983). An Insect Fauna form a Modern Cesspit and its Comparison with Probably Cesspit Assemblages from Archaeological Sites. *Journal of Archaeological Science*. 10, 453-463. https://www.sciencedirect.com/science/article/pii/0305440383900602.

This article is well known among archaeoentomologists as one in which a pressing question was answered. Can we tell from the insect assemblage if we have found a cesspit as compared to something more like a compost heap? Osborne looks at the insects found in medieval cesspits and those found in a comparatively modern one in Britain and finds some interesting comparisons. (See Smith 2013 below) He treated the modern material as if it were archaeological. All species from the modern cesspit are found in Britain today and many are recent introductions which would not be found in the medieval period. Osborne notes that two Ptinids are almost always found in cesspit sites as well as insects that are found in organic refuse. On the older sites, he almost always finds the cereal pests *Sitophilus granarius* and *Oryzaephilus surinamensis*, which, he states, he assumed had been dumped in when the grain had become too infested but he decided to test if these insects could have entered the cesspit after passing through the human digestive system.

He tested this by eating a stew into which 25 dead specimens of each of those species had been placed and then collecting and processing the “appropriate faecal mass” to see how many specimens came through and in what condition. (Pg. 460) He notes that he was able to eat the stew without noticing the beetles and suffered no problems later. The result was that at least 24 individuals of the granary weevil and at least 19 individuals of the saw toothed grain weevil were found. Some were intact and unchanged while others had become disarticulated and the numbers were arrived at by using a minimum number of individuals calculation. Osborne shows that the Oryzaephilus became disarticulated more easily that the Sitophilus with 23 of the second being complete but only 7 of the first. He realized that "not everything that descends the human oesophagus had been chewed into unrecognizability" (Pg. 461) This experiment is often cited not only for its rather interesting nature but also for making archaeologists reconsider how these two common pests might have entered the archaeological record.

Panagiotakopulu, E., Higham, T., Sarpaki, A., Buckland, P., Doumas, C. (2013). Ancient Pests: the season of the Santorini Minoan volcanic eruption and a date from insect chitin. *Naturwissenschaften*. DOI 10.1007/s00114-013-1068-8.

Archaeologists and historians have spent considerable time and effort on determining the date of the eruption of the Santorini volcano because it has strong implications for dating the ancient civilizations of the Aegean and Mediterranean. In this article, the authors describe how they recovered charred insect remains from several storage jars, or pithoi, in a house in the ancient city of Akrotiri, destroyed in the eruption. These insect remains, all of the bean weevil *Bruchus rufipes*, were used for C14 dating as well as to assess the likely season of the eruption.

The remains of the beans and weevils were handled in a different manner than is usually the case for archaeological specimens. The charring had made them very fragile and so a flotation system was not used but rather careful dry sieving. Bruchinae have been found on other ancient sites, including Troy and Pompeii. (Pg. 4) Despite the fragility, the weevils on this site were well preserved enough to make identification possible. The C14 date is between 1744 and 1538 BC, which matches well with other dates that had been estimated.

The authors argue that the season of the eruption was summer because it had taken place in one charring event soon after the beans were placed in storage providing a true death assemblage. They note that, even allowing for time between picking and storing, it's likely that the eruption event occurred in early to mid-summer, sometime in June or early July.

Panagiotakopulu, E., Buckland, P., Kemp, B.J. (2010). Underneath Ranefer's floors- urban environments on the desert edge. *Journal of Archaeological Sciences*. 37, 474-481. https://www.sciencedirect.com/science/article/pii/S0305440309003549.

The ancient city of Tell el Amarna, which was in existence for only around 25 years after its founding by heretic pharaoh Akhenaten in 1353 BC, has yielded a considerable amount of information about all aspects of life in ancient Egypt including archaeoentomological data. This article focuses on one household from the Main City. The Worker's Village is also on this site but the Main City has wealthier houses than does the Worker's Village, which housed the men building Akhenaten's tomb. (See Panagiotakopulu and Buckland 1999 below)

Ra-nefer was chief charioteer and overseer of the stables for the pharaoh and so had status within the community. His house has two clear phases, one of which was likely before his occupation and the second during it. Although the house had been excavated in part, the authors were able to find sealed mud brick floor deposits that provided the first insect evidence on this site for living conditions and pest infestations in a city of this period.

Excavated material was dry sieved through a 5 millimeter mesh sieve and then a 300 micrometer sieve, sorted using a stereomicroscope, and the insect remains identified. The dry conditions of the desert allowed for good preservation although there was considerable fragmentation. Beetle and fly faunas were recovered. These showed that the house, between the occupations and possible after final abandonment, were packed with domestic waste including cereal remains and possible meat or offal. *Sitophilus granarius* as did the flour beetle *Tribolium castaneum*, which can attack milled or damaged grain. The small eyed flour beetle, *Palorus ratzeburgii*, was found and it is known to eat moldy or already infested grains.

Dermestid and Tenebrionid beetles were found in the deposits as well as fly puparia, specifically Sarcophgids, in a corner that may have contained rotted meat or offal. Poor conditions seem to have existed even in the wealthier Main City and, as the authors note, the overall impression is that this house, its pests and garbage, was part of an early urban environment. (Pg. 480)

Panagiotakopulu, E. (2004). Dipterous remains and archaeological interpretation. *Journal of Archaeological Science*. 31, 1675-1684. https://www.sciencedirect.com/science/article/pii/S0305440304000780.

This paper is an overview of the uses of Diptera in archaeological investigations. The author believes that, while beetles are well represented in archaeology, flies have not been used enough and can provide information on many aspects of life, disease, and death in the past. Part of this may be the difficulty of recovering flies from the archaeological record, being often limited to empty pupal cases which often cannot be identified to species. The author also notes that there needs to be more research into the larval environments of relevant fly species in order to help with reconstruction.

The method used for recovery of fly remains is that set out by Coope and Osborne in 1968, unless the material is very dry in which case sieving is recommended. (See Coope and Osborne 1968 and Borojevic et al 2010 above) The recovered pupal cases are treated in a manner similar to recovery on forensic scenes and, in the same way, taphonomic issues must be considered. The initial environment must be understood as well as where the samples are taken from and the changes that may have taken place on the site between the time it was created and the present. For all the difficulties, however, the author sees fly evidence as an important way to reconstruct the past in detail since flies are very much connected to their environments as well as being sensitive to change. (Pg. 1682) They can reveal data concerning trade, paleoecology, disease, and death.

Panagiotakopulu, E., Buckland, P. (1999). *Cimex lectularius* L., the common bed bug from Pharaonic Egypt. *Antiquity*. 73, 908-11. https://doi.org/10.1017/S0003598X00065674

Archaeological materials from ancient Egypt are often found in excellent shape because the conditions are so helpful for preservation. This has been seen on the ancient site of Tell el Amarna south of Cairo. (See Panagiotakopulu, Buckland, Kemp 2010 above) The site was a worker's village used by those building Akhenaten's tomb during the period 1352 to 1336 BC. Insects recovered from the site included human fleas, stored product pests, and, the subject of this brief paper, *Cimex lectularius*. This provides the earliest record of humans and bedbugs on the same site. (Pg. 909) The bed bug was well known in the classical world and is referred to in plays by Aristophanes and Plautus and in scientific works written by Pliny and Dioscorides. (Pg. 909) The last two named even thought that bed bugs could be ground up and used as medicines. The authors discuss the origins of the bed bug and, after considering pigeons, find that the primary host was likely bats and the move to humans was made when people lived in caves. It seems to have been carried around and spread in human clothing and bedding.

Panagiotakopulu, E., Buckland, P., Day, P.M. (1995). Natural Insecticides and Insect Repellents in Antiquity: A Review of the Evidence. *Journal of Archaeological Science*. 22, 705-710. https://www.eeo.ed.ac.uk/globalchange/group5b/QuatEnt/Panagiotakopuluetal1995.pdf.

The authors of this article use examples of insecticides and insect repellants from several ancient sites to understand the history of pests and the war against them in the ancient world. In documentary sources, they have found evidence going back as far as the Ebers Papyrus dating from 1600 BC in Egypt, which states that natron should be used to drive out fleas from a house, that oils should be used to keep gnats away, and burnt dung is effective in discouraging grain weevils from infesting grain in a barn. Natron was also used during mummification and may have helped keep insects away from mummies although not entirely, since some flies and hide beetles have been recorded. (Pg. 706) Sulphur was used during the new Kingdom as a fumigant.

Classical works, such as those by Aristotle, record that olive oil was used as an insecticide and Pliny suggests ashes, wormwood, and charcoal along with cow dung mixed with water. Stored crops were protected with chalks, ashes, and earths generally used as desiccants. Many different plants, for example coriander, were used in various ways as insect repellants but also as perfume and food so it can be challenging to determine what is being used from the documentary record.

The archaeological record helps to work out some of the difficulties of interpretation. Deep pits have been found on multiple ancient sites that seem to have been used for storing grain. Any time large amounts of food and grain was stored, insects were going to be there and the communities had to figure out how to avoid losses. Some of the efforts made included sealing containers with clay, as found on Late Bronze Age Santorini in the Aegean, On ancient Cyprus, potters sealed pithoi, clay storage jars, with hot pitch and turpentine. (Pg. 707) In the classical world, plants, such as laurel, have been found as deliberate additions to stored grains, and grain containers show evidence of first being used to store salted fish, which is recommended by ancient sources as a repellant. It can, however, be difficult to determine what items are present for purposes of insect repelling and what are there for other reasons. In the ancient Egyptian town of Tell el Amarna, the interpretation was more secure, as ash was noted around the bases of ancient querns and was almost certainly a defense against insects since fine mineral powders can cause dehydration by scratching the exoskeleton.

Smith, D.N. (2013). Defining an indicator package to allow identification of 'cesspits' in the archaeological record. *Journal of Archaeological Science*. 40, 526-543. https://www.sciencedirect.com/science/article/pii/S0305440312002531.

Smith in this article is attempting to assemble a group of insect species that indicate that an archaeological feature is a cesspit rather than another type of feature. (See Osborne 1983 above) To do this, he has surveyed 49 cesspit features from eleven archaeological sites in England which date to between the 11th century and the late 16th century. The data set he uses contains 17,479 individuals from 394 taxa, all are either adult beetles or fly puparia. (Pg. 527) Using this data, Smith feels he has successfully identified a distinct indicator group that are associated with cesspits. These include several fly species, Sepsis sp. along with Hydrotaea sp., and Psychodid drain flies. *Fannia scalaris* and the rat tailed maggot *Eristalis tenax* are both prominent in the group. Smith makes the interesting suggestion that the medieval human diet, heavy on vegetables and bran, would produce an environment more similar to herbivore dung than would be found in a modern sewer given the modern diet. (Pg. 533)

The beetles present show a mix of fluid and semifluid environments that dry over time or have drier areas. Rove beetles are prominent and are species that are associated with damp and rotted materials. Two Ptinid beetles, also mentioned by Osborne above, were found as well as species associated with the wooden outbuildings built over the pits for use. Stored product pests including the expected *Sitophilus granarius* and *Oryzaephilus surinamensis* are often found as well, having entered the cesspit in discarded spoiled grain or through humans as Osborne has shown. In addition to insect evidence, Smith identifies other materials, such as plant seeds, eggs of human parasites, small fish bones, and small pieces of moss or cloth used as toilet paper as being part of the indicator package.

Smith, D.N., Kenward, H..(2012). "'Well, Sextus, What Can We Do With This?' The disposal and use of insect-infested grain in Roman Britain." *Environmental Archaeology*. Vol. 17: 141-150. https://www.tandfonline.com/doi/full/10.1179/1461410312Z.00000000012.

This amusingly titled article addresses the question of how Coleopteran pests of stored food products entered the archaeological record during the Roman period. The authors find considerable evidence that insects were in grain even at the point of human consumption. A high level of infestation would have rendered the grain obviously inedible but at low enough levels, people may have eaten it without realizing, or perhaps caring, that anything was amiss. This topic is also covered in another article in this bibliography, although a different investigative route in used. (See Osbourne 1983).

The authors note that back filled wells are very common on sites of Roman era forts. The forts they discuss are largely around York and London, although other sites are considered. The wells seem to have been perceived to be a good place to dispose of not only infested grain but old rushes used for flooring, stable waste, and other domestic refuse. One problem is that grain as such does not preserve well in waterlogged soils and so it is fragments of bran that are usually found rather than grain. Grain eating insects, however, do preserve well and so this differential preservation is often observed (Pg. 145).

Grain pest faunas should, the authors postulate, have distinct characteristics that allow archaeologists to identify them. The deposits should show evidence of both primary grain pests, such as *Sitophilus granarius*, and secondary pests and scavengers, such as *Oryzaephilus surinamensis* and *Laemophloeus ferruginensis*, showing that the infestation was prolonged (Pg. 145). Other species of insect, such as beetles that feed on mold would show that the grain had become inedible. The authors state that the above mentioned pests should be at 50% or more of the total insect assemblage found, which would show large amounts of grain being dumped. Archaeological evidence from these sites indicates that the two primary ways of disposing of such infected grain would be burying, such as in the wells or in waste pits and burning. Charred insect remains along with burnt grain have been found indicating how this disposal method was carried out.

Funerary Archaeoentomology

Benelli, G., Canale, A., Raspi, A., Fornaciari, G. (2014). The death scenario of an Italian Renaissance princess can shed light on a zoological dilemma: did the black soldier fly reach Europe with Columbus? *Journal of Archaeological Science*. 49, 203-205. https://www.sciencedirect.com/science/article/pii/S0305440314001939,

The authors of this article show that the black soldier fly, *Hermetia illucens*, was likely present in Europe earlier than had been previously thought. In 1984, the body of a Renaissan. ce princess, Isabella d'Aragona, who had died in Naples at the age of 54 in 1524, was exhumed for study and a sample was taken of the insect remains associated with her. This sample contained two body parts of the larva of the black soldier fly. The parts were the head and the first thoracic segment.

Prior to this study, the belief was that the black soldier fly had come to Europe in the early 1900s but Isabella had died four centuries before that, around 30 years after Columbus had returned from North America. (Pg. 205) Many ships had come and gone from Naples to the New World and so the fly could have been a stow away on one or more of these voyages and so arrived in Italy. Another proposed solution is that, despite using a scanning electron microscope to identify the species, the identification is incorrect and the larva is that of a related or cryptic species. The authors suggest that follow up research involving a molecular phylogenetic analysis of this species and related species might help solve this problem.

Fornaciari, G., Giuffra, V., Marinozzi,S., Picchi, M.S., Masetti, M. (2009). ""Royal" pediculosis in Renaissance Italy: lice in the mummy of the King of Naples Ferdinand II of Aragon (1467-1496)." *Mem Inst Oswaldo Cruz*, Vol. 104(4): 671-672. July. http://www.scielo.br/pdf/mioc/v104n4/26.pdf.

This article is quite brief, at only one page. The authors consider louse infestation in humans from a historical and archaeological perspective. The specific case set forth in this article is that of Ferdinand II, King of Naples, who lived from 1467 to 1496. His mummy, housed in the Sacristy of the Basilica of San Domenico Maggiore in Naples, had not preserved well but hair from the head and pubic areas was sampled. Evidence of *Pediculus capitis*, head lice, and *Pthirus pubis*, pubic lice, were found on the hair strands along with evidence of the mercury based treatments used in medicines and hair products at the time.

Gilbert, B.M. Bass, W.M. (1967). Seasonal Dating of Burials from the Presence of Fly Pupae. *American Antiquity*, Vol. 32, No. 4, pp. 534-535. https://www.jstor.org/stable/2694081?seq=1.

It was difficult to decide where this piece belonged. It is more in the nature of a letter to the editor of *American Antiquity* than it is any kind of article. It also dates from very early in the study of insect remains when the idea of a separate funerary archaeoentomology denomination would not yet have been recognized. It does, however, discuss the nature of insect remains found in Arikara burials and so found a place here. The letter describes the efforts to determine the season of certain Arikara burials burials by using the pupal cases of Dipterans preserved in the skulls, abdomens, and buffalo robes. The excavation took place in Corson County, South Dakota on then Leavenworth site, dating from 1802 to 1832. This site was visited by Lewis and Clark in 1804. Calliphorid and Sarcaphogagid pupal cases were found in large numbers and it was determined that the burials had been performed during their active period, which in South Dakota, is between late March and mid-October. The main thrust of the letter is that archaeologists should not discard insect evidence since it can be a source of additional information concerning a population. This warning was needed at this point in the development of archaeological technique as smaller evidence such as seeds, animal bones and insect evidence was frequently overlooked in favor of larger artifacts.

Giordani, G., Tuccia, F., Floris, I., Vanin, S. (2018). First Record of *Phormia regina* (Meigen, 1826) (Diptera: Calliphoridae) from mummies at the Sant'Antonio Abate Cathedral of Castelsardo, Sardinia, Italy. PeerJ 6:4176; DOI 10.7717/peerj.4176.

This article is an excellent example of how funerary archaeoentomology can provide information about the past that is otherwise unavailable. The insect remains that the authors have found include a species, *Phormia regina* or the black blow fly, that no longer exists on the island of Sardinia. In 2011, excavations began at the Sant'Antonio Abate Cathedral on the northern coast of Sardinia. This building dates to between 1597 and 1606, although bodies were put in the crypt until the early 1800s.

Other than pupal cases from the black blow fly, there were puparia from *Calliphora vicina*, a *Sarcophaga* species, and several muscids of the species *Hydrotaea capensis*. A few Lepidopteran cocoons from the family Tineidae were also found. The authors assess the insect evidence and believe that it shows an initial exposure of the body in the warm season followed by a secondary colonization when it became cooler, probably within the crypt. The Tineids were likely attracted to the dried tissues of the corpse later on. The authors also hope that additional research will help understand the reasons that P. regina disappeared from Sardinia over time.

The authors also provide a very good and succinct definition of funerary archaeoentomology as "the application of the principles and techniques used in forensic entomology to human and animal remains, tombs, mummies, and other burials of archaeological interest." (Pg.1-2)

Huchet, J-B., Greenberg, B. (2010). Flies, Mochicas, and burial practices: a case study from Huaca de la Luna, Peru. *Journal of Archaeological Science*. 37, 2846-2856. https://www.sciencedirect.com/science/article/pii/S0305440310002220.

This article discusses a case study from the Huacas de Moche site in northern Peru. The Moche culture was active in the area from around 100 AD to 750 AD. Fifty-seven graves were excavated, many of which contained insect remains. One particular grave, that of a young male, was analyzed and described in detail. This grave contained cinnabar pigment, five pieces of copper in the mouth area, ceramic offering vessels, and over 200 fly puparia. The authors subjected the puparia to analysis with the scanning electron microscope and were able to say that they belonged to the Calliphoridae, Sarcophagidea, and Muscidae families. Hide beetle remains were found and, although no parasitoid wasps were recovered, exit holes in the Sarcophagidae pupal cases indicated that they had been parasitized by wasps belonging to the Pteromalidae.

The authors also provide a description of the association between flies and death in many ancient cultures. Documents and jewelry from Mesopotamia and Babylon show an awareness of the connection of flies and death. The ancient Egyptians, focused on preserving the body, did everything they could to avoid letting flies colonize a corpse, embalming and mummifying them and including written prayers with the body. (Pg. 2852) The insect evidence from this site, however, indicates that the Moche viewed flies very differently.

The large number of pupal cases of various flies and the presence of parasitoids and hide beetles indicates an interval of at least 3 to 4 weeks during which the body was deliberately exposed to insects. The authors have determined this by estimating the life cycles of the flies and parasitoids and noting that the larval development was completed in place. The Moche appear to have believed that the spirit would be carried with the flies from the body and complete the cycle.

Huchet, J-B, Pereira, G., Gomy, Y., Philips, K.T., Alatorre-Bracamontes, C.E., Vasquez-Bolanos, M., Mansilla, J. (2013). Archaeoentomological study of a pre-Columbian funerary bundle (mortuary cave of Candelaria, Cohuila, Mexico). *Annales de la Sociétéentomologique de France*. 49,3 277-290.

The excavation of the Candelaria funerary cave in central Mexico has yielded many human funerary bundles along with very well preserved objects including mats, wooden tools, arrows, and baskets. These burials have been C14 dated to between 940 and 1020 AD and were deposited in the cave by hunter-gatherers. Of three intact bundles, the bundle containing a one-year-old child was analyzed for entomological remains. The insects were recovered from parts of the bundle that were damaged and the residues were processed by dry sieving, examined using a stereomicroscope, and then mounted on cards (Pg. 280).

The insect remains recovered were largely Diptera and Coleoptera although, oddly, no Calliphorid flies were recovered. Musicidae, Fanniidae, and Sarcophagidae are the three families found. Dermestidae, Staphylinidae, and Histeridae are the beetles that were found. Also present were some ants, Hymenoptera, of a fungus growing species.

The authors believe that the lack of Calliphorid remains means that either the child's body was exposed for only a short time or the season of death was during a cold period. The other flies are thought to have arrived later and were able to oviposit since the bodies, though in a cave, were only a few meters from the entrance. The presence and biology of the muscid *Synthesiomyia nudiseta,* specifically the tendency of the larvae to secrete a sticky substance to cover itself with debris, allowed researchers to find fragments of dermestid larval skins stuck to the cocoons. They used this to hypothesize that the bundle had been rehydrated in the few weeks following death. They offer two options for why this might have happened.

The corpse might have been exposed in open air before final placement in the cave but the likelihood is that at least some Calliphorids would have been found. The other possibility is that the hunter gatherers had temporarily or periodically removed the bundles out of the cave for periods, possibly for funeral rituals, when the corpse would no longer be attractive to early arriving flies and thus allowed the late colonization by *S. nudiseta.* (Pg. 287)

Huchet, J-B. (2014). Insect Remains and Their Traces: Relevant Fossil Witnesses In The Reconstruction of Past Funerary Practices. *Anthropologie.* LII/3, 329-346.

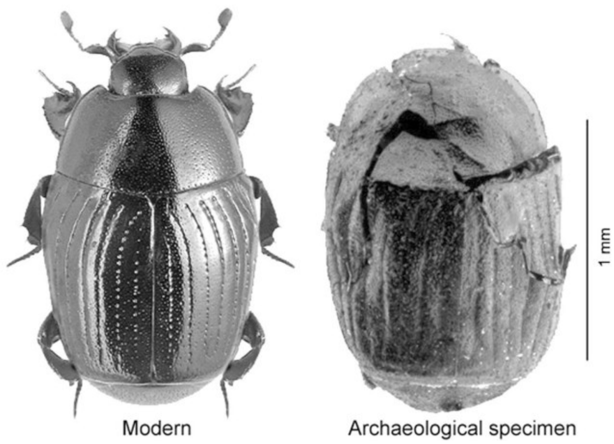

Figure 3. Comparison of a modern Coleopteran, *Carcinops pumilio*, with an archaeological specimen of the same genus, *Carcinops tenella*. Huchet (2014: 331).

The photograph above (Figure 3) is a good representation of the difference between identifying a modern insect specimen and identifying one that has been recovered from an archaeological context. In some cases, the author notes, when it is not possible to find the insects themselves it may still be possible to find traces or imprints on other materials that can provide information about the insects that were present. This approach is known as ichnology. This article describes the combination of archaeoentomological and forensic analyses that has come to be known as funerary archaeoentomology and argues that it can provide insight into past burial practices, taphonomy, grave disturbances, and mummification processes.

Huchet divides the arrival of insect remains in funerary contexts into two modes of colonization. The first is pre-depositional and this includes the insects that arrive on cadavers and carcasses soon after death, especially if a body is exposed for any length of time. The second is post-depositional and this is an underground phase and often includes muscid and phorid flies. He notes that it is imperative to collect puparia and record their number, location, species, and whether they are closed or open. A large number of puparia should be taken into consideration since this would indicate that flies had easy access to a body and could help to determine the season of death and the time during which the body may have been exposed. Whether the puparia are open or closed can tell researchers if the complete life cycle occurred before burial.

The absence of expected insects provides information as well. Huchet uses the example of the bog body known as the Lindow Man which had a large amount of well-preserved insects with it that indicated the surrounding environment but none that colonize the dead, indicating that the body was sunk into the bog soon after death.

A large section of this article is devoted to ichnology, as mentioned above. Huchet describes traces and imprints of insects corroded into metal, mineralized onto ceramics, imprinted onto ancient pottery. He also provides information and illustrations concerning insect-created lesions on bones. Termites have mimicked syphilitic lesions on skulls and dermestid pupal chambers on leg bones have puzzled archaeologists. Wasps and burrowing bees can cause lesions on bones when they use them for nests. These can also cause confusion by their resemblance to bone problems such as osteomyelitis, periostitis, or syphilis. Huchet sees these studies as innovative and increasingly important.

Huchet, J-B., Le Mort, F., Rabinovich, R., Blau, S., Coqueugniot, H., Arensburg, B. (2013). Identification of dermestid pupal chambers on Southern Levant human bones: inference for reconstruction of Middle Bronze Age mortuary practices. *Journal of Archaeological Science*. 40, 10, 3793-3803. https://www.sciencedirect.com/science/article/pii/S0305440313001532.

This article considers how the taphonomic modification of human bones by insects might be interpreted. It is known that bones in archaeological contexts may provide information about disease, trauma, and cultural behavior but the authors show that insect damage on human bones may help inform archaeologists about funerary activities, even when other insect remains were absent. Two Middle Bronze Age sites in the Southern Levant area provided human bones that showed bored holes that were interpreted as dermestid pupal chambers. The authors considered disease as a possible cause but the regularity and distribution of the holes were found to be consistent with modern dermestid pupal chambers constructed by larvae in wood (Pg. 3795).

In contrast to most of the other studies in this bibliography, no insect remains were found and it was necessary to use the traces in the bones to determine that the insects had been present. These traces allowed a reconstruction of the funerary practices of the Middle Bronze Age in this area.

Nystrom, K.C., Goff, A., Lee Goff, M. (2005). Mortuary Behaviour Reconstruction through Palaeoentomology: A Case Study from Chachapoya, Peru. *International Journal of Osteoarchaeology*. 15, 3, 175-185. https://onlinelibrary.wiley.com/doi/10.1002/oa.767.

The authors describe a Peruvian mummy bundle, from the Chachapoya culture dated to between 800 and 1532 AD, and the insect evidence they used to understand how this individual died and was wrapped. The mummy is that of an adult female wrapped in a tightly flexed position with considerable soft tissue remaining on the head and body. The face, markedly swollen looking on one side, is perforated with many insect holes and insect casings were found in the skin and brain tissue. The skull shows two incidents of blunt force trauma and at least two trepanations. Insect remains were recovered from the brain tissue and identified. Empty Calliphorid puparia, adult parasitoid wasps from the family Diapriidae, and the larval casings of Tineid moths.

Based on the evidence from the injuries and the insect remains, the authors speculate that this person survived the injuries and surgery for a short amount of time but long enough for myiasis to occur. The parasitoids arrived to parasitize the Dipteran larvae. The finding of one adult fly of Diapriidae means that the cloth wrappings were applied just prior to its emergence, trapping it. (Pg. 182) Based on the small amount of healing of the bone, the authors estimate the individual died around 9 or 10 days after the head injuries with insect colonization occurring before death and the wrapping a day or so after death.

Panagiotakopulu, E., Buckland, P. (2012). Forensic archaeoentomology- An insect fauna from a burial in York Minster. *Forensic Science International*. 221, 125-130. https://www.sciencedirect.com/science/article/pii/S0379073812001910.

The authors examined an English medieval burial for insect remains and compared them to similar evidence from other medieval burials. In December of 1315, Archbishop Greenfield was buried beneath the floor of York Minster in a lead coffin that had been placed within a stone sarcophagus. He was an important person who had served as chancellor to Edward I and then become Archbishop of York, which explains his prominent burial place in a canopied stone sarcophagus in the north transept of York Minster. (Pg.126) In the late 1960s and early 70s, civil engineering work was carried out to stabilize the tower and, in so doing, some stone sarcophagi were disturbed allowing for some archaeological recovery. A sample of material from the coffin along with a portion of the skull and some black material were recovered.

From this material, the authors recovered insect remains numbering 81 specimens among which were Coleoptera, Diptera, and some indeterminate pupal cases. The dominant beetle, at 25 specimens, is *Rhizophagus parallelocollis* usually found in graveyards and so often called the graveyard beetle or coffin beetle. The rove beetle Quedius mesomelinus, at 16 specimens, was also present probably feeding on maggots as it is predacious. Other beetles were present indicating rotten wood and molds, both of which would be likely in a burial environment. There were some fragmented pupal cases of Diptera, specifically phorids, which can be related to dead bodies.

The authors posit that this fauna is a subterranean assemblage that was a post-burial development. They feel that the Archbishop would have been buried soon after death and the winter cold would have precluded immediate decomposition. The lead coffin probably did not keep the insects away from the corpse and so what the authors refer to as a “hypogean biota” developed on the corpse without any outer indications.

Battlefield Archaeoentomology

Raoult, D., Dutour, O., Houhamdi, L., Janauskas, R., Fournier, P-E., Argadna, Y., …Aboudharam, G. (2006). Evidence for Louse-Transmitted Diseases in Soldiers of Napoleon's Grand Army in Vilnius. *The Journal of Infectious Diseases*. 193,1, 112-20. https://academic.oup.com/jid/article/193/1/112/863741.

The retreat of Napoleon's Grand Army from Russia in 1812 was a disaster for the soldiers trying to survive the arduous march while hungry and cold. In addition, the paper shows, they were dying of louse-borne trench fever and epidemic typhus.

In 2001, mass graves were found in the northern suburbs of Vilnius in Lithuania. The graves contained between 2000 and 300 corpses, all buried very close together and so indicating that they had been buried at the same time. (Pg. 112) At least one third of these men died of louse-borne infectious diseases. (See photo below)

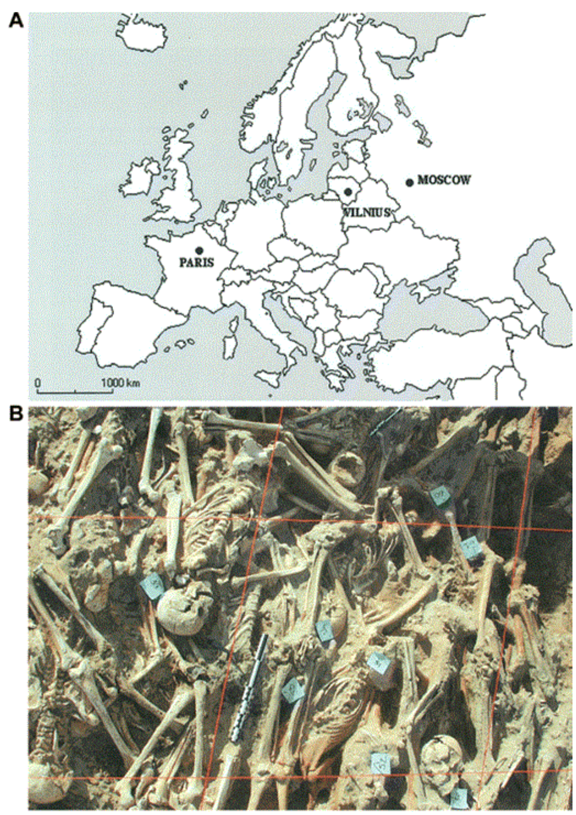

Figure 4.

The authors were able to find segments of five lice in amongst the remains in a grave containing fragments of uniforms. These lice were tested for DNA and three were found to contain Bartonella quintana, which causes trench fever. In addition, the tooth pulp of 35 soldiers was tested similarly and seven of the soldiers had DNA showing trench fever while three others had

had epidemic typhus. In light of these findings, the authors speculate that louse-borne diseases may have been a major factor in the French defeat in Russia and subsequent retreat. (Pg. 112)

Vanin, S., Turchetto, M., Galassi, A., Cattaneo, C. (2009). Forensic Entomology and the Archaeology of War. *Journal of Conflict Archaeology,* 5,1, 127-139. https://www.tandfonline.com/doi/pdf/10.1163/157407709X12634580640371?redirect=1.

In this paper, entomological techniques are used in conjunction with other analyses to determine the identity of soldiers whose remains were found in north-eastern Italy. The time period is that of the First World War. The main question that the authors hope the insect evidence will answer is that of season of death as well as if and when the corpses were buried (pg. 128).

The skeleton was found in the Italian Alps at an altitude of 1000 meters, still wearing a helmet but without other indications of identity. Skeletal analysis showed the soldier was a short statured male who was in his late teens when shrapnel from a shell penetrated his helmet, ending his life (pg. 127). Discovery of these bodies is not uncommon in this area, since many more people died than were ever recovered or identified (pg. 131).

In the soldier's ammunition pouch were found puparia and cuticle fragments from *Phormia regina*, *Protophormia terranovae*, and *Fannia cannicularis* suggesting colonization in early summer (pg. 127).

From records of WWI, it is known that battles were fought in this area of the Alps from Spring 1916 until the Autumn of 1918 (pg. 135). The authors make the point that even simply knowing the season of death could help narrow the field of search in determining identity and allowing, finally, burial under the soldier's name.

Archaeoentomology: Chapters in books

Buckland P.I., Buckland P.C., Olsson F. (2014) Paleoentomology: Insects and Other Arthropods in Environmental Archaeology. In: Smith C. (eds) *Encyclopedia of Global Archaeology*. Springer, New York, NY. https://link.springer.com/referencework/10.1007/978-1-4419-0465-2.

This chapter, within a larger work on global archaeology, is an excellent overview of Paleo- and archaeoentomology. The authors include the historical background of the field ranging from the foundational work in the late 1950s and the development of good techniques for extracting insect remains to the development of insect assemblages for different types of sites and warnings about their limitations to the modern DNA testing and use of database management systems.

They also address problems with identification of insects in an archaeological context. The available identification keys often are based on insect parts that so not survive in the archaeological record, such as antennal segments, tarsal structures, and genitals. Some more recent work has helped to alleviate this, however. It is also stressed that the best results come about when there is collaboration among field archaeologists and the specialists involved, something the authors do not feel happens often.

The use of insects in archaeology is covered, many of the works cited are in this bibliography, as are the many ways in which insect evidence can help to indicate past environments and habitats. Climate change is another topic that this chapter addresses and discusses the use of Buckland's BugsCEP software for answering these questions. (See Buckland 2000 under Webpages below)

The chapter finishes with a look at future directions for this field. The authors hope that insect-based approaches will be used more in the future as archaeologists learn that they can provide a considerable amount of information. They feel that DNA based studies can be of use although they should not replace morphological identification. A combination of these approaches is the best way to extract as much data as possible from insect evidence.

Buckland, P. (2002). Insect fauna from within the cranium of skeleton 570. In *Excavations at the Glasgow Cathedral 1988- 1997*. Driscoll, S. (ed) Routledge, Taylor and Frances Group, London and New York.

The excavations of Glasgow Cathedral were undertaken in order to locate the first, 12th-century, cathedral and provide information about the changes over time. Researchers located early burials dating from the 7th or 8th centuries onward to provide insights into medieval and post-medieval populations and burials in Glasgow. (Pg. 19)

The archaeoentomology piece is brief, occupying only a portion of the chapter in which the human remains were discussed. Within the cranium of one skeleton Buckland found 54 coffin beetles, of the species *Rhizophagus parallelocollis*. Buckland notes that this beetle has been found on exhumed corpses and archaeological bodies in the past going as far back as the Roman period. There has been some controversy concerning the food source that attracts these beetles. Suggestions have ranged from fungus growing on the wood of the coffin, to the body itself, to predation on either the larvae or adults of small phorid flies such as coffin flies. Buckland reviews these opinions but is unable to confidently provide an answer, although two sealed medieval burials found to have breeding populations of this beetle suggest that at least one of the proposed answers is correct. (See also Girling, 1981, in Unpublished Works)

Kislev, M. E. (1991). Archaeobotany and storage archaeoentomology. In *New Light on Ancient Farming.* Renfrew, J. Ed. University Press, Edinburgh. 121-136. https://www.researchgate.net/publication/283349192_Archaeobotany_and_storage_archaeoentomology.

The book in which this chapter appears considers a variety of topics related to ancient farming and its development, especially in the Near East. Kislev's contribution is this chapter on using archaeobotany and archaeoentomology to try to determine if post-harvest agricultural loss was lower or higher in the ancient world than it is now. He estimates the modern losses at between 10 and 20%. Another question he asks is what the major pests were in antiquity and if any are the same as those found today. He recognizes 11 beetles and 2 moths as major pests today, and of those, he identifies 7 beetles as major pests documented in the archaeological record. In order for him to consider the insect a major pest, it must cause severe damage to stored food items, spread easily to new stored foods, and adapt easily to changing conditions. On his list of ancient pests is one that he believes has been a major pest since the development of farming and that is *Sitophilus granarius*.

His conclusion is that losses to insects were lower in ancient times than they are now because there were fewer pest insects and they had not yet had time to spread to human storage sites. Kislev thinks the rates increased during the Roman era when storage pests began to spread. This type of spread would have continued as trade routes became longer and new insect pests came to Europe from the Americas, Africa, and Asia over the centuries. He notes that archaeobotanists are needed to identify damaged grains and other foods in the archaeological record and entomologists who understand the issues of storage to identify the insects. Some other questions he hopes to answer involve when pests from different continents spread to other places and how the range of pests seen today developed over time.

Vanin, S., Huchet, J-B. (2017). Forensic Entomology and Funerary Archaeoentomology. In *Taphonomy of Human Remains: Forensic Analysis of the Dead and Depositional Environments.* Schotsmans, E., Marquez-Grant, N., and Forbes, S.L. (eds) John Wiley and Sons Lt. Oxford. ISBN10: 1118953320.

This chapter is divided into roughly two halves. The first covers forensic entomology as it is used on modern bodies and for food storage issues. The second describes and addresses the problems specific to funerary archaeoentomology. Vanin and Huchet are the two main practitioners of funerary archaeoentomology today and are well positioned to define the subdiscipline. They discuss the properties of certain insects that can help preserve them under the right conditions. Chitin, a component in the insect exoskeleton, is chemically stable and resistant to decay and when the environmental conditions are good, will allow preservation of insect remains. Beetle exoskeletons and fly puparia are the main parts found in archaeological burials. (Pg. 169)

The authors are careful to remind their readers that insect death assemblages from archaeological or paleoenvironmental contexts are not perfect representations of the community when it was living. As they put it, “not all insect orders display the same aptitude for preservation.” (Pg. 171) Still, there are some pieces of information that may be gleaned from the remains such as season of death, condition of the body, the environment, and accessibility of the body. For these reasons, they recommend researchers pay particular attention not just to the type of insects present on a site but also to the location of the insect remains. Absence of expected insect remains must be noted as well since that can provide information as well. Cold weather at the time of death, quick burial and other conditions may have contributed to the lack of insects.

The article ends on a cautionary note. There are several kinds of modern insects whose activities can damage archaeological materials and human remains. The results of feeding, burrowing, and nesting can trick a researcher into seeing what is not there. Ants can produce lesions on the skin of a mummified body, termites are notorious for causing physical damage, and nesting wild bees can burrow into bones. These changes can be mistaken for diseases and injuries that occurred to the person before or at death and are known as pseudopathologies. The authors conclude by noting that insect evidence, when properly collected and analyzed, are an important archaeological tool but it is equally important to remember that their presence can cause changes that must be kept in mind.

Archaeoentomology: Other media

Webpages

Frederick, C., Black, S. Ancient Southwest Texas Project: Texas State University. 2014. Archaeoentomology?https://aswtproject.wordpress.com/2014/03/31/archaeoentomology/comment-page-1/ Accessed December 19, 2019.

Texas State University has undertaken excavations at the Eagle Nest Canyon rockshelters, located near Langtry Texas, and the excavators were interested in having soil samples from several contexts analyzed for entomological information. They invited Dr. Eva Panagiotakopulu (See above articles) to visit from her home base at the University of Edinburgh to sieve and scan these samples and then identify any insects found. Other organic materials at the site have preserved very well and this raises hopes that insect evidence will be available and identifiable. This is a very preliminary report and no results have been shared online. It is, however, very encouraging to read about archaeoentomology being used on an active archaeological site.

Buckland, P.C. 2000. The Bugs Coleopteran Ecology Package or BUGSCEP. http://www.bugscep.com/phil/publications/buckland2000_cdpaper.pdf. Accessed December 19, 2019.

Phil Buckland, in this online work, describes and provides instructions for using his BUGS Database Management System. The site is divided into three sections. The first section provides a discussion of palaeoentomology along with its concepts and methodologies, the second is an overview of the BUGS computer program, and the third is a group of case studies using the program.

The BUGS program is designed to help with interpreting archaeological and paleoenvironmental insect assemblages from buried deposits. (Pg. 28) A researcher can look up information on a species and find out the modern ecology and distribution information for the insect as well as a list of archaeological or older sites on which it has been found along with the oldest known fossil record. Pictures and maps are there if available. A list of other internet resources and a bibliography are provided for further research. The main case study is of a midden site excavated in Greenland and dated to the Norse settlement period.

Oral Presentations

Campobasso, C., Fornaciari, G., Vanin, S. (2017). A Journey through Forensic Entomology and Funerary Archaeoentomology. Presented at the University of Pisa in November of 2017. https://www.researchgate.net/publication/321145916_A_journey_through_Forensic_Entomology_and_Funerary_Archaeoentomology_Hidden_information_within_mummies_and_other_burials.

This presentation consists of PowerPoint slides that detail excavations of mass burials and cemeteries that provided human and insect remains. Several of the sites described were pits used to bury large numbers of people killed by the Black Plague, for example the East Smithfield Black Death Cemetery in London, similar cemeteries in Provence and the Languedoc in France, and the Alghero plague cemetery in Sardinia. The presentation also discusses the mummified remains of Neapolitan nobles, princes, and kings from the Sacristy of the Neapolitan Basilica of Saint Domenico Maggiore. The presented provides a more detailed analysis of one mummy, that of Ferdinand II, who lived from 1467 until 1496 when he died of malignant fever four years after becoming king of Naples. Despite poor preservation of the body, fragments of both head and pubic lice were found on the remaining hair. This demonstrates that even the wealthiest could end up infested with lice.

Kirgis, P., Bou, C., Lemaitre, S., Thomas, A., Huchet, J-B. (2019). Contribution of Archaeoentomology, Archaeoparasitology, and 3D reconstruction to the study of Prehispanic human mummies. Presented at the 3rd International Conference in Funerary Archaeoentomology at Bordeaux, France. June 5th, 2019. https://eafe2019.sciencesconf.org/resource/page/id/1.

This presentation was made for the purpose of describing the results of an archaeoentomological and archaeoparasitological study of eleven Prehispanic human mummies from the collections of the *Musée Royaux d'Art et d'Histoire* in Brussels, and the *Musée de l'Homme* in Paris. The abstract is the only portion available online and so this assessment will be brief.

The investigators were able to find large number of insect remains from ten orders, allowing them to study funerary practices along with the health of the South American populations to which these mummies belonged (Pg. 9). Noninvasive imaging of mummy bundles and 3D modeling techniques were used to reconstruct some of the anatomical regions that may have been affected by insects, thus sparing the collections from damage and allowing the detection of insect remains that may, in future, allow for precise sampling.

Unpublished Works

Girling, M.A. (1981). Beetle Remains from a Medieval Burial at St. Augustine's Canterbury. Accessed on February 7, 2020. research.historicengland.org.uk.

The beetle Rhizophagus parallelocollis or coffin beetle, also referred to as the graveyard beetle, were found in the clothing of Abbot Dygon at St. Augustine's Cathedral in Canterbury UK. Girling was an early archaeoentomological researcher in Britain and joined the discussion, mentioned above in Buckland 2002, concerning what these beetles were eating in the tombs and coffins of the dead.

She notes that, outside of cemeteries, this species is found where there is evidence of forests with decaying trees and thus their natural patterns are likely to involve either predation or feeding on mold. There is some evidence that carrion is part of their natural diet as well. Girling sees these natural tendencies as coming together in the man-made environment of the old graveyard where corpses, mold, moldy wood, and fly maggot fauna would all be present. This turned into an ideal environment for the beetle to thrive until recently when graveyards and cemeteries have been cleaned up.

For the particular burial of Abbot Dyson, Girling points out that the beetles give evidence of his funeral. She believes that the beetles occurred from eggs laid in the body directly, implying that the period between death and burial was long enough to allow decay and promote the presence of maggots. (Pg. 2) She posits that he was lying in state for days and, as this would have been happening in the church, the adjacent churchyard would have been the source of the beetles.

Rousseau, M. (2017). Des insects et des Hommes: archéoentomologie et paléoentomologie à l'Îlot des Palais (CeEt-30), Québec. Doctoral thesis. Université Laval. https://corpus.ulaval.ca/jspui/handle/20.500.11794/28208.

This unpublished dissertation is written in French, although some notes on insect species are in English, and describes the archaeoentomological investigations into a site in Quebec known as the Ilot des Palais, which, as the residence of one of the leaders, was very important in the history of New France. The site was dated to around the years 1675 to 1760. The author of this dissertation is a student of Allison Bain's, whose work is part of this bibliography.

The author is investigating the impact of Europeans and colonization on the landscape using archaeoentomology. Among the finds were more than 9,850 individuals, all Coleoptera, belonging to 250 taxa associated with ten periods of occupation both before and after the French arrival and settlement of the area. She used this information to track the changes in the landscape outside and inside the Ilot des Palais over time, gradual changes before settlement and more drastic changes after. This allowed comparison between insect fauna of the natural landscape and the human contexts within the Ilot des Palais. She found evidence of deforestation after

European colonization such that the ground cover was affected thus affecting the insects that were dependent on the wood and vegetation for survival.

Conclusion

Archaeoentomology is a growing subfield within archaeology with an ever expanding range of sites, eras, places, and subjects. Even a modest bibliography such as this contains sites as different from each other as a bone pit from Late Prehistoric North America, a 14th-century ecclesiastical burial from England, and European conflict sites from just slightly over a century ago. The coverage of the topic is, without question, uneven with more work being done in England and Canada than in some other areas but this is largely a result of where the specialists are being educated and trained. As the discipline expands, the sites and time periods will follow.

It is exciting to consider this area of interest from both the archaeological and the entomological point of view. Different aspects are revealed by each approach. While a firm grounding in archaeological technique, history, and theory are required to assess the meaning of the insect evidence from the past, it is essential as well to understand how insects behave, live, feed, and reproduce both in the natural world and in human-created contexts. To integrate each part into an understanding of a whole and use the archaeological evidence to inform the entomological data and vice versa yields a better overall sense of what has occurred than either approach on its own. It has been said that, although archaeology is about the past, it is necessarily done in the present. To get the most out of what information is available, all scientific specialties must be brought bear on the data and used to construct the past to the best degree possible. Entomology is well suited to this end and its use in combination with all the other specialties within archaeology brings out much that would otherwise be hidden.