Part III - Parasite Findings in Archeological Remains: a paleogeographic view

22. The Findings in Europe

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The Findings in Europe

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EARLY PALEOPARASITOLOGY IN EUROPE

Few parasitologists had experienced the opportunity to study the life of extinct populations through the discovery of parasitic infections that affected such populations. This possibility became a reality when paleoparasitology emerged, launching the search for vestiges of parasites in archaeological material and other remains from ancient cultures.

During the period of “Egyptomania” that so fascinated Europe in the late 19th and early 20th centuries, numerous studies focused on diseases diagnosed in Egyptian mummies. Research on diseases in Ancient Egypt featured the work of Sir Marc Armand Ruffer, including his description of the first parasite find in archaeological material, namely *Schistosoma haematobium* eggs in kidney tissue from a body dated to 3200 BC (Ruffer, 1921, 1910).

Until the mid-20th century, few finds were added to Ruffer's work. One example is an article in which Szidat (1944) describes *Trichuris trichiura* and *Ascaris lumbricoides* eggs in the mummified bodies of a man and girl found in a bog in Prussia, dated between 600 BC and 500 AD.

The classical divide between the human and medical sciences, common in Europe at the time, may have discouraged cooperation between scientists from the two sides of these major fields (Bouchet, Harter & Le Bailly, 2003). Initial collaboration between parasitologists and archaeologists was only sporadic. Studies were done when some special necropsy was organized in a mummified body in a museum. Perhaps through prior knowledge or friendship, experts from various areas met to complete the study in mummies or in latrine sediments or coprolites (Bouchet et al., 2003).

Nevertheless, Europe has a long tradition of parasite studies in archaeological material. Mummified bodies have always provided an important source of study, and the peat fields, swampy places with high acidity and thus excellent conditions for preservation of organic matter, are an important source of material. Various mummified bodies have been found in these bogs, some very well preserved. Parasite eggs are also found in sediments from archaeological sites, especially in permanently wet or even flooded areas in France and Switzerland (Bouchet et al., 1996).

The following is a review of parasites found in Old World archaeological material, along with some relevant comments.

A REVIEW OF THE INITIAL FINDS

Eleven years after publication of the article by Szidat (1944), other studies began to emerge. Taylor (1955) published interesting results from material collected in excavations in England, where archaeologists discovered a cesspit used at the time of Roman occupation. The find consisted of layers of fecal material deposited for years in a specific location. Microscopic examination revealed *Ascaris lumbricoides*, *Trichuris trichiura*, and *Dicrocoelium dendriticum* eggs. The author discusses the presence of *Dicrocoelium dendriticum* in human feces and concludes that this parasite may have been introduced by slaves or soldiers from other regions.

Another *Trichuris trichiura* find was in the Netherlands, based on necropsy tests in a body offered in sacrifice during the 3rd or 4th century AD (Helbaek, 1958).

In Poland, *Fasciola hepatica* eggs were found in samples sent by archaeologists that identified the material as feces preserved by desiccation. The samples were dated to the 11th to 13th centuries. Based on the coprolites' shape and alimentary content, Grzywinski (1960) concluded that they were not from human hosts, but may have been excreted by rodents, pigs, dogs, and horses.

Jansen Jr. & Over (1962) examined archaeological material from Germany, dated between 100 BC and 500 AD, and described *Ascaris lumbricoides*, *Trichuris trichiura*, *Trichuris ovis*, and *Trichuris globulosa*, *Fasciola hepatica*, *Taenia solium* or *Taenia saginata*, *Diphyllobothrium latum*, *Toxocara canis*, and *Oxiuris equi* eggs. They concluded that human feces were mixed with those of other animals in a single common deposit.

Also in Germany, Specht (1963) obtained positive results in night soil from a cesspit built by Romans and dated to between 140 and 150 BC. He found *Trichuris trichiura* eggs and concluded that soldiers were infected.

Ascaris lumbricoides and *Trichuris trichiura* were found again in a Roman military camp in Germany (Jansen Jr. & Over, 1966). This study was presented at the 1st International Congress of Parasitology, in Rome, drawing attention from experts concerning the potential for finding parasites in archaeological remains.

Pike & Biddle (1966) and Pike (1967) analyzed parasite finds in ancient material, based on parasite forms and bone and tissue lesions suggestive of parasitic infections, artistic or ritualistic depictions, and intermediate hosts or vectors of parasitic diseases in archaeological sites. The authors found *Ascaris* sp., *Trichuris* sp., and *Dicrocoelium dendriticum* eggs in coprolites from Winchester, England, dated 1000 AD. Pike (1967) further commented on the zinc phosphate flotation technique, which he used to analyze material from latrine sediments. The material had been preserved wet, apparently since it was deposited in the latrines, but the author also recommends the spontaneous sedimentation technique to avoid damaging the eggs.

Pike (1968) refers again to examination of coprolites dated to the period of Roman occupation in England and finds ascarid, trichurid, and capillarid eggs, in addition to *Dicrocoelium dendriticum* eggs and nematode rhabditoid larvae.

In England, Gooch (1972) published the first review of all the helminth finds in archaeological material as of that year.

Aspöck, Flamm, & Picher (1973) reported *Trichuris trichiura* and *Ascaris lumbricoides* eggs in coprolites dated 2000 to 3000 BP, belonging to the Hallstatt culture and found in a salt mine in the Austrian Alps. The following year, the authors observed high infection rates with *Trichuris trichiura* and *Ascaris lumbricoides* in an Austrian population, with coprolites also dating between 2000 and 3000 BP and containing high egg counts for these helminths (Aspöck, Flamm & Picher, 1974).

Boersema & Jansen (1975) again described the association of *Ascaris lumbricoides* and *Trichuris trichiura* in fecal material from two cesspits from the 13th and 14th centuries in the Netherlands, which began to call scientists' attention. Years later this association became the object of research at both the Paleoparasitology Laboratory at the University of Reims (Loreille et al., 2001; Loreille & Bouchet, 2003) and at FIOCRUZ in Rio de Janeiro (Leles et al., 2008).

Pike (1975) found eggs of these same parasites in excreta from the 13th and early 14th centuries in Southampton, England, but raised the hypothesis that the coprolites were from pigs, since the samples were obtained from what had been yards at the time. This showed the need for techniques capable of separating parasite species according to their specific hosts.

Nansen & Jørgensen (1977) reported finding *Fasciola hepatica*, *Ascaris* sp., *Taenia* sp., and *Trichuris* sp. eggs in coprolites from the 8th and 9th centuries in Denmark, during the Viking period, but did not define their origin, whether from humans or other animals.

Roeber-Bonnet et al. (1979) described *Trichuris* sp. eggs in an archaeological deposit dated to 5400 BP, but without commenting on the possible host or recording the eggs' size.

The 1980s were particularly productive for paleoparasitology studies in Europe. In England, Andrew Jones published a series of studies on coprolites and latrine sediments found in archaeological sites in York, as well as reports on the examination of a mummified body found in a peat field (Jones, 1982, 1983, 1985). During this period, Jones (1983) introduced the use of hydrochloric acid to disaggregate mineralized coprolites, yielding positive parasite finds.

Greig (1981, 1982), examined medieval latrine sediments from 15th and 16th century England and found *Ascaris* sp. and *Trichuris* sp. eggs. Moore (1981) found similar results in other medieval latrines in England, from the 10th to the 15th centuries, thus demonstrating continuing infection with these geohelminths.

Weiss & Möller-Christensen (1971) and Ortner & Putschar (1981) also published interesting articles on lesions caused by helminth infections, especially echinococcosis, in skeletons and scattered bones found in archaeological strata.

Gooch (1983) conducted a broad commented review on coprolite studies, showing that the search for parasites, food remains, and other elements from the diet of ancient peoples could provide important information on the past. Paleoparasitology began to be consolidated in various parts of the world.

In Germany, Herrmann (1986, 1987) published a series of articles with an epidemiological approach. Reinhard et al. (1987) provided an in-depth commentary on these studies in a review article containing an analysis of paleoparasitological methods and techniques. No significant differences were found in helminth egg counts in latrines in which the pH varied between 5.8 and 9, but the attempt was made to establish the best quantitative technique for a paleoepidemiological study. Herrmann (1986) commented that none of the techniques for concentration of parasite eggs (sodium chloride flotation, zinc phosphate or the Telemann method – or concentration in mercury, iodine, formalin, and ether) is really efficient for processing archaeological material.

Legendre, Marie & Rieb (1986) examined medieval latrine sediments from 15th and 16th-century France and found *Ascaris* sp. and *Trichuris* sp. eggs. A year later, Rouffignac (1987) published a review of parasite finds in human material from medieval Europe, including not only nematodes, but also *Fasciola* sp., *Dicrocoelium* sp., and *Diphyllbothrium* sp.

Jones, Hutchinson & Nicholson (1988) published an interesting article that discussed parasite findings in human and equine archaeological material dated to the Roman period. They referred to deposits in which one would not usually expect the presence of archaeological remains, but which yielded parasite eggs. Jones & Nicholson (1988) commented again on *Ascaris* sp. and *Trichuris* sp. eggs in archaeological material from England.

Bouchet et al. (1989) published an initial study of parasites in sediments and coprolites from three closed structures on Rue de Lutèce, Paris, with *Ascaris* sp., *Trichuris* sp., and *Taenia* sp. eggs.

Bouchet (1991) published a paleoparasitological study of sediment from an archaeological excavation yard in Beauvais (Oise), Picardy, dated to the medieval period (13th to 17th centuries), where they found *Trichuris* sp., *Ascaris* sp., *Heterakis* sp., and *Capillaria* sp. eggs.

The 1990s witnessed growing interest in paleoparasitology in Europe. Various specialized laboratories emerged in France, for example at the University of Reims (Bouchet, Harter & Le Bailly, 2003) and Perpignan (Jouy-Avantin et al., 1999). New finds were made, and partnerships grew between the paleoparasitology laboratories, involving both exchange between researchers and graduate students and participation in specialized congresses. This same decade also featured the articles by Aspöck, Auer & Picher (1995, 1996) on the finding of intestinal parasites (*Trichuris trichiura*) in the mummified body found in the Alps, known as Ötzi, the Tyrolean Iceman.

These pioneering articles opened the way for paleoparasitology in Europe. The following is a brief summary, dividing the helminth finds in flatworms or platyhelminths (tapeworms or cestodes and flukes or trematodes) and roundworms (nematodes).

FLATWORMS (PLATYHELMINTHS)

Flukes (Trematodes)

Dicrocoeliidae and Fasciolidae eggs have been found in archaeological sites ranging from the Pleistocene to historical times. The oldest dates for these parasites go back 550,000 years, with *Dicrocoelium* sp. eggs found in sediment from the archaeological site in Tautavel, southern France (Jouy-Avantin et al., 1999). The possible hosts, both extinct, belonged to either a species of hyena (*Crocota spelaea*) or bear (*Ursus spelaeus* or *Ursus ringeri*).

These finds raise interesting questions due to their antiquity and the host's extinction, as discussed by Ferreira, Araújo & Duarte (1993) upon finding nematode larvae in coprolites from an extinct hyena in Italy, dated to 1.5 million years. The first is that the parasites' cycles may have changed over time, and the second is that the intermediate or definitive hosts may have disappeared and been replaced by new hosts. At any rate, finding parasites in such ancient material, often completely mineralized, is extremely rare, requiring great patience and persistence by the examiner.

Fasciola hepatica and *Dicrocoelium* sp. eggs were found in Arbon, dated to 3384-3370 BC, as well as in Chalain, dated to 3200-2900 BC, both in France (Bouchet et al., 1996; Dommelier-Espejo, 2001; Le Bailly, 2002). These trematode eggs were also found in the Hallstatt mines in Austria, in coprolites dated to before and during the Bronze Age (Aspöck, Flamm & Picher, 1973, 1974; Aspöck & Auer, 1998), as well as in the underwater site in Gresine, France (Le Bailly, 2001).

These trematodes were present in humans and their domestic animals during the Gallic-Roman period and Middle Ages. Material from archaeological sites in the French cities of Paris, Montbéliard, Reims, and Bordéus also show the presence of *Fasciola hepatica* and *Dicrocoelium* sp. eggs (Bouchet, 1993, 1994, 1995; Bouchet et al., 1997; Bouchet, Benträd & Paicheler, 1998).

The ancient Europeans were hosts to *Fasciola hepatica*, and therefore they probably ate raw salads with such green leaves as water cress (*Nasturtium officinale*), chicory (*Cichorium intybus*), lettuce (*Valerianella olitoria*), dandelion

(*Taraxacum dens leonis*), and other green vegetables. A book by Guillaume de Villeneuve written in 1545 provides a description of water cress vendors in Paris who cried, “Vey ci bon cresson Orlénois” (“Come get the good original Orleans water cress”) (Pitrat & Foury, 2003).

Dicrocoelium sp. infection is very rare in humans but common in various other hosts, including domestic animals. Its occurrence in human feces can result from false parasitism or more rarely from true infection (Helmy & Al-Mathal, 2003; Rana et al., 2007).

As for flukes, *Schistosoma haematobium* eggs were found in Egyptian mummies spanning a period from 3200 BC to 500 AD (Ruffer, 1910; Reyman, 1976; Deelder et al., 1990; Miller et al., 1992; Contis & David, 1996). East Africa appears to have been the center for dispersal of schistosomiasis haematobium; from there, the infection spread to other parts of the world where both the human host and intermediate host existed (Chamot & Amat-Roze, 1993). The emergence and dispersal of *Schistosoma haematobium* infection along the Nile were described by Harter (2003), who found the parasite's eggs in Nubian mummies dated to 2400 BC. According to Nozais (1987, 2003), the parasite dispersed gradually with nomadic caravans and the slave trade along the Nile, since prehistory in the Sahara Desert.

During the Middle Age, individuals infected with *Schistosoma* species were already found in Europe, demonstrating the migration of persons carrying the parasite, but without evidence that the life cycle was established among Europeans. *Schistosoma haematobium* eggs were found in a latrine dated to the 15th or 16th century in France (Bouchet & Paicheler, 1995). *Schistosoma mansoni* eggs were also found in the same latrine (Bouchet et al., 2002).

It is important to discuss the presence of these two species of parasites in the same archaeological context. Both the urogenital and intestinal forms of schistosomiasis are believed to have originated in Africa; based on the paleoparasitological data, it is possible that a European returned from Africa infected with both parasites. But it is also possible that an individual of African origin brought these eggs and eliminated them in France. It was common during the 15th and 16th centuries to bring Africans to exhibit them in circuses or in the nobility's ballrooms, even caged like animals (Gould, 1985).

Tapeworms (Cestodes)

The oldest records of *Taenia* eggs in human remains in Europe date to the Neolithic, from coprolites found in the archaeological site in Chalain, France, dated from 3200 to 2900 BC (Dommel et al., 1998). *Taenia* sp. eggs were also found in the Hallstatt salt mines, dated to the Upper Neolithic (Aspöck, Flamm & Picher, 1973).

Mummified bodies of Egyptian origin are housed in museums worldwide. Horne & Lewin (1977) prepared histological sections of intestine from an Egyptian mummy in the Royal Ontario Museum and found *Taenia* sp. eggs. These were also described by Harter (2003) in Nubian mummies from what is now Sudan, dated to 2400 BC. These findings raised discussions on the introduction of human infection into Europe.

Interesting observations were made on the European historic period, especially in France. *Taenia* sp. eggs have frequently been found in archaeological remains recovered from houses of the nobility, in the regions of Louvre, Marly le Roi, and Montbéliard (Bouchet, 1995; Bouchet & Paicheler, 1995; Bouchet, Bentrud & Paicheler, 1998). At that time it was common for nobles to eat raw meat. In contrast, *Taenia* sp. eggs have not been found in remains from the rural and poor regions of France, where the main dish was soup containing small bits of very well cooked meat.

Pseudophyllid cestodes

Diphyllbothrium sp. eggs have been recorded, dated as far back as Neolithic times in the sites of Chalain and the wetlands and bogs of Concise and Arbon, in France (Dommelier-Espejo, 2001; Le Bailly, 2002). This is a parasite of freshwater fishes, from which the larvae are transmitted to carnivores, where they develop into adults in the gut. The eggs are eliminated in the feces, and when they come into contact with water they are ingested by crustaceans or fish. Humans acquire the infection by ingesting raw or poorly cooked fish.

In Germany and France, *Diphyllbothrium* sp. eggs have been found in human coprolites from the Gallic-Roman and Medieval periods (Jansen Jr. & Over, 1962; Herrmann, 1987; Bouchet et al., 2000). Again, these parasites were only found in latrines in well-to-do homes, since it was a custom to eat beef and fish either raw or dried with salt, which does not eliminate the parasite's larvae.

ROUNDWORMS (NEMATODES)

Ascaris lumbricoides

Ascaris eggs, extremely abundant in European archaeological sites, are indicative of fecal pollution (Taylor, 1955; Pike, 1967; Greig, 1981, 1982; Bouchet, 1994, 1995; Bouchet & Paicheler, 1995). The number and abundance of eggs allow identifying different degrees of fecal pollution and can be used to differentiate archaeological remains such as latrines, cesspits, wells, silos, sewage drains, stables, and other structures (Bouchet, 1994; Fernandes et al., 2005).

Ascaris lumbricoides is considered to be present in nearly all paleoparasitology studies in historical sites. However, the findings in Europe do not confirm the hypothesis of this parasite's antiquity. *Ascaris* sp. eggs are absent in organic remains dated to the Neolithic both in Switzerland and France (Bouchet, Harter & Le Bailly, 2003). Their absence has not been explained. Even in the Ötzi mummy, no eggs of this parasite were found (Aspöck, Auer & Picher, 1996).

The oldest records of *Ascaris lumbricoides* eggs in human coprolites were found in the Hallstatt salt mines, dated to the Iron Age, circa 800 to 350 BC (Aspöck, Flamm & Picher, 1973), and from mummies in Prussia from 600 BC (Szidat, 1944). *Ascaris lumbricoides* eggs were also found in Egyptian mummies from the Ptolemaic period, circa 170 BC (Cockburn et al., 1975).

Ascaris sp. eggs were found in coprolites from Pleistocene, in the Arcy-sur-Cure cave in France, which was inhabited by Neanderthals. However, the origin of these eggs was not confirmed, whether from humans, bears, or other animals (Bouchet et al., 1996). One school of parasitologists proposes the origin of parasitism with *Ascaris lumbricoides* in the human species following the domestication of pigs. However, the fact that this parasite was found in populations from the Pleistocene, a period prior to domestication of pigs, invalidates the assumption that the species found in humans originated from *Ascaris summ.* This finding in France is thus highly important. The material is extremely precious, and if molecular biology techniques confirm its human origin, it will provide interesting answers to questions concerning the origin of ascariasis. Tests have begun to be designed concerning the *Ascaris* species involved (Loreille et al., 2001; Loreille & Bouchet, 2003; Leles et al., 2008) in order for the definitive diagnosis to be based on the origin of the archaeological remains (whether human or from another animal).

Trichuris trichiura

Well-preserved *Trichuris* sp. eggs were found in flooded regions of Western Europe, some with the embryo well-preserved inside and others filled with pyrite crystals, proving their antiquity (Bouchet, 1995). *Trichuris trichiura* was also found in the mummy known as Ötzi, found in Hauslabjoch, in the Alps, dated 3200 BC. (Aspöck, Auer & Picher, 1995, 1996).

Trichuris trichiura and *Ascaris lumbricoides* infection is one of the most common combined infections at present in most regions lacking minimum sanitation. In order to reach the adult form, both parasites require a development phase in the soil with sufficient moisture and heat. *Ascaris lumbricoides*, *Trichuris trichiura*, and fecal contamination appear to have been interlinked. This also occurred in historic times in Europe, but not in more ancient times.

Capillaridae

Abundant *Capillaria* sp. eggs were found in three Neolithic archaeological sites, dated to 10,000 BP, from the Alps and the Jura Valley in France (in Chalain, Arbon, and Concise). Of 23 human coprolites in Chalain, 21 were positive for *Capillaria* spp. eggs (Bouchet, 1997; Bouchet et al., 1997).

The eggs' outer membrane varied considerably, and three species were identified as parasitizing humans: *Capillaria aerophila*, *Capillaria hepatica*, and *Capillaria philippinensis*. The first two species have rats and mice as intermediate hosts. It is known that these rodents were introduced into Europe after the Neolithic. Thus, more research is needed to elucidate the origin of infection by this parasite in such ancient periods.

It is not easy to explain the human species' participation in the life cycle of *Capillaria* species. Were humans definitive, intermediate, false, or paratenic hosts in the past? In the case of obligate heteroxeny, the same animal could have been the definitive host if the larva was ingested or the intermediate host if the egg was ingested. As suggested by Combes (1995), changes in the life cycle of parasites are possible over time, with the acquisition of new hosts, especially considering such long periods. The paleoenvironment may have provided other possibilities for parasites to complete their life cycles. In this context, it is important to mention the egg shells' characteristics in different species of *Capillaria* as a diagnostic element, according to Fugassa et al. (2008).

PROTOZOA

There is growing paleoparasitological evidence of the presence of intestinal protozoa in archaeological material. Although easily destroyed, their vestiges can be recovered by immunological techniques, as in the case of infection with *Giardia duodenalis* and *Entamoeba histolytica* (Gonçalves et al., 2002, 2004; LeBailly et al., 2008).

PALEOPARASITOLOGY AND PATHOCENOSIS

A paleoparasitological record has been constructed little by little, although it was believed in the past that parasite fossils would never be found. Still, the more ancient the material, the more difficult it is to find well-preserved eggs, larvae, and even cysts. The taphonomic process puts strong pressure on parasite form, and large amounts of them are lost, or only unrecognizable elements are left. One must also consider the extinction of parasite species over

time, making diagnosis more difficult. Meanwhile, such cases raise the possibility of studying extinct species and comparing them to current ones in phylogenetic studies.

Human agglomerations appear to have facilitated the preservation of parasite forms in archaeological sites. The epidemiological transition during the change from nomadic hunting and gathering habits to sedentary agriculture led to many changes in the disease profile of prehistoric groups. In Neolithic sites, the effect of agglomeration and the presence of domestic animals contributed to changes in the human parasitic fauna. Anthroponotic diseases emerged and established themselves, circulating in humans and in their domestic animals (Bouchet, Harter & Le Bailly, 2003).

As for the preservation of helminth eggs and larvae, it is important to highlight the exceptional conditions in wet or flooded environments. European archaeological sites that are close to bodies of water or even submerged display the best preservation of eggs. These are the sites most visited by malacologists, archaeozoologists, palynologists, and other specialists, now including paleoparasitologists, in search of well-preserved organic remains.

The European historic period appears to have been written on a parchment made of *Ascaris* sp. and *Trichuris* sp. eggs. The well-known chronostratigraphy of the European archaeological sites allows interpretations on the sanitary conditions and hygienic habits of very well-studied human clusters. There are major contrasts between the eating habits of rich and poor, or between living in cities or in the countryside, thus influencing the preservation and finding of parasites.

Some parasites are not necessarily associated with humans but may have infected them in the past. Eggs of some species such as *Metastrongylus* sp., *Passalurus* sp., *Paramphistomum* sp., *Alaria* sp., and *Parascaris* sp. were found by Beeching & Moulin (1983), Bouchet & Benrad (1997), and Bouchet et al. (2000). One needs a broad idea of the environment in the past and the parasites that circulated in animals in order to better interpret the context in which human parasitic infections were found (Ferreira et al., 1991).

The following is a case description exemplifying situations that human groups experienced in Europe in ancient times, recovered from the paleoparasitological record (adapted from Le Bailly, 2005).

Evolution of intestinal parasitic infections in European archaeological sites dated between 6000 and 5000 years BP

Most intestinal parasitic infections are alimentary in origin. The study of parasites preserved in archaeological material, particularly intestinal helminths, thus provides important information on the eating habits of ancient peoples. Paleoparasitology thus produced data on ancient populations, for example from the Neolithic period, when diet was not very diversified and major nutritional changes had still not occurred.

Paleoparasitological data allow precise clues to populations' eating patterns. Changes in eating habits are induced by different factors: climatic, ecological, environmental, and sociological. Variations in parasitic infections result from modifications in eating habits or ways of storing foods. By inverse reasoning, it is therefore possible, when studying parasitic infections, to construct hypotheses on the origin of these variations. To investigate parasite variation, a qualitative and quantitative study was conducted in several archaeological sites in France and Germany.

The samples discussed here are from ancient lacustrine villages from the Middle and Upper Neolithic, dated between 3900 and 2900 BC, therefore between circa 6000 to 5000 BP. The sites are located in northeast Switzerland, in the canton of Thurgau, and in southwest Germany, in the Baden-Württemberg region. Two lacustrine zones were chosen, one at Lake Constance (or Bodensee) and the other at Lake Federsee.

The Middle and Upper Neolithic period in this region of Europe corresponds mainly to the chronological development of two cultures, Pfyn (dated to circa 3900 to 3400 BC) and Horgen (dated between 3400 and 2850 BC). The following is a brief presentation of the study sites.

HORNSTAAD-HÖRNLE I

Excavated between 1983 and 1993, this site is located in Germany on the banks of Lake Constance (Bodensee). Precise dates were obtained on the occupation strata by dendrochronology (Billamboz, 1998) (dendrochronology uses the sequence of tree rings to obtain dates). The site's occupation dates between 3917 and 3905 BC, corresponding to a local culture belonging to the so-called "Hornstaad group", which predates the Pfyn culture (Dieckmann, 1990; Schlichtherle, 1990). It is the oldest lacustrine site from the Upper Neolithic in the Lake Constance region. It measures 14,000 m², consisting of the charred remains of 50 houses measuring an average of 24.5 m² each and facing the water. Based on the recovered archaeological remains and average size of the dwellings, the population is estimated at 240 individuals (Dieckmann, Maier & Vogt, 2001).

ARBON-BLEICHE 3

Located on the banks of Lake Constance in the Swiss canton of Thurgau, it was excavated from 1993 to 1995. It is an ancient Neolithic lacustrine village, occupied during a short period of 15 years, from 3384 to 3370 BC (dating by dendrochronology). It is one of the only currently known sites from this particular period corresponding to the transition phase between the two cultures discussed here, Pfyn and Horgen.

This is a lacustrine station, known for its excellent state of preservation. The 1,100 m² studied in the site are exceptionally well-preserved. The village was abandoned at the time because of a fire in 3370 BC. Twenty years later there was a considerable rise in the lake's water level, submerging the site under several meters of freezing water. This submersion was accompanied by debris and various sediments that created anaerobic conditions, favoring the preservation of organic matter. Thus, an enormous amount of precious material was extracted for various studies, including paleoparasitology.

TORWIESEN

The Neolithic site of Torwiesen is located around the Federsee swamp, on the ancient island of Bad Buchau in southwest Germany. Dated by dendrochronology to 3283-3281 BC, it corresponds to the early Horgen culture (Schlichtherle, 2002; Schlichtherle & Hohl, 2002).

The village consists of 12 large houses and three smaller ones, open on one side and lined facing each other on the central street. Due to its imposing proportions, one of the houses stands out from the rest. As in the other sites, some stakes used in the construction are very well-preserved and were used in the tree-ring dating.

The terrain is boggy, with acid pH. Preservation of animal bones and wooden remains is generally poor. To collect samples from the site, PVC tubes were inserted through the full thickness of the strata, extracting material for biological and chemical tests, including phosphates, pollen, parasites, insects, and macroscopic remains.

SIPPLINGEN

The Sipplingen station is located in southwest Germany, next to the northern tributary river of Lake Constance. It was occupied for a long period, from the Hornstaad culture to the Schnurkeramik culture (Kolb, 1997). Dendrochronology dates the site between 3912 and 2417 BC (Billamboz, 1985). The site has been known since

the 19th century, and large amounts of material have already been removed, thereby improving knowledge on the transition from the Pfyn to the Horgen culture.

SEEKIRCH-STOCKWIESEN

Located in the Federsee Swamp in Germany, in the Biberach region, close to the county of Seekirch, this site was discovered in 1991 by Erwin Keefer while digging a drainage pit. The absence of oak did not allow tree-ring dating, but radiocarbon dates were obtained, situating the site's occupation between 3036 and 2703 BC, i.e., in the Late Horgen culture.

A total of 11 houses were found on 280 m², representing 20% of the total area. The houses are longer than in the other sites, thus becoming their distinguishing characteristic. The site has yielded abundant archaeological artifacts (Kolb, 1997).

WALLHAUSEN-ZIEGELHÜTTE

This site is located in southwest Germany, in the Baden-Württemberg region, on the banks of Lake Constance. Part of the site remains underwater all year round. It has been known since the mid-19th century (Staub, 1864), and much of its material was removed without proper scientific rigor. Scientific work began in 1982, in a salvage operation known as the Bodensee-Oberschwaben Project.

The excavated strata were dated between 3800 and 3700 BC, using radiocarbon, and the remains show the transition between the two cultures of the region.

Study samples

Table 1 shows the results of this paleoparasitological analysis, obtained from 137 samples of coprolites and sediments of supposedly manmade origin.

Table 1 – Number of samples analyzed per archaeological site. Europe, Neolithic period

Sites	Cultures	Dates (BC)	Number of samples
Hornstad-Hörnle I	Early Pfyn	3917-3905	26
Sipplingen	Early Pfyn	3911-3909	07
Wallhausen-Ziegelhütte	Middle Pfyn	3700	05
Arbon-Bleiche 3	Transition	3384-3370	41
Sipplingen	Early Horgen	3317-3306	04
Wallhausen-Ziegelhütte	Early Horgen	3300-3050	06
Torwiesen	Early Horgen	3283-3281	22
Wallhausen-Ziegelhütte	Middle Horgen	3300-2900	04
Wallhausen-Ziegelhütte	Late Horgen	3100-2900	06
Seekirch-Stockwiesen	Late Horgen	3000-2900	16
Total			137

Next, Tables 2, 3, and 4 show the parasites found in the archaeological sites for each culture and their respective dates.

Table 2 – Parasites found in sites from the Pfyn culture. Europe, Neolithic period

Parasites	Hornstaad-Hörnle Ia (3917-3905 BC)	Sipplingen (3711-3709 BC)	Wallhausen- Ziegelhütte (3700 BC)
<i>Diphylobothrium</i> sp.	Yes	Yes	Yes
<i>Taenia</i> sp.	—	—	—
<i>Fasciola</i> sp.	Yes	Yes	Yes
<i>Dicrocoelium</i> sp.	Yes	—	—
<i>Opisthorchis</i> sp.	—	—	—
<i>Trichuris</i> sp.	Yes	Yes	Yes
<i>Capillaria</i> sp.	—	Yes	—
<i>Diocotophyma</i> sp.	—	—	—
Total	4	4	3

Table 3 – Parasites found in Arbon-Bleiche and in the Horgen culture sites. Europe, Neolithic period

Parasites	Arbon-Bleiche (3384-3370 BC)	Sipplingen (3317-3306 BC)	Torwiesen II (3283-3281 BC)
<i>Diphylobothrium</i> sp.	Yes	Yes	Yes
<i>Taenia</i> sp.	Yes	Yes	Yes
<i>Fasciola</i> sp.	Yes	Yes	Yes
<i>Dicrocoelium</i> sp.	—	Yes	—
<i>Opisthorchis</i> sp.	Yes	—	—
<i>Trichuris</i> sp.	Yes	Yes	Yes
<i>Capillaria</i> sp.	Yes	—	Yes
<i>Diocotophyma</i> sp.	Yes	—	—
Total	7	5	5

Table 4 – Parasites found in other sites from the Horgen culture. Europe, Neolithic period

Parasites	Wallhausen-Ziegelhütte (3300-3050 BC)	Wallhausen-Ziegelhütte (3100-2900 BC)	Seekirch-Stockwiesen (3000–2900 BC)
<i>Diphylobothrium</i> sp.	Yes	Yes	Yes
<i>Taenia</i> sp.	Yes	—	—
<i>Fasciola</i> sp.	Yes	Yes	Yes
<i>Dicrocoelium</i> sp.	—	?	—
<i>Opisthorchis</i> sp.	—	—	—

Table 4 – Parasites found in other sites from the Horgen culture. Europe, Neolithic period (continued)

Parasites	Wallhausen-Ziegelhütte (3300-3050 BC)	Wallhausen-Ziegelhütte (3100-2900 BC)	Seekirch-Stockwiesen (3000–2900 BC)
<i>Trichuris</i> sp.	Yes	Yes	Yes
<i>Capillaria</i> sp.	Yes	Yes	Yes
<i>Diocetophyma</i> sp.	–	–	–
Total	5	4	5

The Middle and Upper Neolithic period in the region features ancient lacustrine villages, dated between 3900 and 2900 BC, located in northeast Switzerland (canton of Thurgau) and southwest Germany (Baden-Württemberg region), with special attention to two lacustrine zones, Lake Constance (Bodensee) and Lake Federsee. The Pfyn culture dates from 3900 to 3400 BC and the Horgen culture from 3400 to 3850 BC. All sites listed in the tables are situated on this chronological scale, which allows comparing the populations, observing the evolution of parasitic infections over time. The tables' graphic representation clearly shows a huge explosion in the number of parasites around 3380 BC, namely during the assumed transition from the Pfyn culture to the Horgen culture (Graph 1).

Graph 1 – Number of parasite species found in archaeological sites. Europe, 3900-2900 BC

The peak between 3900 and 2900 BC may have various origins, such as climate, dietary, and cultural changes, among others. The answer to this question requires examining each parasitic infection in detail. The parasitic infections listed in the previous graph have different alimentary origins and may be related to fishing, hunting, gathering, or storage of plant foods.

Parasitic infections related to fishing

The above-mentioned study showed the consumption of fish based on the presence of four parasites: *Diphyllbothrium* sp., the most frequent parasite; *Opisthorchis* sp., found only at the Arbon-Bleiche 3 site; *Diocotophyma* sp., also found only in the Swiss occupation strata and coprolites; and *Capillaria* sp. eggs with ornate shells, belonging to species with freshwater intermediate hosts.

Among the parasitic infections constituting the infection peak, four are transmitted by ingesting freshwater fish or frogs: bothriocephaliasis, opisthorchiasis, diocotophymiasis, and capillariasis.

DIPHYLLOBOTHRIUM SP.

Diphyllbothrium sp. eggs are present in all the sites studied. The graph on infection with *Diphyllbothrium* sp. also shows a higher peak frequency in the samples from Arbon-Bleiche 3 (transition period), persisting until Torwiesen II (early Horgen culture) (Graph 2). The graph suggests important fish consumption during the transition period.

Graph 2 – Frequency of *Diphyllbothrium* sp. eggs in samples from the archaeological sites. Europe, 3900 to 2900 BC

Source: Adapted from Le Bailly et al. (2005).

OPISTHORCHIS SP. AND *DIOCTOPHYMA* SP.

Opisthorchis sp. and *Diocotophyma* sp. eggs were found in the Arbon-Bleiche 3 site (Le Bailly, Leuzinger & Biuchet, 2003). The appearance of these two parasites reinforces the hypothesis of an increase in fishing (and thus of fish consumption). But the diagnosis of *Opisthorchis* sp. and *Diocotophyma* sp. only in the Swiss site, around 3400 BC, raises questions, particularly because these parasites were not found in the other sites. Two relevant questions are sampling and the diversification of fishing.

Since this region harbors numerous Neolithic sites, further research is necessary. Few sites have been studied so far, and the results of paleoparasitological tests are still recent and scanty.

As for the diversification of fishing, the appearance of new parasitic infections may be explained by the obligate consumption of new fish species that were previously overlooked. The consumption of these new fish species, potentially infected with *Opisthorchis* sp. and/or *Diocotophyma* sp., then began causing disease in the human population.

The extensive consumption of frogs, identified in the Swiss archaeological site, could explain the presence of *Diectophyma* sp. However, frog-eating was recorded in the other sites, such as in Chalain (Bailon, 1997), while the paleoparasitological analyses failed to detect this parasite. It thus appears that fish were the most important source of contamination with *Diectophyma* sp., which reinforces the hypothesis of diversification of fish species consumed during this period.

Importantly, infection with *Diectophyma* sp. can result directly from the ingestion of annelid worms such as *Lumbriculus variegatus*, the host of the parasite's larval form. Worm-eating by the inhabitants of these Arbon-Bleiche 3 sites is thus possible.

CAPILLARIA SP.

Capillaria sp. eggs with speckled shells, attributed to species that parasitize freshwater fish, appeared in the samples from Arbon-Bleiche 3, corresponding to the cultural transition period (Graph 3). The parasite's appearance lends further credence to the preceding hypotheses on the increasing diversification of fishing.

Graph 3 – Frequency of samples with *Capillaria* sp. eggs from the archaeological sites in Hornstaad-Hörnle I (3917 to 3905 BC), Arbon-Bleiche 3 (3384 to 3370 BC), Torwiesen II (3283 to 3281 BC), and Seekirch-Stockwiesen (3000 to 2900 BC)

We can conclude that fish were eaten in nearly all of the sites. In Hornstaad-Hörnle I, fish remains were recovered, representing 14.8% of the bone remains of other animals.

Arbon-Bleiche 3 yielded abundant fish remains, including redfin perch (*Perca fluviatilis*), pike (*Esox lucius*), Wels catfish (*Silurus glanis*), burbot (*Lota lota*), whitefish (*Coregonus* sp.), trout (*Salmo trutta*, *Salmo trutta fario*), and various small freshwater fishes (*Rutilus rutilus*, *Scardinius erythrophthalmus*, *Leusiscus* sp., *Barbus barbus*, *Tinca tinca*). Fish consumption was estimated at 22% of the population's total diet at the site (Hüster-Plogmann & Leuzinger, 1995).

Some fish remains were found at the Sippligen site, but without defining the genus or species. At Torwiesen II, some remains of pike, bream (*Blicca (Abramis) brama*, *B. bjoerkna*), and other minnows were found. In Wallhausen-

Ziegelhütte the list of fish remains is more varied. Finally, at the Seekirch-Stockwiesen site no information is available on fish remains.

Frog-eating

Frog-eating (batracophagy) is one possible hypothesis in certain Neolithic populations, particularly that of Arbon-Bleiche 3. This hypothesis is backed by the discovery of numerous fragments of digested frog bones from genus *Rana* sp. The large amount of hind leg bones suggests the preferential consumption of frog legs. This assumption is reinforced by the presence of *Diectophyma* sp., the food source of which can be the consumption of either fish or frogs. The hypothesis of frog-eating by Neolithic populations has raised several times (Bailon, 1993, 1997).

The presence of frog remains demonstrates the ingestion of this host at the Arbon-Bleiche 3 site. The bone fragments included remains from *Rana esculenta*, or common water frog or green frog, *Rana lessonae*, pool frog, and *Rana ridibunda*, or marsh frog.

Parasites associated with hunting

Eggs identified as genus *Paramphistomum* sp. were found in the Hornstaad-Hörnle I and Seekirch-Stockwiesen sites. These flukes parasitize deer, with no record of cases in humans. *Paramphistomum* sp. eggs in human samples probably resulted from a pseudoparasitic infection, or pseudoparasitism. The eggs were probably in transit through the human intestine, following the slaughtering of deer and consumption of venison.

CAPILLARIA SP.

Capillaria sp. eggs with reticulate shells can be attributed to the species *Capillaria bovis*, a specific parasite of deer. The importance of hunting during the Neolithic and consumption of red deer (*Cervus elaphus*) and European roe deer (*Capreolus capreolus*) reinforces the identification of eggs belonging to this species. Findings of eggs with reticulate shells begin at the level of the Swiss site and the parasite's frequency appears to remain stable throughout the Horgen culture (between 10 and 13%) (Graph 3). This parasite's presence in human samples may have resulted from an increase in hunting, but especially from a narrow selection of game animals, since young deer are more heavily parasitized than adults.

Concerning hunting by Neolithic peoples in these regions, remains of wild animals are present in all the sites. In Hornstaad-Hörnle I, wild animals represented 50% of the archaeozoological remains. The red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) are present in all the sites discussed here. Roe deer was found in all the sites except Seekirch-Stockwiesen.

Parasitic infections associated with livestock

The consumption of domestic animals is ancient and was known to all the cultures discussed here. It is a source of contamination by some intestinal parasites, such as tapeworms, including the species found in swine, *Taenia solium*, and in bovines, *Taenia saginata*. Other parasites may not cause infections and are considered pseudoparasites or cases of false parasitism. An example is *Dicrocoelium* sp., the eggs of which can be found in human feces following consumption of liver from ruminants, especially sheep and goats.

TAENIA SP.

The peak in parasite finds was followed by a drop around 3200 BC (Graph 4). Opisthorchiasis and a dioctophymiasis decreased from 70% to 10%. The temperature rose and another parasite emerged, with an increase in the number of tapeworm infections. The curve on *Taenia* sp. egg finds in the Neolithic archaeological sites shows a slight increase during the early Horgen culture.

Pig-raising was a key characteristic of the Horgen culture (Furger, 1980). The Neolithic Horgen culture sites yielded a high percentage of pig remains (Schibler & Jacomet, 1999). The emergence and evolution in the frequency of *Taenia* sp. eggs beginning in the cultural transition appears to reflect the importance of pig-raising in the Horgen culture. Various questions were raised before reaching a conclusion on this hypothesis.

Pig-raising did not begin with the Horgen culture. Previously, during the Pfyn culture, pigs had already been raised for domestic consumption. Curiously, no *Taenia* sp. eggs were found in the coprolites and sediments from the Pfyn sites.

Graph 4 – Frequency of *Taenia* sp. eggs in samples from Neolithic archaeological sites. Europe, 3900 to 2900 BC

Source: Adapted from Le Bailly et al. (2005).

Tapeworms from genus *Taenia* that parasitize humans are transmitted by ingesting raw or poorly cooked pork (*Taenia solium*) or beef (*Taenia saginata*). The embryophores found in the strata of the archaeological sites are identical for the two species, and the parasite's species cannot be distinguished by the eggs.

Remains from domesticated cattle (*Bos taurus*) were found in both the Pfyn and Horgen cultures. Due to the presence of the intermediate host, the absence of *Taenia* sp. eggs in the Pfyn sites is surprising, suggesting the ingestion of well-cooked meat. *Taenia* eggs found in the Arbon-Bleiche 3 site correspond to the oldest dates for this parasite's association with human organic remains.

DICROCOELIUM SP.

Dicrocoelium sp. eggs were found in Hornstaad-Hörnle I, Arbon-Bleiche 3, and Seekirch-Stockwiesen, but not in Torwiesen II, possibly due to sampling problems. There was a decrease from 3900 to 3280 BC., to 4% in Hornstaad-Hörnle I and 0% in Torwiesen II. This was followed by an important increase, reaching 13% in Seekirch-Stockwiesen.

This parasitic infection, closely linked to sheep raising, showed a considerable increase around 3000-2900 BC (Graph 5), coinciding with the known resurgence of raising small ruminants around 2800 BC (Schibler & Chaix, 1995).

Graph 5 – Frequency of *Dicrocoelium* sp. eggs in samples from archaeological sites. Europe, 3900 to 2900 BC

Fasciola sp.

Fasciola sp. mainly parasitizes ruminants, and human infection only occurs accidentally due to the consumption of vegetables contaminated with encysted metacercariae. The parasite's presence is thus associated with that of bovines in the same environment. However, cattle-raising was not very widespread between the 36th and 27th centuries BC (Schibler & Chaix, 1995). It is thus surprising and especially contradictory that there was an increase in findings of this parasite's eggs around 3380 BC (Graph 6).

Fasciola sp. infection can be transmitted by other animals besides bovines. In fact, wild ruminants such as red deer and roe deer can carry adult forms of the parasite (Shimalov & Shimalov, 2000). Likewise, lagomorphs and rodents can be definitive hosts of the parasite (Ménard et al., 2000). The coypu or river rat (*Myocastor coypus*) transmits fascioliasis as readily as bovines (Ménard et al., 2001) [Editor's Note. The species *Myocastor coypus* was originally from South America, but was taken to Europe, where it reproduced in nature].

Graph 6 – Frequency of *Fasciola* sp. eggs in samples from archaeological sites. Europe, 3900 to 2900 BC

The proven presence of numerous wild ruminants and mustelids at the Arbon-Bleiche 3 site may explain the importance of this parasitic infection during this period. Consumption of these animals may have caused infection with *Fasciola* sp., causing a pseudoparasitic infection, which would explain the presence of so many eggs in the samples.

Parasitic infections related to the consumption of vegetables

Fasciola sp.

This parasite uses aquatic plants or those growing on the banks of rivers and lakes for the encystment of its larval form. Such plants include some edible ones for both animals and humans, like water cress. The discovery of *Fasciola* sp. eggs in human coprolites thus demonstrates the consumption of these plants by humans. In this case, ingestion of the parasite's infective forms, metacercariae, would lead to the fluke's development in the digestive system, with the appearance of symptoms associated with fascioliasis.

It is difficult to distinguish pseudoparasitic infection from true parasitic infection based on the data. All hypotheses for the presence of *Fasciola* sp. eggs in samples should be explored.

Trichuris sp.

The presence of *Trichuris* sp. eggs in modern stool samples suggests ignorance of elementary rules of hygiene as well as the risks involved in the contamination of food or water with fecal matter. Such basic notions were likely unknown during the Neolithic. Thus, the discovery of *Trichuris* sp. eggs in numerous samples dated to this age appears to fall within normalcy.

However, such findings provide some information. The parasite's developmental cycle requires a passage through the external environment. Transmission thus occurs by accidental ingestion of earth, called geophagy, or consumption of fruits or vegetables contaminated with feces and the parasite's eggs. The use of human fecal matter as fertilizer could have increased the parasite's presence, but as far as we know such fertilization was not used in the Neolithic.

Unlike the other curves, finds of *Trichuris* sp. eggs show a downward trend during the transition between the two cultures (Graph 7). This decrease is surprising, and no explanation has been proposed thus far. The sampling issue could also be raised here, but no conclusion is possible to date.

Graph 7 – Frequency of *Trichuris* sp. eggs in samples from archaeological sites. Europe, 3900 to 2900 BC

Potential hypotheses

There are at least three hypotheses for the increase in fish consumption: cultural changes, a population increase, or even an economic crisis.

A sudden, significant change may have occurred with the arrival of an outside cultural group, in this case the Horgen culture, with different eating habits, e.g., greater fish consumption, which could explain the findings in Arbon-Bleiche 3.

However, according to archaeologists specializing in this transition period, the passage from the Pfyn to the Horgen culture resulted more from accumulation than dominant colonization. Important exchanges in the Baden culture highlighted this as the possible reason for the emergence of the Horgen culture in Arbon-Bleiche, (Leuzinger, 2000; De Capitani et al., 2002).

A population increase in the region could explain the growing importance of fishing in Arbon-Bleiche 3, as well as infection with *Diphyllbothrium* sp. But population growth would also impact the size of the villages, for which no archaeological record has been found (Schibler & Chaix, 1995).

The third hypothesis (an economic crisis) can draw on information from such fields as archaeobotany, paleoclimatology, and archaeology. Between the 38th and 33rd centuries BC, the region underwent an important climate fluctuation known in the Alps as Piora 2 or Rotmoos 2 (Zoller, 1977; Jacomet, Magny & Burga, 1995). Precipitation increased and temperatures dropped (Magny, 2004). This climatic phenomenon is visible in sediments in the lakes around the Alps and in the Jura region (Magny, 1992, 1993).

In the sites from this period located around Lake Zurich, this climate change was followed by an increase in hunting. Deer were identified in more than 60% of the archaeozoological remains. In parallel, archaeobotanical

studies showing declining percentages of cultivated grains due to the climate fluctuation, accompanied by an increase in the use of wild plants.

The archaeozoological and archaeobotanical results suggest an attempt at compensating for nutritional losses due to climate change by simultaneously increasing hunting and gathering (Schibler & Chaix, 1995; Schibler et al., 1997).

The Arbon-Bleiche 3 site is situated in the cold period following the period between the 37th and 33rd centuries BC. Inhabitants turned to hunting and fishing to survive this phase of climate crisis, with a drop in grain reserves. Important proportions of bones from game animals were found, particularly deer, with venison representing 50% of the meat consumed by the Arbon-Bleiche population. Fish accounted for 22% of the overall diet (Hüster-Plogmann & Leuzinger, 1995). Wild plants also played an important part in diet, representing nearly 40% of the sustenance of plant origin.

The climate crisis and obligatory return to an economy based heavily on fishing and hunting probably triggered the development of parasitic diseases associated with the consumption of freshwater fish. The paleoparasitological findings appear to corroborate the hypothesis of an economic crisis during the European Neolithic, but cultural changes may have played a greater role in intestinal parasitic infections, especially due to the diversified consumption of fish species (Le Bailly, 2005).

A HISTORY OF PARASITES IN OCCUPATIONS OF ARCHAEOLOGICAL SITES IN BELGIUM

The occupation of the region where the Namur archaeological site is located dates to the Neolithic period, with remains of various origins following a chronological sequence, including the Gallic-Roman (2nd-3rd centuries) and Carolingian periods (9th-11th centuries) and proceeding until the 19th century (Chaves da Rocha et al., 2006).

The region where the current province of Namur is located has always been a strategic location for human presence. Situated where the Meuse and Sambre Rivers join, it was occupied ever since the Neolithic. A first Gallic village developed shortly before the Roman occupation, which established a fort surrounded by the small fishermen's village. Various forts were built from then until the Middle Age, thus characterizing the site as a military zone (for some time there was even a prison there) (Plumier & Vannechelen, 1996). The site includes seven different archaeological contexts. Sediments collected from latrines and other deposits are well-preserved, despite the successive overlaying of occupation layers (Plumier, Mees & Vannechelen, 1997; Loreille & Bouchet, 2003).

Parasites found at the Namur site include eggs from *Ascaris suum*, *Trichuris suis*, *Ascaris lumbricoides*, *Capillaria* sp., *Oxyuris equi*, *Fasciola hepatica*, *Dipyllobothrium* sp., and *Taenia* sp., with a conspicuously high concentration of *Trichuris trichiura* eggs. Species identification drew on statistical treatment, measuring the eggs' length and width. Chaves da Rocha et al. (2006) discussed the findings, showing which structures in the archaeological site had been used as pits to dump household garbage and other waste, latrines with human fecal matter, stables, and cleaning ditches.

The site was the object of the PhD thesis by Gino Chaves da Rocha, who at the time was a doctoral student at the National School of Public Health (ENSP/FIOCRUZ) in Rio de Janeiro, and who spent a year doing thesis research under the Paleoparasitology Laboratory of the University of Reims, with a grant from Programa Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Comité Français d'Évaluation de la Coopération Universitaire et Scientifique avec le Brésil (COFECUB).

Another site studied by the paleoparasitology team from the University of Reims in collaboration with the FIOCRUZ team was the Belgian site of Raversijde, dated to the medieval period, at the time a fishing village. The material

analyzed by Fernandes et al. (2005) was removed from the layer corresponding to the 16th century. The structures were full of organic material, from which 20 samples of sediment were collected (ten each). The archaeology team investigated whether the structures had been used as privies, deposits for human garbage, or waste accumulated from stables or some other source. The paleoparasitological analysis was elucidative, since the *Trichuris* eggs found there were identified (based on their size and shape) as belonging to *Trichuris trichiura*, an exclusively human parasite species, thus revealing the origin of the constructions' content.

FUTURE PALEOPARASITOLOGY RESEARCH IN EUROPE

Much remains to be studied on parasites and their human hosts in Europe. Various questions have still gone unanswered, while others have emerged in the wake of new findings. For example: which infections were brought to Europe by the first humans to arrive from Africa, and where did they spread in the Old World? Which parasites were acquired after the domestication of animals and plants? How many remained as zoonotic infections transmitted occasionally to humans and how many adapted to the new host and diversified into new species? The most interesting questions appear to be: how did parasites change the profile of parasitic infections in the New World? And how did they change the profile of parasitic infections when Europeans left the Old World for the New World? This research perspective raises curious questions, capable of producing knowledge on the evolution of parasitic diseases at different moments in the history of humankind.

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