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Continuity in intestinal parasite infection in Aalst (Belgium) from the medieval to the early modern period (12th-17th centuries)

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ABSTRACT

Objective: To characterize patterns in the taxonomic diversity of parasites infecting the population of Aalst, Belgium, between the 12th and 17th centuries.
Materials: 14 sediment samples from seven cesspits dated 1100–1700 CE.
Methods: Digital light microscopy and Enzyme-linked immunosorbent assay (ELISA).
Results: We identified eggs of four species of helminths: whipworm (*Trichuris trichiura*), roundworm (*Ascaris lumbricoides*), *Echinostoma* fluke and *Dicrocoelium* fluke. ELISA results for protozoal parasites were negative.
Conclusions: Taxonomic diversity of parasite infections remained constant from the 12th to the 17th centuries. Roundworm and whipworm, spread by poor sanitation, were dominant. Two species of zoonotic parasites were also identified, including for the first time ever in the Low Countries the *Echinostoma* fluke, which may have been spread by eating uncooked freshwater animal foods.
Significance: Analysis of sediment samples spanning such a broad chronology (six centuries) from a single city offers the opportunity to track diachronic change, which is rare in paleoparasitological studies.
Limitations: We were unable to acquire samples from cesspits dating to the 14th century.
Suggestions for further research: Additional data from other Low Countries towns may strengthen the patterns identified in this paper. A similar approach can be used to investigate towns in different regions of the world.

1. Introduction

The aim of this study was to see if there was change over time in intestinal parasite infections in the population of Aalst (Flanders, Belgium), using samples spanning the Medieval, Renaissance, and Early Modern periods. Flanders, the northern part of Belgium was, together with northern Italy, one of the most densely populated and urbanized regions in medieval Europe. Ghent, Bruges, and Ypres developed as major Flemish trading centers from the 11th century onwards, followed by Antwerp, Brussels and Aalst (Nicholas, 1992; Verhulst, 1999). During the 12th to 17th centuries, the population density fluctuated in the Low Countries, and trade expanded to the East (Indonesia) and West (Caribbean) (Ervynck and van Neer, 2017; Soens and Thoen, 2010; Van Ittersum, 2006). However, the degree to which these changes could have affected the intestinal health at Aalst remains unknown. It could be hypothesized that parasites can be used as proxies for us to explore cultural practices in these past populations.

There are a number of reasons as to why parasite infection might potentially change over time in the Low Countries. Cesspits dating from the 12th and 13th centuries in Aalst were unlined pits dug into the ground, while from the 15th to 17th centuries more advanced cesspits with a brick lining were commonplace. We might suspect that parasites could spread into the water supply from unlined 12th-century cesspits more easily than in brick lined 16th-century cesspits. If so, we might see a reduction over time in those parasites spread by the fecal contamination of food and drink, such as roundworm, whipworm, and the protozoa that cause dysentery. From a dietary perspective, if there had been a change in the consumption of freshwater fish due to evolving

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dietary preferences and culinary fashions, this could lead to a drop or increase in parasites contracted from eating freshwater fish. From a perspective of migration and travel the presence of parasites not endemic in the Low countries could indicate trade where sailors and merchants contracted these diseases in other regions of the world, and left evidence for them in the cesspits of the Low Countries when they returned.

Past work on ancient parasites has highlighted change in infection patterns over time with modification of their lifestyle, dietary preferences, mobility or sanitation. For example, in neolithic Europe intestinal parasite infection was typically comprised of a mixture of species spread by the fecal contamination of food and drink, along with zoonotic species contracted by consuming wild animals foods (Ledger and Mitchell, 2022). However, by the Bronze Age and Iron Age we see that those farming on dry land sites were heavily prone to parasites spread by ineffective sanitation, and zoonotic parasites from eating wild animals became much less common (Mitchell, 2017). To give another example, in the arid Great Basin and South-West region of North America, hunter gatherer populations from as early as 4800 BCE often have the eggs of thorny headed worms (potentially *Moniliformis clarki*) in their coprolites, and occasionally pinworms eggs were found (Hall, 1977). The thorny headed worms could indicate that they had eaten crickets and become infected by the parasite, or that they had eaten the rodents that had fed on the crickets. However, when the Ancestral Puebloans developed agriculture and lived together in high-density fortified settlements around 1100–1300 CE, thorny headed worm eggs were not present but pinworm infection became widespread (Camacho and Reinhard, 2020). These examples highlight how studies investigating change over time can enlighten us as to which past social changes had a genuine impact upon past health, and which did not.

While a number of past studies have investigated intestinal parasitism in northern Europe during the medieval to early modern period, the majority of past research in the Low Countries has focused on single latrines, or groups of latrines from similar time periods (Appelt et al., 2014; De Cupere et al., 2021; Deforce et al., 2015; Graff et al., 2020; Rácz et al., 2015). The one exception to this has been the thorough study by Rocha et al. (2006), where parasite data was gathered from analysis of sediment layers in a well, pit, drain and latrines from Namur in Belgium dating from the 2nd century CE (Roman Period) to the 19th century. Palaeoparasitological analysis of cesspits from Aalst from consecutive centuries from the medieval to early modern era should provide insight into infection over long periods of time. Given that ecological and sociological changes are known to have taken place over time, we sought to explore whether paleoparasitological analysis could shed light on the potential effects of these changes on the health of the city's inhabitants.

2. Materials

In the 11th century, the city of Aalst (Fig. 1) was a small but dense urban center situated near the eastern border of the County of Flanders. Its location at the intersection of the Dender river and the Bruges - Cologne trading route awarded it political and commercial value (Bouckaert, 2018; De Groote, 2010). In the 12th century, the city had to expand to accommodate its growing population, though some areas within the city walls retained a rural character until the 13th century (De Groote, 2010; De Groote et al., 2004). From the end of the 13th century, stressors imposed on the city, including plague epidemics from 1349 (Roosen, 2017), a major city fire in 1361 (Bouckaert, 2018), and the religious wars of the 16th century (Duke, 1990), caused a degree of demographic stagnation. Aalst was ruled by the Spanish from 1555 to 1713, and then by the Austrians from 1713 to 1792. The industrial revolution occurred here in the 19th century (De Groote, 2013: 24; Bouckaert, 2018). Nevertheless, Aalst was a thriving economic centre between the 15th and 18th centuries, renowned for its specialised crafts, most notably the cloth industry (Courteaux & Martens, 1973), and its monopoly over the trade in hops (Aerts, 1999).

We analyzed sediment samples from seven cesspits from Aalst (Fig. 1; Table 1) spanning a period of six centuries. All cesspits were discovered and excavated between 1999 and 2021 during rescue archeological excavations preceding construction work. Consequently, different excavations teams used different sampling strategies, and we analysed those samples that were available to us. The cesspits originate from three different locations within the 12th-century city walls. The contents of the cesspits from the Stadhuis (town hall) and Hopmarkt site have been extensively studied for cultural objects (ceramics, glass, metal objects, etc.) and organic remains (animal bones, including a large number of fish bones, mollusk shells, seeds and pollen) (De Groote et al. 2004;

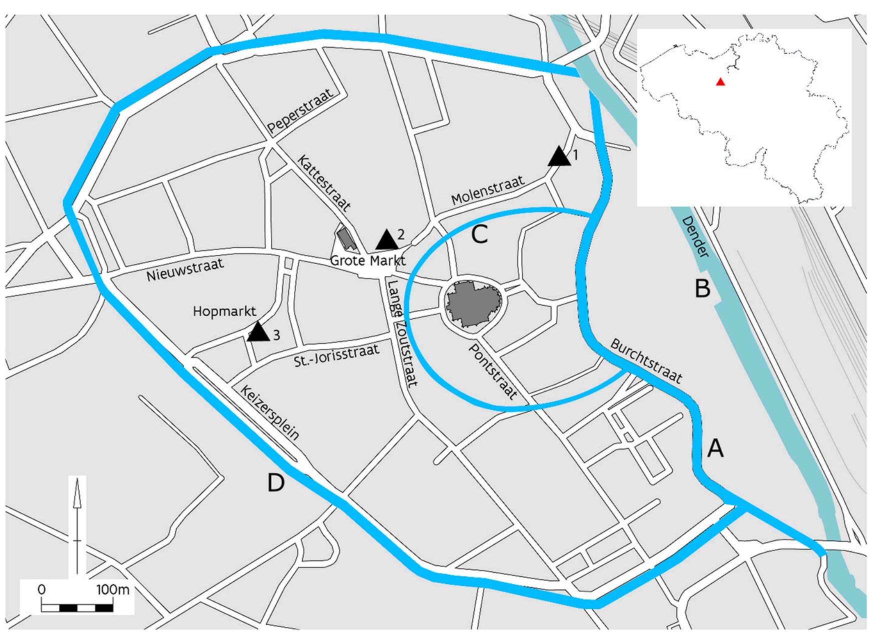

Fig. 1. Location of the sites from Aalst examined in this study:A, ancient course of the River Dender; B, present course; C, first town defence (second half of the eleventh century); D, second town defence (around 1200 CE); 1, Molenstraat; 2, Stadhuis; 3, Hopmarkt. (Map template from De Groote and Moens, 2018).

Table 1
Taxonomic diversity of parasites, with number of eggs given per gram of sediment. Table includes cesspit dates based on material-culture and provenience information.

Location	Start Date	End Date	Feature Type	Feature	Layer	Sample code	*Ascaris*	*Dicrocoelium*	*Echinostoma*	*Trichuris*
Stadhuis	1100	1225	Unlined cesspit	E	3	99/AA.ST/111	90	5	5	195
Stadhuis	1225	1300	Unlined cesspit	I	12	99/AA.ST/116(1)	20	0	5	100
Stadhuis	1225	1300	Unlined cesspit	I	12	99/AA.ST/116(2)	25	0	0	50
Hopmarkt	1400	1500	Brick-lined cesspit	XIV B/A6	36	1	4570	0	5	2330
Hopmarkt	1400	1500	Brick-lined cesspit	XIV B/A6	38	2	3165	0	20	3105
Stadhuis	1450	1550	Brick-lined cesspit	Cesspit 1	6	99/AA.ST/6	315	0	5	515
Stadhuis	1450	1550	Brick-lined cesspit	Cesspit 1	7	99/AA.ST/7(1)	210	5	5	4860
Stadhuis	1450	1550	Brick-lined cesspit	Cesspit 1	7	99/AA.ST/7 (2)	325	0	10	4515
Stadhuis	1450	1550	Brick-lined cesspit	Cesspit 1	7	99/AA.ST/7 (3)	805	20	0	10705
Molenstraat	1500	1600	Brick-lined cesspit	Cesspit 2	741	701	7620	0	5	6605
Molenstraat	1500	1600	Brick-lined cesspit	Cesspit 2	712	711	3310	5	0	1460
Molenstraat	1500	1600	Brick-lined cesspit	Cesspit 2	743	714	4850	5	0	4880
Molenstraat	1600	1700	Brick-lined cesspit	Cesspit 1	571	416	5345	0	0	3205
Molenstraat	1600	1700	Brick-lined cesspit	Cesspit 1	579	416	2865	0	0	2445

2009; 2018; Deforce, 2017; Wouters et al. 2021). Most of the studies of the cesspits from the Molenstraat are still ongoing. The age of the fill of the cesspits was established based on the typology of the cultural finds, mostly ceramics, as this generally allows finer dating compared to radiocarbon dating from the 12th century onwards in the Low Countries (De Groote, 2008). While cesspits are cleaned out when full and then reused, these discarded pottery fragments will date from when the cesspit was reused, and not before it was emptied.

The oldest cesspits, from the Stadhuis site, were unlined pits and date to the 12th and 13th centuries (De Groote et al. 2009). All other studied cesspits were brick-lined pits dating to the 15th, 16th and 17th centuries (Fig. 2). All pits were situated on individual private parcel plots, but it cannot be excluded that these were connected to multiple neighboring households. The oldest cesspits from the Stadhuis site (1100–1300 CE) can be attributed to moderate socio-economical class households, as fish bones of codfish, sea bass and pike have been found, but there were no exotic spices and few remains of luxury ceramics and other cultural objects (De Groote et al. 2009). The more recent cesspits from the Stadhuis site and those from the Hopmarkt site, dated to the 1400–1550 CE, can be attributed to the upper-middle class based on finds of a large range of freshwater fish, exotic spices such as grains of paradise and cloves, several luxury glass and ceramic objects as well as on historical information on these sites and their occupants (De Groote et al. 2004; 2018; de Groote and Moens, 2018). Animal and plant remains from the cesspits from Molenstraat (1500–1700 CE) are still under study, but the cultural finds indicate that these were connected to moderate socio-economical class households (Couchez et al. 2020). However, we should highlight that we cannot know whether people from different socio-economic classes had been using the same cesspits, since both landlords and servants, or different households, were potentially connected to the cesspits at the same time.

From each of the studied cesspits, samples (roughly 2 cm^3) for parasitological analysis were taken from the lower part of the fill that consisted mostly of fecal material.

3. Methods

Here, we use the colloquial term parasites to denote the taxonomic groups helminths (worms) and single celled protozoa. In archaeological samples, the eggs of helminths can be identified and quantified using light microscopy. In contrast, intestinal protozoa that cause dysentery reproduce via cysts or oocysts, which are fragile and deform in

Fig. 2. Examples of Aalst cesspits at excavation, showing serial layers of deposits. A) cross section of unlined cesspit E from Stadhuis (1100–1225 CE); B) unlined cesspit I from Stadhuis (1225–1300 CE); C) brick lined cesspit XIV/BA6 from Hopmarkt (1400–1500 CE); D) brick lined cesspit 2 from Molenstraat (1500–1600 CE). © Flanders Heritage Agency for A, B and C and © SOLVA for D.

archaeological contexts, and so are hard to detect with microscopy. Enzyme Linked Immunosorbent Assay (ELISA) is a biomolecular test that can be used to detect these cysts and oocysts. While many different organisms can cause diarrhoea and dysentery, the three commercially available ELISA kits developed to detect protozoal infections are specific for *Entamoeba histolytica*, *Giardia duodenalis*, and *Cryptosporidium parvum*. ELISA results indicate whether the sample is positive or negative for the species of protozoan being tested but cannot quantify the number of cysts or oocysts present in the way that we can count helminth eggs.

3.1. Microscopy

Analysis was conducted at the Cambridge Ancient Parasites Laboratory using a modified version (Anastasiou and Mitchell, 2013) of the Rehydration-Homogenization-Micro-sieving (RHM) protocol. For each sediment sample, a 0.2 g subsample was weighed and transferred to a 15 mL test tube. Five mL of 0.5 % trisodium phosphate was added to the subsample, which was shaken and vortexed for 30 s then left in suspension for two hours or until the materials disaggregated. The solution containing the subsample was filtered through a set of stacked micro-sieves, measuring 300, 160, and 20 μm, with a catchment container at the bottom. The sediment on each sieve was thoroughly washed with distilled water. The residual sediments from the 300 μm and 160 μm sieves and catchment container were discarded. The eggs of parasites in northern Europe typically measure between 20 and 140 μm in size (Garcia, 2016), so that only the material deposited on the 20 μm sieve was relevant for microscopic analyses. The material deposited on the 20 μm sieve was rinsed free with distilled water, collected into a fresh 15 mL tube, then centrifuged for five minutes at 4000 rpm (3100 x g), or until the supernatant was clear. The supernatant was removed using a pipette, leaving a dark brown deposit at the bottom of the tube. This deposit was diluted with glycerol until light brown, then mounted on microscope slides for digital light microscopy at x400 magnification (Olympus BX40F microscope with GXCAM-9 digital camera). Parasite eggs were identified based on color, morphology, and size, using reference medical manuals such as Garcia (2016).

3.2. ELISA

ELISA kits (Techlab©, Blacksburg) were employed for the detection of the intestinal protozoa *C. parvum*, *E. histolytica* and *G. duodenalis,* which can cause dysentery. 1 g subsamples were disaggregated. Protozoal cysts measure under 20 μm (Garcia, 2016). For this reason, ELISA analysis relies on the material collected in the catchment container under the 20 μm sieve. The manufacturers' protocols were followed for each kit (Cryptosporidium II, E. histolytica II, and Giardia II). Samples were added to a row of eight well plates and combined with primary antibodies that bind to species-specific protozoan antigens (oocyst antigens for *C. parvum*, adhesins for *E. histolytica* and cell-surface antigens for *G. duodenalis*). An enzyme linked to a secondary antibody was then added to the wells. Substrate was added, which in the presence of the antibody-linked enzyme, transforms the solution into a coloured product, the intensity of which can be measured using a spectrophotometer. Colour intensity is broadly proportional to the amount of protozoan antigens. Absorbance values were generated using an ELISA plate reader (BioTek Synergy HT). ELISA positives were based on absorbance values established by the protocol. All ELISA analyses were repeated one month after the first run, and a positive result on both tests was required to regard the sample as positive. Past research has indicated these tests have 96.9–100 % sensitivity and specificity (Boone et al., 1999; Sharp et al. 2001).

4. Results

All 14 sediment samples were positive for parasite eggs. We identified four species of parasites (Table 1): roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*), *Echinostoma* sp. fluke and *Dicrocoelium* sp. (Fig. 3). Roundworm eggs were identified by their oval shape, brown colour, mamillated coat, and dimensions 45–75 μm long and 35–50 μm wide. Whipworm eggs have lemon shape, polar plugs, smooth surface, and dimensions 50–54 μm long and 20–23 μm wide. *Echinostoma* eggs have oval shape, thin transparent eggshell, operculum at one end, no opercular shoulders, and dimensions 86–116 μm long and 58–69 μm wide. *Dicrocoelium* eggs have oval shape, sometimes with one side flatter and the other more curved, have a thick shell, operculum at one end, deep golden brown colour, and dimensions 38–45 μm long and 22–30 μm wide (Garcia, 2016).

Roundworm and whipworm eggs were found in cesspits throughout the chronological series, from 12th to 17th centuries (Table 1). *Echinostoma* and *Dicrocoelium* fluke eggs were found in the 12th to 16th centuries, but not the 17th century (Fig. 4). All four species were found in cesspits thought to have been used by moderate status households (Stadhuis 1100–1300 CE and Molenstraat 1500–1700 CE) and higher status households (Hopmarkt 1400–1500 CE and Stadhuis 1450–1550 CE). There was no relationship between socio-economic status and parasite species. ELISA tests were negative in each cesspit for *E. histolytica*, *G. duodenalis*, and *C. parvum*.

5. Discussion

5.1. Sanitation at Aalst

Roundworm and whipworm were present in every sample (1100–1700 CE). These parasites are acquired from the faecal contamination of food or water. Consequently, their presence is typically interpreted as indicative of ineffective sanitation (Bethony et al., 2006; Zeigelbauer et al., 2012). Previous studies identified a similar pattern in 14th-17th-century Brussels (Graff et al. 2020) and 2nd-19th-century Namur (Rocha et al. 2006). Roundworm and whipworm contribute to malnutrition and anaemia in the affected population, especially in growing children (Bethony et al., 2006).

In both Aalst and Namur, roundworm and whipworm egg counts were much higher than other parasite species. The dominance of roundworm and whipworm eggs in the cesspits of all time periods shows that sanitation based upon cesspits alone was not sufficient to break the cycle of reinfection in the population. Cesspits built in the 12th and 13th centuries were unlined pits dug into the soil, and so sewage could potentially seep into the water supply, especially if located near a well. In contrast, cesspits dating from the 15th to 17th centuries were brick lined, which might have provided some protection against sewage seeping into the water supply. However, our findings would suggest that sanitation in the 1600s was no more effective at preventing intestinal parasite infection than it was during the 1100s. This continuous prevalence of both parasites during this long period can most likely be attributed to the use of the content of cesspits as manure in fields and gardens, which was common practice until the widespread use of the water closet and of synthetic fertilizers at the end of the 19th/early 20th century (Van Oosten, 2015). We did not find evidence for protozoal parasites that cause dysentery, such as *Giardia* and *Entamoeba*, despite positive results at other medieval sites in northern Europe (Mitchell, 2015). A range of options might explain this finding, including that dysentery was rare in Aalst, that dysentery was present in the town but those using these particular cesspits were not infected, or that the environmental conditions did not favor survival of the fragile protozoal cysts to enable modern detection. For example, the protozoal antigens could have degraded, changed their morphology, and failed to bind to the antibodies in the ELISA kits.

5.2. Zoonotic parasites at Aalst

Dicrocoelium was identified in 5 of the 14 analyzed samples, dated 1100–1600 CE, while *Echinostoma* was identified in 8 out of the 14

Fig. 3. Parasite eggs from the cesspits at Aalst. Top left whipworm (dimensions 55 ×25 µm), top right *Dicrocoelium* liver fluke (40 × 21 µm.), bottom left roundworm (69 ×40 µm), bottom right *Echinostoma* sp. (118 × 69 µm).

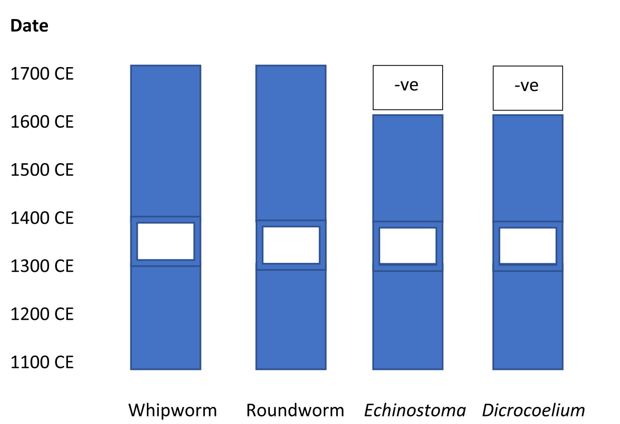

Fig. 4. Graph showing the presence of each parasite species by date. Key: Solid blue shows parasite species present in that century. -ve indicates parasite not identified in samples from that century. Empty white box indicates no samples available dating from that time (1300–1400).

analyzed samples, dated 1100–1600 CE. *Dicrocoelium* and *Echinostoma* are zoonotic parasites, meaning that they can be transmitted between human and non-human animal species; for example, when humans eat raw, undercooked, or preserved foods contaminated with infectious eggs (Ledger and Mitchell, 2022). The presence of *Dicrocoelium* suggests consumption of unwashed edible plants or raw or undercooked ruminant liver (Le Bailly and Bouchet, 2010). The presence of *Echinostoma* most likely indicates consumption of undercooked or preserved freshwater fish, although the parasite's lack of definitive host specificity (Huffman and Fried, 1990: 224; Toledo and Esteban, 2016) suggests that it could also have been contracted from other animals such as amphibians, birds, mammals, mollusks, and reptiles, if eaten raw.

The identification of *Echinostoma* eggs in cesspits dating from 1100 until 1600 indicates the persistent consumption of raw, smoked, dried or pickled freshwater fish or other animals that live in fresh water. Stable isotope analysis of human skeletal remains from 16th-18th-century Aalst detected a distinct signal from the consumption of marine fish, especially in men (Quintelier et al., 2014). This is in accordance with the archeozoological data indicating the importance of sea and fresh water fish in the assemblages of all of the studied cesspits (De Groote et al. 2004; 2009; 2018; Wouters et al., 2021), although this last dataset does not provide information on how fish was prepared and eaten.

Cookery books from the Low Countries indicate that fresh water fish were eaten throughout the medieval and early modern periods (Adamson, 2004, p.141–153; Van Otterloo, 2008). In a 15th-century cookery book, recipes describe the freshwater fish barbel, pike, carp, and also lampreys and eel, which spend part of their life cycles in fresh water (Braekman, 1986). In a 16th-century cookery book recipes use the freshwater fish carp, pike, bream, and gudgeon, as well as lampreys and eels (Jansen-Sieben and Van Winter, 1989). In all these recipes the fish are cooked, and not eaten raw, smoked, or pickled. Therefore, where people were infected by *Echinostoma*, this would suggest that the infection was likely from freshwater foods that had not been thoroughly heated through, and not from deliberate eating of raw fish.

If the population had stopped eating freshwater fish and instead favored sea fish (which cannot transmit the parasite), then we would expect *Echinostoma* to be absent in later centuries. However, the evidence from cookery books and zooarchaeological data indicates this was not the case, and explains why there were low but consistent numbers of eggs from the 12th through the 17th centuries, suggesting continuity in culinary use of freshwater resources.

5.3. Absence of exotic parasites at Aalst

Since the 12th century, cities in the Low Countries traded with other parts of northern Europe, the Mediterranean and Middle East. From the 16th century, they sent merchant vessels to trade across the world in the Caribbean (Dutch West Indies), South America, southern Africa and southeast Asia (Dutch East Indies) (Gaastra, 2003; Hunt, 2005; Page, 1997). However, there were no examples of the eggs of parasites endemic in the tropics, such as Southeast Asian liver fluke (*Opisthorchis viverrini*) or the giant liver fluke (*Fasciola gigantica*) (Wang and Mitchell, 2022). Some examples of exotic parasites have previously been found in Europe from this time period, such as *Schistosoma mansoni* and *S. haematobium* in 15th-century France (Bouchet and Paicheler, 1995; Bouchet et al., 2002). As these species are endemic in Africa and the Middle East, this suggests either the people from those regions travelled to France and used their toilets, or traders from France travelled abroad and became infected. Other such examples of population movement with exotic parasites are known in Russia, China and the USA (Reinhard et al., 2008; Yeh et al., 2016; Slepchenko, 2020). However, no such examples of exotic parasites were found in Aalst. This might indicate that those merchants who travelled to Aalst had not undertaken long distance journeys to other regions of the world, and perhaps the ports of Bruges, Ghent and Antwerp might be more promising locations to find such evidence.

5.4. Social status and parasites

Past stable isotope analysis of skeletal remains from Aalst during the medieval and early modern periods have noted differences in protein intake and seafood consumption between lower and higher status individuals (Palmer, 2019; Quintelier et al., 2014). Those of higher social status appear to have consumed more meat and more marine resources. However, when we assessed intestinal parasites cesspits associated with varying social status at Aalst, we were unable to detect a noticeable difference in parasite species between groups. All four species were found in cesspits thought to have been used by moderate-status households (Stadhuis 1100–1300 CE and Molenstraat 1500–1700 CE) and higher status households (Hopmarkt 1400–1500 and Stadhuis 1450–1550 CE). This could indicate that certain factors that put people at risk of parasite infection were common to both the wealthy and less wealthy. However, we should highlight that we cannot know whether people from different socio-economic classes had been using the same cesspits, such as both landlords and servants, or different households that were potentially connected to the cesspits at the same time.

5.5. Limitations of the study

We were unable to obtain samples from Aalst cesspits dating from 1300–1400 CE, leaving a hiatus in our dataset. A further limitation is that during medieval and early post medieval times cesspits were largely restricted to middle class and upper class households (Evans, 2010), thus limiting our information on parasite infection for the poorest members of the population.

The concentration of eggs in cesspit sediment is also worthy of discussion. Unlike coprolites where egg counts per gram are an approximate indicators of intestinal parasite load, the relationship between egg counts and the number of worms causing infection is much more complicated for cesspits. Multiple people used cesspits, often for decades and sometimes centuries, and the sediment will only reflect a mixture of the feces from those individuals. Some people may have had heavy infection, and others no infection at all. The location where the sediment was sampled may, therefore, affect the egg counts. If one family just used their cesspit for feces and another also added kitchen waste and rubbish to their cesspit, then the latter would dilute their feces and so may appear to have lower egg counts to archaeologists who later examined the cesspit sediment. It is possible that the brick lining from the post 1400 s cesspits may have protected the contents to a degree from decomposition by soil organisms, and so may explain the higher egg counts noted in more recent centuries compared with the unlined cesspits. However, the higher egg counts in later centuries may instead reflect the shorter period of time that has elapsed in which the eggs may be destroyed by taphonomic processes. For all these reasons we have chosen not to statistically analyze changes in egg counts over time, as the result may well not be as meaningful as it might appear at first glance.

6. Conclusion

This study of fourteen samples from seven cesspits dating from 1100 to 1700 CE found remarkable consistency in the species of parasite that affected the population of Aalst during seven centuries. There was a dominance of species spread by poor sanitation. We were interested to see if the change from unlined cesspits in the 12th and 13th centuries to brick lined cesspits in the 15th and 16th centuries had resulted in a reduction in the spread of roundworm and whipworm, but this was not the case. We also found evidence for the consumption of raw or undercooked freshwater fish and other water-living animals over the centuries, indicating that it remained part of the cuisine of the region. We found no noticeable difference between cesspits in wealthy households and those of more modest households. While the population of Flanders is well known for its long distance sea trade with Asia, Africa and the Caribbean, we found no evidence for exotic parasites from these regions. If samples from consecutive centuries can be acquired at other sites, this approach may highlight trends in parasite infection over time that might not otherwise become apparent from single cesspit studies.

Declarations of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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