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## A glimpse into daily life in an Ottoman harbour: Evidence from a cesspit in Ainos (Türkiye)

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### ABSTRACT

The daily life of non-elite people from the past is usually hard to evaluate, since historical sources largely concentrate on the upper classes. This knowledge can be gained by archaeological excavations and use of geo- and bioarchaeological methods. In 2021, geophysical prospections in Enez (Türkiye) revealed a circular stone structure. The excavators identified a latrine probably used from 17th until the 19th century. Palynological, palaeoparasitological and archaeobotanical methods have been applied for understanding the diet, hygiene and diseases of the people using the latrine. The cesspit was a closed round structure with walls made of stones. It had no contamination from outside and was filled with liquid or semi-liquid content with dissolved salts and organic matter derived from urine, faeces, kitchen waste, dung and other rubbish. Results show a broad diet including wheat, chili peppers, olives, spices, a wide range of fruits, meat, fish and oysters. This sanitation did not protect the inhabitants of the house from intestinal parasites in the forms of helminths whipworm, roundworm and the protozoan *Giardia duodenalis* that causes diarrhoea. The data highlight the special role played by the harbour of Ainos in the establishment and possible expansion of new food products from the New World.

### 1. Introduction

Between the 14th and the 19th centuries, the Ottoman Empire dominated the Eastern Mediterranean, from the Balkans to North Africa and the Arabian Peninsula. Controlling this vast territory, it was famous for its strong agrarian policy and the development of trade as well as for rich culinary traditions harmonically blending Central Asian, Persian and Byzantine practices with local influences (Işin, 2018). People under Ottoman control usually preserved their religions and cultures, but very little is known about their daily life (Baran and Carroll, 2002; Carroll, 2002). Questions about daily food, hygiene and diseases cannot be answered easily, since the historical sources largely concentrate on the description of the upper classes from Istanbul and the other major administrative centres (Faroqhi and Neumann, 2003; Işin, 2018;

Yenişehiroğlu, 2020). Instead, this knowledge can be gained by the geo- and bioarchaeological methods applied in archaeological excavations. In particular, water-logged material from cesspits bring rich information about food and diet, environmental conditions, waste disposal, hygiene and disease (Smith, 2013; Kalis et al., 2019). Archaeobotanical and palynological studies on latrines and cesspits have successfully been carried out for the Roman and medieval periods in Italy (Bosi et al., 2011), medieval in the U.K. (Greig, 1981) and Latvia (Brown et al., 2017), medieval and post-medieval in Belgium (Deforce, 2010, 2017; De Cupere et al., 2022), Denmark (Hald et al., 2020), Germany (Hellwig, 1997; Kalis et al., 2005, 2019; Wierzgoń, 2022), Poland (Badura, 2003; Święta-Musznicka et al., 2020), 18th century in Finland (Lempiäinen-Avcı and Kykyri, 2017), just to name a few. Despite the high value of rubbish and cesspit sediments, their studies for the Ottoman period are

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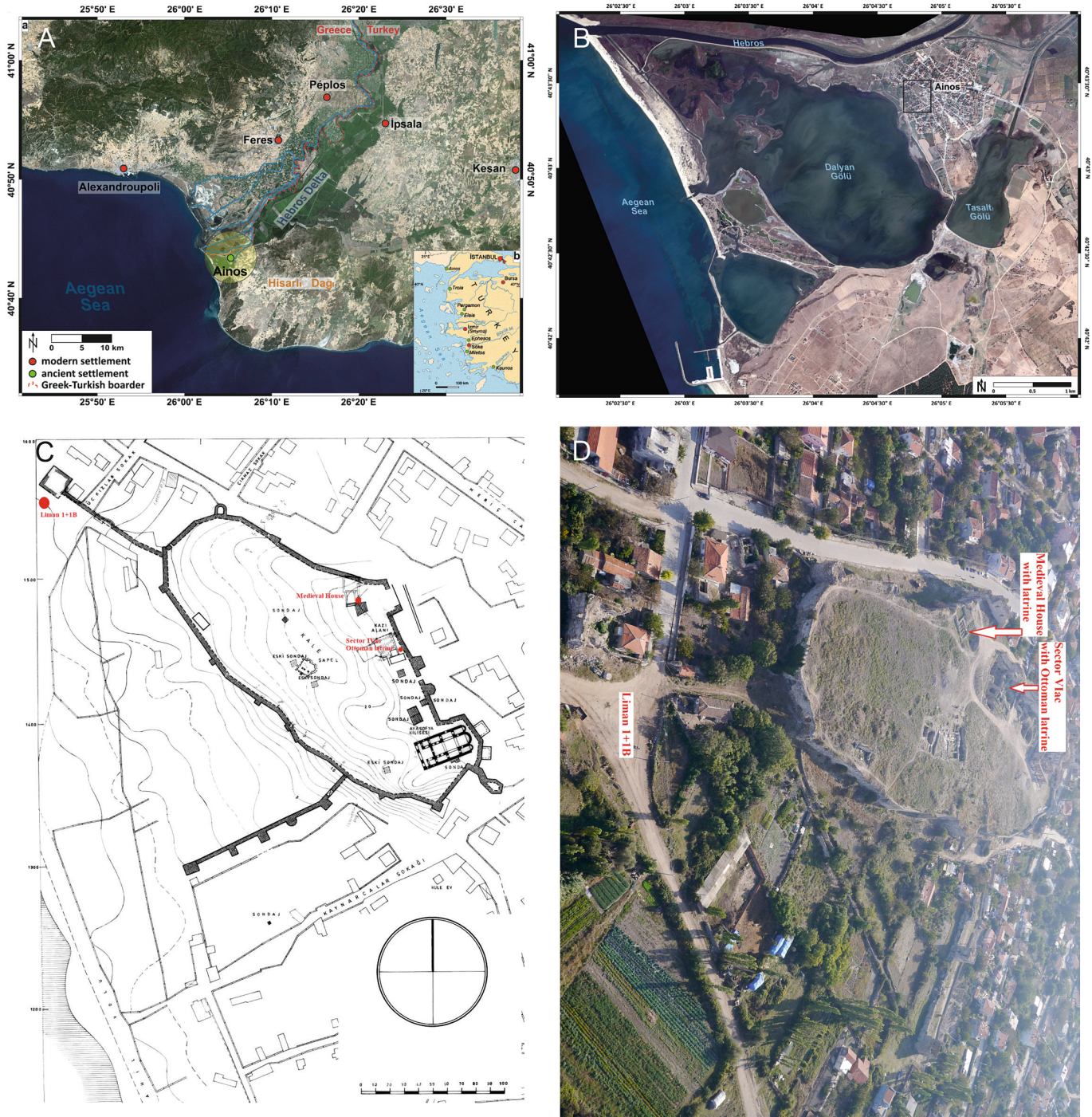
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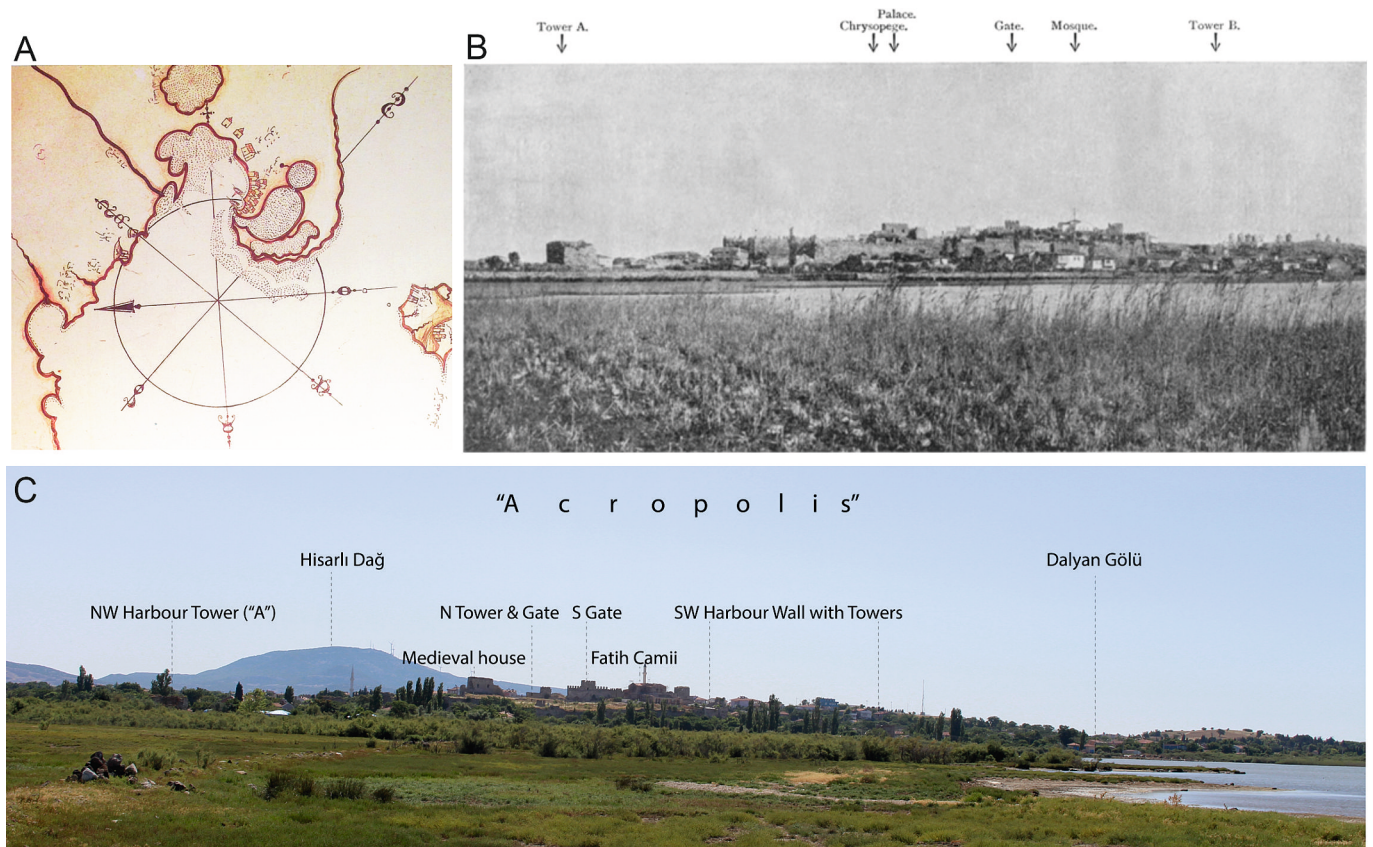
still rare and mainly focused on the ceramics (Vroom, 2006; Vroom, 2007; Van der Veen, 2011). Only one Ottoman public latrine located in modern Israel has been studied from the palaeoparasitological perspective (Eskew et al., 2019).

In 2021, a circular stone structure was detected by ground-penetrating radar (GPR) prospection in the area of the main Byzantine and Ottoman harbour of Ainos (modern Enez) in Thrace at the NW extremity of Türkiye (Fig. 1; Soustal, 1991; Brückner et al., 2015; Dan et al., 2019; Dan et al., 2020; Schmidts et al., 2020). An excavation was organised in order to understand one of the anomalies near a Byzantine

and Ottoman tower (Tower A in Hasluck (1908-1909); tower C in Schmidts et al. (2020); Fig. 2), ca. 85 m NNW from the gate of the urban fortress (Kale in Turkish), above Dalyan Gölü. Today this is the enclosed lagoon that was the city's Byzantine, Genovese and Early Ottoman major harbour and then a fishery. The archaeological excavation revealed a cesspit without connection to a sewage system, which could belong to a domestic latrine. This paper investigates the contents of this cesspit through palynological, palaeoparasitological and archaeobotanical analyses, placing them in their historical and geoarchaeological context, in order to document the lifestyle of the harbour during the Ottoman



**Fig. 1.** Location. A: regional map of the Hebros River mouths, between Türkiye and Greece (based on Seeliger et al., 2018); B: local map of Ainos (modern Enez) (based on Seeliger et al., 2018); C: archaeological plan of the NW part of Ainos with the location of the latrine (red dot, top left, near the Tower A of the Byzantine and Ottoman harbour) and of the two other Byzantine and Ottoman latrines inside the fortress; D: oblique aerial view of the same area with the studied latrine in the left part of the photo ('Liman 1+1b') and the two other archaeological parallels inside the fortress.



**Fig. 2.** Topographical and historical context of Ainos. A: Ainos on an Ottoman map from a manuscript of Piri Reis (Ökte, 1988); B-C: photos from the Dalyan Gölü towards the fortress, taken by Hasluck (1908-1909) (BSA SPHS 01/4586.9425 + BSA SPHS 01/4587.9426) compared with a photo taken in 2019 by Dan et al. (2019); they show the lack of houses on the shore of the Dalyan Gölü in the 20th and 21st centuries, fixing the terminus ante quem for the existence of the latrine at the beginning of the 20th century.

period. It describes the methods and results of the various disciplines involved in this research, from the identification of the archaeological structure by geophysics (ground-penetrating radar), to the excavation of the archaeological contexts and the drilling below the water table that made possible the dating, later confirmed by  $^{14}\text{C}$ , and to the macro- and micro-samples of organic rests, analysed in the lab. Besides the new biological data, the discussion and the conclusion of this article points to the importance of this type of study for the historical archaeology of food and health.

## 2. Material and methods

### 2.1. Geophysical prospection

The GPR measurements were carried out with a GSSI Dual Frequency antenna with centre frequencies of 800 MHz and 300 MHz. A Leica differential GPS system was used for positioning. The investigation areas were covered with up to 60 m long profiles with 30 cm crossline spacing. On each profile, scans were recorded every 5 cm. Parallel 2D profiles were interpolated and binned in a 20 cm  $\times$  20 cm horizontal grid resulting in a 3D data representation. From this data prism horizontal sections (“time slices”) were cut parallel to the modern ground. They represent the GPR reflection strength at the corresponding depth and were plotted as maps, from which horizontal contours of ancient building remains – including a circular structure – can be recognized.

### 2.2. Sampling and dating the archaeological site

Above the circular structure (cesspit) revealed by the GPR, two excavations of 2 m  $\times$  2 m each – “Liman 1” and “Liman 1B” – were opened

one after the other. When the excavation had reached 2.10 m below surface (b.s.) and had to be stopped due to the groundwater table, the sediment core Ain 156 (from 2.10 to 3.62 m b.s.) was obtained from the circular cesspit. The borehole was drilled with the Cobra pro vibratorer from Atlas Copco (inner diameter of the augerheads: 5 cm; Brückner, 2011; Brückner and Gerlach, 2020).

Starting from the top of the organic-rich deposits, sediment samples were obtained using subjective strategy for different analyses (Table 1).

Dating Ottoman structures is difficult, due to the vague chronologies of the lead-glazed ceramics never studied in Ainos and to the wide intervals of the  $^{14}\text{C}$  age estimates. All the ceramic fragments were collected, classified according to shape and compared with analogous productions from Çanakkale, Iznik, Istanbul and Didymoteicho (Bakirtzis, 1980; Atasoy and Raby, 1989; Liaros, 2018).

In addition, seeds and fruits collected directly from the excavation layers and from the core Ain 156 were  $^{14}\text{C}$ -dated (Supplementary Data 1). The ages were calibrated using IntCal2020 (Reimer et al., 2020). The uncertainty of the calibrated radiocarbon ages was constrained in a Bayesian sequence-deposition model in OxCal v4.4.4 (Bronk Ramsey, 2008, 2009, 2021), which uses the stratigraphic order of the samples to constrain the age uncertainties. Samples that were taken at the same depth were combined into one age for the age-depth model using the R\_Combine function in OxCal. The ages at specific depths were approximated by interpolating between the modelled ages of samples located above and below these targeted depths (Supplementary Data 6).

### 2.3. Botanical macroremains

Seven sediment samples with volume of 100–500 ml were obtained for the analysis of botanical macroremains (Table 1, Supplementary

**Table 1**

Overview of collected samples and maintained analyses. Studied and reported here samples are notified by +, preliminarily studied by (+).

Sample ID	Depth below surface (cm)	Site	Context	<sup>14</sup> C	Macroremains	Wood	Palynology	Protozoal parasites
Liman 1 US7	185	Liman1 + 1B	Cesspit	+	+		+	
Liman 1 US7	190	Liman1 + 1B	Cesspit	+	+		+	
Liman 1B US7	170–210	Liman1 + 1B	Cesspit	+	+			
Liman 1	170–190	Liman1 + 1B	Cesspit			+		
Ain 156A	210	Liman1 + 1B	Cesspit		(+)			
Ain 156A (1)	210	Liman1 + 1B	Cesspit	+	+	+	+	
Ain 156A (2)	210	Liman1 + 1B	Cesspit		(+)			
Ain 156 (3)	210	Liman1 + 1B	Cesspit	+	(+)		+	
Ain 156/1	228–234	Core Ain 156	Cesspit				+	+
Ain 156/2H	234–240	Core Ain 156	Cesspit	+			+	+
Ain 156/3	240–245	Core Ain 156	Cesspit			+	+	+
Ain 156/4	245–252	Core Ain 156	Cesspit	+			+	+
Ain 156/5	252–256	Core Ain 156	Cesspit	+			+	+
Ain 156/9	296–300	Core Ain 156	Sands	+				
Ain 156/11	355–362	Core Ain 156	Sands	+				

Data 2). In the laboratory, they were sieved with water through a sieve with 125 µm mesh size. Four samples of different stratigraphic position have been studied under 1× – 50× magnification. Identifications of seeds and fruits are based on Cappers et al. (2006), Neef et al. (2012), Cappers and Bekker (2013) and the reference collection of seeds and fruits of the University of Göttingen. Identification of fly puparia were carried out under a light microscope with 1× – 50× magnification using Carruthers and Smith (2020). Thin sections of wood fragments (Supplementary Data 3) were prepared and identified in water under light microscope with 400× – 1000× magnification using Schweingruber (1990) and Akkemik and Yaman (2012).

#### 2.4. Palynology

Four archaeobotanical samples from the cesspit excavation and five samples from the core Ain 156 were palynologically analysed (Table 1). Laboratory treatment included 10 % HCl, cold 48 % HF over two nights, sieving through 6 and 200 µm, and 3 min of acetolysis. One tablet containing known numbers of *Lycopodium* spores (Batch number 177745; 18584 ± 371 spores) was added at the beginning of the treatment in order to calculate the concentration of palynomorphs (Stockmarr, 1971). The samples were studied under 400× – 1000× magnification. The eggs of intestinal parasites were viewed in slides documentation of pollen and non-pollen palynomorphs alongside (Supplementary Data 4). Eggs were identified using Lardín and Pacheco (2015), pollen using Beug (2004), and non-pollen palynomorphs using NPP-ID (Shumilovskikh et al., 2022).

#### 2.5. Protozoan parasites

Five sediment samples from the sediment core AIN 156 (Ain 156/1 to Ain 156/5; Table 1) were studied using enzyme-linked immunosorbent assay (ELISA) to detect common protozoan parasites that cause diarrhoea and dysentery (*Giardia duodenalis*, *Entamoeba histolytica*, and *Cryptosporidium parvum*). The commercially available test kits were produced by TECHLAB® (Blacksburg, Virginia, USA), where antibodies are designed to bind specifically to antigenic proteins unique to each species. They have been shown to possess 96–100 % sensitivity and specificity (Boone et al., 1999; Garcia and Shimizu, 1997). 1 g from each sample was disaggregated in 0.5 % trisodium phosphate solution to create a suspension and poured through a micro-sieve stack with mesh sizes of 300 µm, 160 µm, and 20 µm. The ELISA analysis was performed on the component that passed through the 20 µm sieve, as the cysts and oocysts of *Giardia*, *Entamoeba*, and *Cryptosporidium* measure 5–19 µm in diameter (Garcia, 2016). The sieved suspension underwent centrifugation to concentrate it to the volume required to fill the ELISA microassay plate wells. Samples 1–4 were tested in 8 wells, while sample 5 was tested in 6 wells. Absorbance values were determined using a BioTek

Synergy HT ELISA plate reader set to 450 nm. Positive and negative results were determined as per the absorbance values recommended by the manufacturer. The analysis was performed twice on different dates using different sediment subsamples to ensure reproducibility of the findings (Supplementary Data 5).

### 3. Results and interpretation

#### 3.1. Geophysical prospection: Location and dimensions of the cesspit

The horizontal GPR sections are represented by maps of GPR reflections originating from ~ 1 m (Fig. 3a) and 2 m (Fig. 3b) depth underneath a road crossing, ca. 22 m SE from the Byzantine Tower A (Fig. 1C-D) and ca. 40 m NE from the last visible remains of Ainos' Byzantine and Ottoman harbour basin (Fig. 2B-C). The patterns of GPR reflections show rectangular structures, which can be interpreted as remains of a complex of densely spaced small buildings. The excavation, centred on one of the spot-like GPR reflections showing up at ~ 1 m depth (Fig. 3b), revealed stones of different sizes around a circular cesspit. The GPR reflections from these stones interfered with the reflections from wall remains and made the recognition of the archaeological remains more difficult than usual, especially in the uppermost metre.

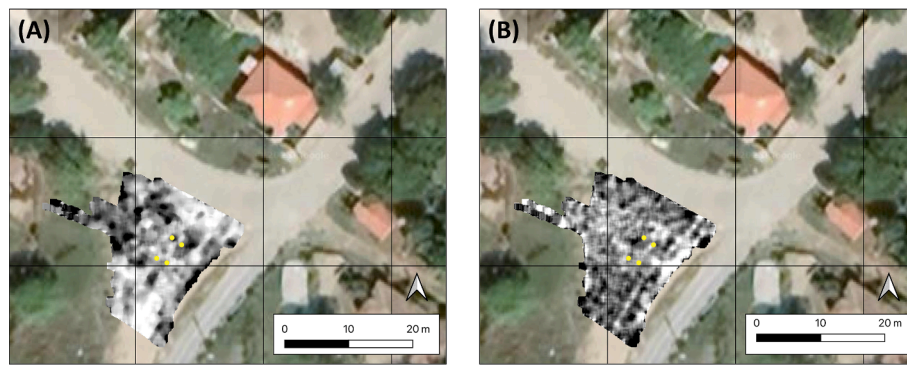
#### 3.2. Stratigraphy and chronology

##### 3.2.1. Archaeological excavation Liman 1 and 1B

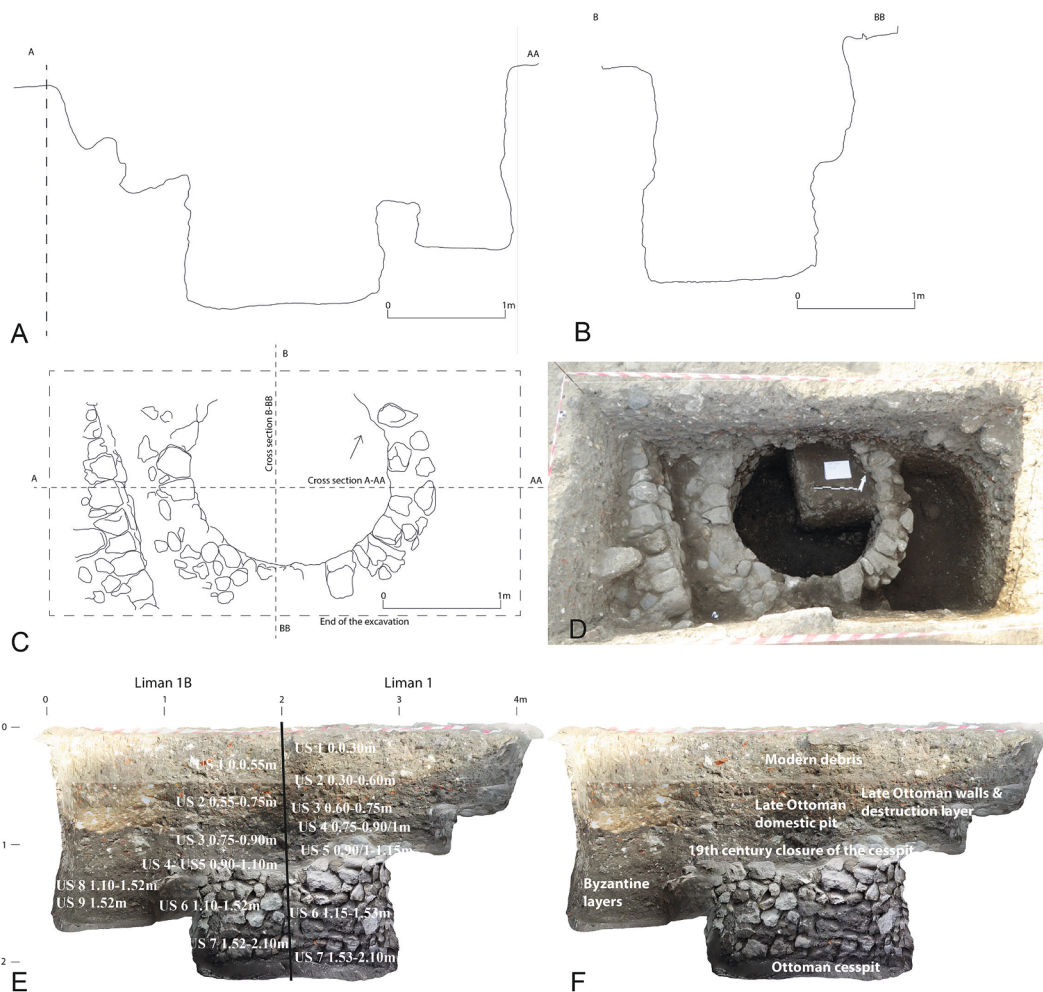
The excavation, which started at a level of 2.53 m above sea level (a.s.l.), revealed remains of the wall of a late Ottoman domestic building, with two phases of construction, as well as the latrine containing two main layers. The stratigraphy of the excavation (Fig. 4) is as follows:

0 – 0.55/0.60 m below surface (b.s.) (Liman 1/US 1–2; Liman 1B/US 1 [US, abbreviation for “Unité stratigraphique”, French for “Stratigraphic Unit”]): layer of big, regular block stones (up to 0.4 m) and debris (including important quantities of ancient ceramics) piled up with a backhoe by the Enez Town Hall in the 1970s–1980s, according to local witnesses. The filling levelled the ruins of the Ottoman houses to the ground and drained the swamps. The first traces of houses are visible at a depth of 0.55–0.60 m.

0.55/0.60 – 0.75 m (Liman 1/US 3–4; Liman 1B/US 2–3): at the E end of the excavation, in a direction NNW-SSE, roughly parallel to the old shore of the Dalyan Gölü, there is one row of stones, which superposes an earlier wall, from which two rows of stones were uncovered. This older wall served as foundation for the latest phase of the building (whose soil can be seen at –0.55–0.6 m). The house was covered with fragmented tiles together with pieces of wood, fish and animal bones, nails and an iron hoe. An important mass of Late Ottoman shards of big storage containers, cooking pots, amphorae, pitchers, plates, some of



**Fig. 3.** GPR horizontal sections mounted into air photographs, excavation corners indicated by yellow dots: (a) depth slice at ~ 1 m depth from 300 MHz records; the latrine shows up as a dark spot. (b) depth slice at ~ 2 m depth from 800 MHz records; it shows that the latrine is placed within a complex of densely spaced small rectangular buildings. Background images from Google Earth (© Maxar Technologies). UTM coordinates of upper left corner: E422110 m, N4508680 m.



**Fig. 4.** The excavation: A-B drawing of the vertical profiles; C plan of the structure by photogrammetry; D orthophoto at the end of the excavation; E identification of the stratigraphic units (US) with depths; F interpretation of the contexts.

them unglazed, others with simple patterns incised in the clay, many with dark green or yellowish glaze, or with white wave-bands and points or plates of the white-blue “Iznik” type were uncovered (Supplementary Fig. 1). Two smoking pipes of clay and several fragments of glass vessels were also found. Notable are some overburnt ceramic rests and metallic tripod stilts suggesting that ceramic kilns could have been situated in this neighbourhood. At the S extremity of the Liman 1 excavation, the whole layer was cut by a small pit for domestic garbage, with traces of

fire. It had a maximum diameter of 0.60 m and went down to 0.70–1 m. It must be dated to the end of the 19th-beginning of the 20th century, during the last phase of occupation of the house, when the latrine was already out of use.

0.75 – 0.90 m (Liman 1 US4, Liman 1B US3): soil corresponding to the earliest wall and to the last period when the latrine was in use and then finally closed with debris including construction materials (wood) and 19th century shards of kitchen ceramics, tableware, and various

containers of local production, reflecting the modest lifestyle of the inhabitants.

0.90/1 – 1.10/1.15 m (Liman 1 US 5; Liman 1B US 4–5): the circular structure is a cesspit with an internal diameter of 1.5 m and an external diameter up to 2.5 m. The walls are made of one row of stones, ca. 0.5 m large; the internal face is regularly cut, the external face is rough. The pit is totally filled and closed with stones, tiles, mortar and big wood fragments with nails (which could have been part of the latrine, when it functioned). They are mixed with an important quantity of common Late Ottoman pottery (mostly of the 19th century), including fragments of dark-green glazed and unglazed containers as well as tableware, glass vessels and rare intrusions of fine Byzantine *sgraffito* tableware.

1.15–1.52 m, outside the circular structure, to the W (Liman 1B US 8–9): a heterogeneous sandy layer of domestic debris, including fish and animal bones and shells, wood, nails, tiles, bricks and various ceramics, predominantly Byzantine (12th–15th centuries) and early Ottoman (15th–17th centuries). There are also a few traces of ancient fine ceramics. Seven tripods or fragments of tripods used in ceramic kilns, one of them with traces of Ottoman dark-green glaze, were found, confirming the proximity of ceramic workshops. This early Ottoman layer was cut by the digging of the cesspit, probably in the 17th century.

1.15–2.17 m, inside the circular cesspit (Liman 1 US 6–7; Liman 1B US 6–7): the stone walled cesspit is filled with decomposed faeces and significant quantities of plant remains, oyster shells, numerous tiles of different shapes and sizes, some nails, a bronze bead, and Ottoman ceramics with some Byzantine intrusions. Chalk lime incrustations can be observed on several shards, roughly dated to the 19th century. The most important stratigraphic feature, at ca. 1.52 – 1.70 m below surface, is a layer of smaller stones and pebbles, bricks and tiles, with fragments of mortar and a stratum of chalk lime. Under this consolidated layer, which distinguishes two major phases in the use of the latrine, the fragments of fine Byzantine tableware become more numerous, accompanying the Ottoman dark-green and dark-brown glazed tableware, burnt cooking pots, big unglazed containers decorated by pinching but also brownish-glazed pots and pitchers (including a piece of kiln waste). These ceramics (Supplementary Fig. 1) show that the upper, latest layer of use of the latrine must be dated to the 19th century while the layer below 1.52–1.70 m may have been filled progressively in Ottoman times, between 17th and 19th centuries.

At 2.17 m, the maximum level was reached in the Liman 1 excavation due to high groundwater table.

### 3.2.2. Coring Ain 156 below bottom of excavation Liman 1

Ain 156 has four lithological units (Fig. 5A): unit A (0 – 0.45 m below excavation bottom, b.e.b.) represents the inferior layer of the filling of the circular cesspit and contains mixed ceramic fragments, datable between Antiquity and Early Ottoman times; unit B (0.45 – 0.86 m b.e.b.) contains several layers with big stones; unit C (0.86 – 1.50 m b.e.b.) is composed of shallow marine and littoral sands, possibly from a beach; unit D (1.50 – 2.00 m b.e.b.) represents weathered bedrock (limestone with layers of greenish grey clay).

### 3.2.3. Radiocarbon ages and age-depth model

Radiocarbon ages (Supplementary Data 1) demonstrate that the bottom sediments in core Ain 156 date to 664–877 CE. The filling of the circular cesspit started in the 17th century (Fig. 5B).

## 3.3. Macroremains

### 3.3.1. Seeds and fruits

In total, 343 to 870 specimens and 40 identified taxa of fruits and seeds were obtained. The assemblage of botanical macroremains is largely dominated by seeds and fruits of edible plants (Fig. 6, Supplementary Data 2), mainly presented by woody endocarps such as fig (*Ficus carica*), grape (*Vitis vinifera*), plums and cherries (*Prunus avium*, *P. armeniaca*, *P. cerasus*, *P. domestica*, *P. spinosa*) and cornelian cherry

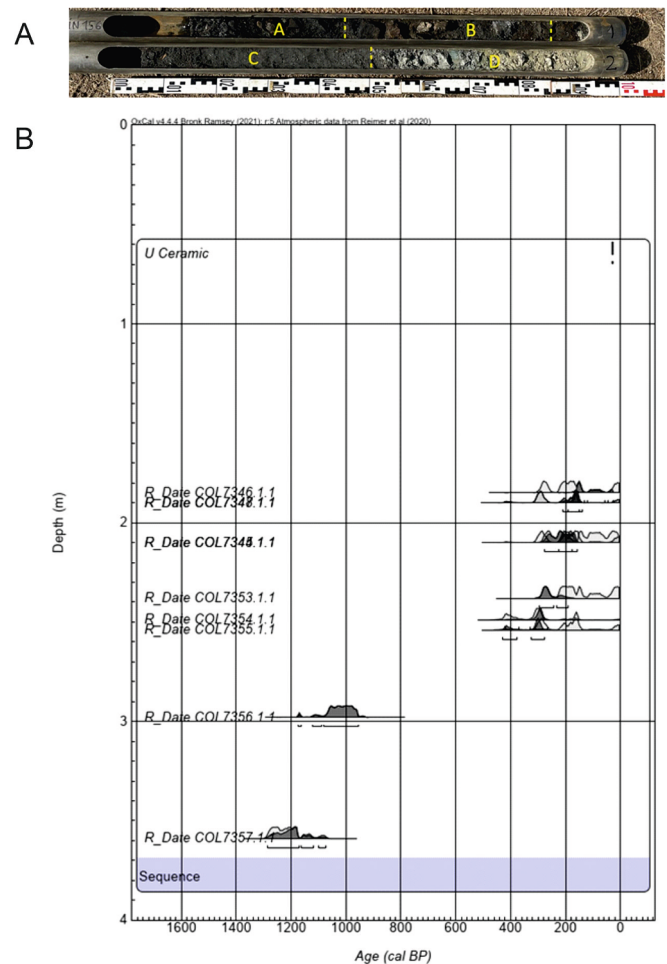
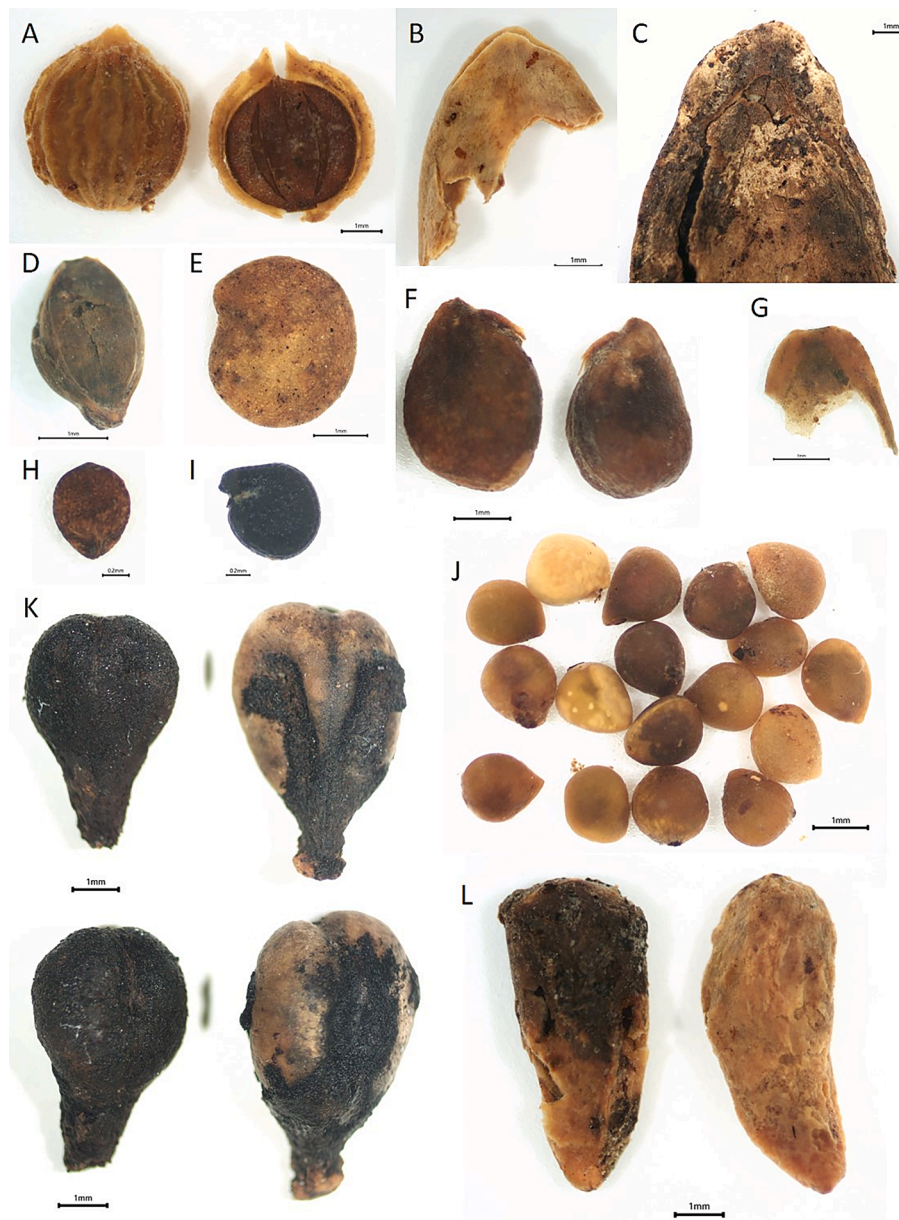


Fig. 5. Lithology and chronology. A: photo of the core with lithological units. B: Age-depth model for sediment core Ain 156 and excavation Liman, resulting from Bayesian deposition modelling with OxCal v4.4.4 (Bronk Ramsey, 2008, 2009, 2021). Age uncertainties are provided with 2-sigma intervals.

(*Cornus mas*). A few seeds of pomegranate (*Punica granatum*) and a few fruits of white mulberry (*Morus alba*) were found. Crops are presented by only one charred grain of bread wheat (*Triticum aestivum/durum*). While olives (*Olea europaea*) and cucumber (*Cucumis sativus*) are rare, seeds of *Capsicum annuum* are present in all samples. Seeds of water melon (*Citrullus lanatus*) and melon (*Cucumis melo*) are also common. Coriander (*Coriandrum sativum*), mint (*Mentha* sp.) occur in several samples indicating their possible usage as spice. *Portulaca oleracea* (purslane) could potentially be eaten as a cultivated or wild plant. Fruits of *Rubus caesius* and *R. fruticosus* occur occasionally. Single finds of wild plants are present in all the samples and include *Carex*, *Chenopodium album*, *Cyperus fuscus*, *Fumaria officinalis*, *Galeopsis*, *Heliotropium*, *Hyoscyamus niger*, *Polygonum*. The assemblages of botanical macroremains are very similar between samples. Only the sample Liman 1B US7 shows exceptionally good preservation and high numbers of endocarps. This might be related either to a single deposition of fruit remains or to post-depositional processes, e.g. accumulation of endocarps caused by a flotation during high water stands.

### 3.3.2. Zoological remains

Zoological remains include fly puparia, beetle fragments, molluscs and numerous fish remains (Fig. 7, Supplementary Data 2). Fly puparia were identified and reveal a wide range of species related to cesspits or kitchen wastes. The highest abundances reach *Thoracochoeta zosteriae* (seaweed or cesspit fly), followed by a carrion feeder *Calliphora*



**Fig. 6.** Fruits and seeds: A *Coriandrum sativum* (Ain 156A(1)); B *Cucumis melo* (Ain 156A(1)); C *Citrullus lanatus* (Liman 1B US7); D *Setaria* sp. (Ain 156A(1)); E *Capsicum annum* (Ain156 A(1)); F *Morus alba* (Ain 156A(1)); G *Cucumis sativus* (Ain 156A(1)); H *Mentha* sp. (Ain 156A(1)); I *Portulaca oleracea* (Ain 156A(1)); J *Ficus carica* (Ain 156A(1)); K *Vitis vinifera* (Ain 156A(1)); L *Punica granatum* (Ain 156A(1)). Scale 1 mm.

vomitoria (rural bluebottle) and fruit fly *Drosophila*, associated with waste of fruits. Further finds include carrion feeder *Lucilia caesar*, drain fly *Psychoda alternata* and *Fannia* cf. *scalaris*.

### 3.4. Wood

Thirteen wood fragments from three samples were studied and four species were identified (Supplementary Data 3). Oak (*Quercus* sp.), belonging to the natural vegetation, is the most frequent find. Wood and bark of scotch pine (*Pinus sylvestris*) correlate well with the palynological diagram from the coring Ain 50, showing the expansion of pine in the last few hundred years, most possibly due to Ottoman plantations (Dan et al., 2019, 2020). Findings of fir wood (*Abies*) indicate its transport from mountain areas. Wood of *Vitis* indicates possible cultivation of *Vitis vinifera* in the garden, which is in accordance to pollen data (s. 3.6); however, use of *Vitis sylvestris* wood from local riverine environment cannot be excluded.

### 3.5. Parasites

All studied samples included eggs of intestinal parasites (Fig. 8, Supplementary Data 4). The assemblage is dominated by roundworm *Ascaris* (4,000–18,000 eggs/cm<sup>3</sup>) and whipworm *Trichuris* (3,000–18,000 eggs/cm<sup>3</sup>). These parasites are spread by the contamination of food, water or hands by faeces (Garcia, 2016). In addition to whipworm and roundworm, lancet fluke (*Dicrocoelium*) was present in the latrine in Ainos from 1655 to 1760 (Ain156/2) upwards. Its adult stage lives in the bile ducts of cattle, goats, sheep and deer (Le Bailly and Bouchet, 2010). These herbivores become infected by eating infected ants located on the grass that they consume. Finding the eggs of *Dicrocoelium* in human faeces indicates pseudo-parasitism, due to a consumption of animal liver infected by lancet liver fluke. Intestinal egg assemblages change through time. *Dicrocoelium* is absent in the lower part (Ain 156/3–5, 240–256 cm, dated to ~ 1520–1736) and appears from the sample Ain156/2 (dated to ~ 1660–1776) upwards. This may



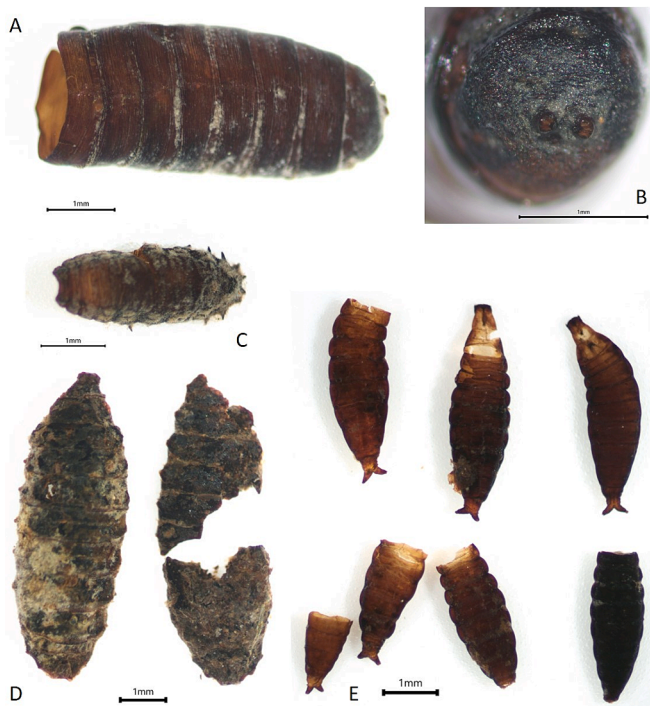


Fig. 7. Fly puparia: A, B) *Calliphora vomitoria* (Ain 156A(1)), C) *Fannia cf. scalaris* (Ain 156A(1)), D) Diptera, puparia indeterminata (Ain 156A(1)), E) *Thoracochoaeta zosterae* (Ain 156A(1)). Scale 1 mm.

indicate either a start of the infection of the animals or a change in the human diet with the introduction of liver into the cuisine in the 17th–18th centuries.

In three of the five samples, namely 156/2, 156/4 and 156/5, ELISA analysis was positive for the protozoan *Giardia duodenalis*, which causes diarrhoea (Supplementary Data 5). Results were negative for *Entamoeba histolytica* and *Cryptosporidium parvum*.

### 3.6. Pollen and fungal spores

In total, 54 pollen types and 1 sporophyte spore have been identified. Pollen concentration in the samples is rather low varying between 6,000 and 21,000 pollen/cm<sup>3</sup> (Supplementary Data 4). The pollen spectra are dominated by Poaceae and Cerealia-type, accompanied by *Pinus diploxylon*-type, Chenopodiaceae and *Centraurea jacea*-type. Diverse herbs and trees have occasional occurrence. Further palynological findings include a wide spectrum of coprophilous fungi, e.g. *Podospora anserina*-type, *Sordaria*-type, *Sporormiella*-type, and spores of plant parasites, dominated by *Tilletia caries* (Supplementary Data 4).

## 4. Discussion

### 4.1. Ainos, its population and cesspits

From Antiquity until the 19th century, the peninsular harbour of Ainos was an important commercial hub between the northern Aegean Sea and the Hebros River (Fig. 1). The progressive siltation of the lagoons which once served as harbours, fishing ponds (Turkish: *dalyan*) and salt marshes, the progradation of the Hebros' delta and the end of all riverine navigation determined the economic collapse and the isolation of the late Ottoman and then Turkish city of Enez (e.g. Grisebach, 1841). As a consequence, in the later part of the 19th century and the first quarter of the 20th century, a part of Ainos' population emigrated to the northern shore of the Hebros delta, at Dedeğaç (known as Alexandroupoli since 1920). In 1923, the fixation of the national border and the

exchange of population between Türkiye and Greece put an end to Ainos' Greek history. Turkish families arrived in various waves during the 20th century from the Balkans and Eastern Anatolia; they knew nothing about the life of their predecessors.

In the late Ottoman period, the houses built around the larger harbour of Ainos, which had become a fishing lagoon (Dalyan Gölü), formed the *Kato Machalas* – the “lower neighbourhood”. They may have been inhabited by families whose work was related to the harbour, such as traders, fishermen, ship-constructors, or potters (Greek *tsoukalades*), who still exported large and rough ceramic vessels throughout the Aegean at the beginning of the 20th century (Hasluck, 1908–1909). Since the map of Piri Reis and the photographs made by F.W. Hasluck show no building west of the tower, on the dock of the Byzantine and Ottoman harbour (Fig. 2), one must conclude that all the structures observed in the excavation date from the 17th century onwards and were destroyed and buried before 1908.

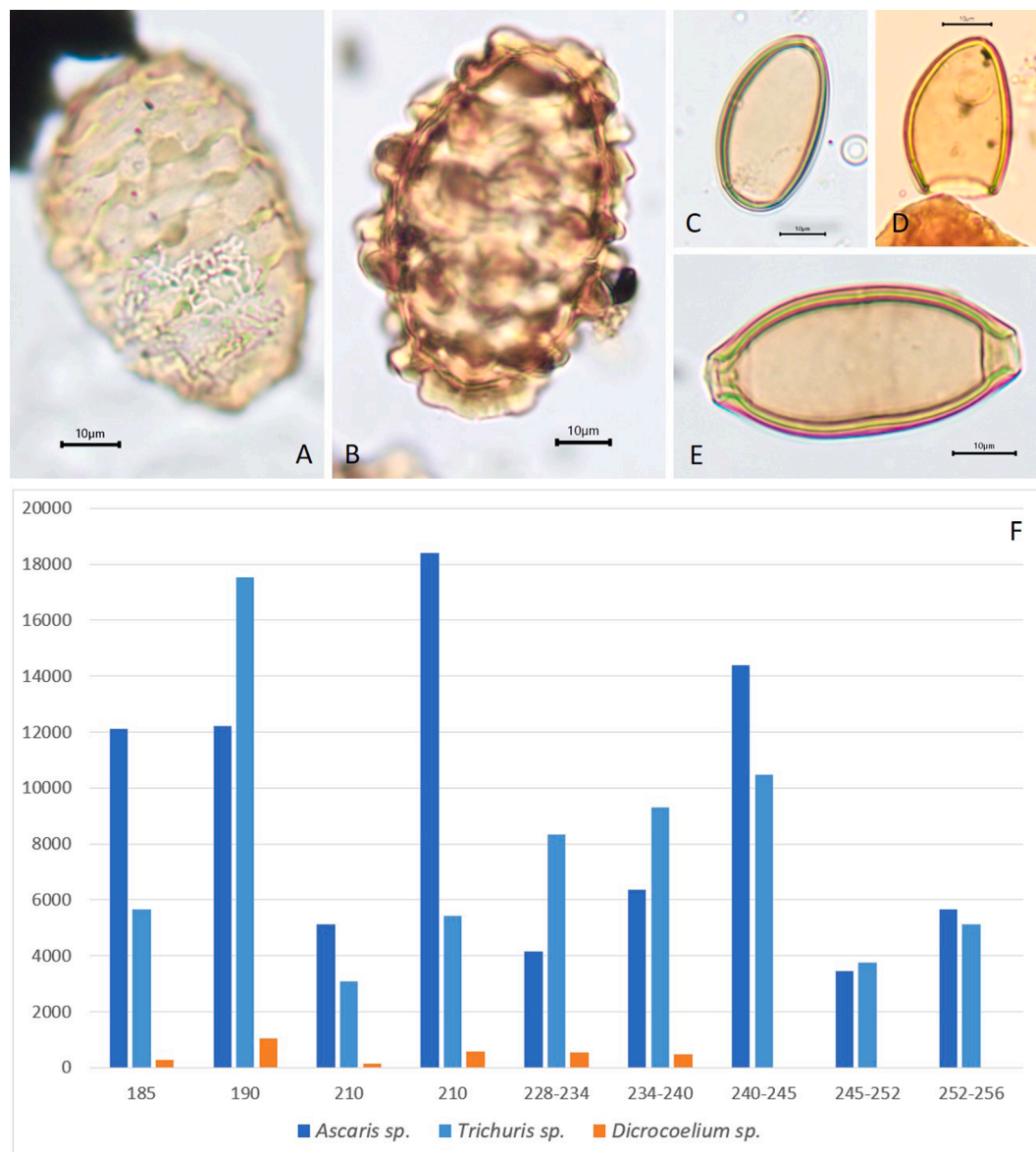
The archaeological excavations revealed a round cesspit constructed in the 17th century in a domestic neighbourhood of the Dalyan Gölü harbour, which was already in decay judging by the Ottoman map attributed to Piri Reis (Fig. 2A). At that time, the sea-level was ca. 0.3–0.5 m lower (Seeliger et al., 2021). The cesspit was dug into Early Ottoman and Byzantine deposits (Liman 1B US 8–9, Fig. 4). The groundwater table of the 17th century was probably reached by the constructors and covered with the layer of stones identified in the core Ain 156 (Unit B; Fig. 5). Such stone base and walls are characteristic for medieval cesspits and are particularly useful when the house was situated in a muddy environment. Besides the testimonies of travellers and locals, traces of the houses in this neighbourhood can be observed on the GPR profiles (Fig. 3). However, the geophysical and archaeological data are not sufficient to reconstruct their plans and the form of the latrine which could cover this cesspit.

From previous archaeological excavations, it is known that the tradition of latrine construction in Ainos continued from the Byzantine period (Başaran, 2011; Yeşil et al., 2017). For example, in the “Medieval house” (Fig. 1D), a squared latrine pit, 1 m × 1 m, was excavated (Başaran in Yeşil et al., 2017) with 12th–14th centuries glazed Byzantine ceramics and Venetian glass vessels (Canav-Özgümtüş and Kanyak, 2017). Another Ottoman latrine, excavated in 1998 inside the fortress (Fig. 1D), offers the best parallel and has roughly the same chronology as the excavation presented here: the pit of oval shape contained Ottoman ceramics and a funerary stone dated to the 17th century (Başaran, 2000; Başaran, 2001; Başaran, 2002). Apart from the archaeological findings, the filling of these latrines has never been studied by natural scientists. All that can be said is that they contributed to the hygiene of the Byzantine and Ottoman city.

### 4.2. Taphonomy and deposition practices for cesspit

All the analysed samples were obtained from the organic-rich layers in the cesspit (s. 3.2, Table 1). Most macroremains are subfossil organic rather than mineralised, suggesting preservation in a waterlogged environment (Figs. 6, 7). The studied macroremain samples were rather small (0.1 – 0.5 l), resulting in 343 to 870 specimens and a total of 40 identified taxa of fruits and seeds. Extrapolated concentration of seeds and fruits in the sediment might reach 1740–3430 specimens/litre. Higher sample volume could potentially (but not necessarily) result in a higher number of species (Jacomet and Kreuz, 1999). For comparison, 36 plant taxa were identified in 2 l of sediment from a Medieval cesspit of 10th–11th centuries in Italy (Bosi et al., 2011).

Fly puparia shed light on the depositional environment. The puparia of *Thoracochoaeta zosterae* (seaweed or cesspit fly), mainly found with seaweed on the coasts, often occur in semi-fluid ‘filth’, which contains a high level of dissolved salts and organic matter derived from urine and cess (Carruthers and Smith, 2020). *Psychoda alternata*, normally associated with bacterial mats and sludge in wet or damp areas and decaying vegetation, is commonly associated with clogged plumbing, pooled



**Fig. 8.** Eggs of intestinal parasitic worms: A: roundworm (*Ascaris* sp.), egg with bacterial degradation (Ain 156A(3)); B: *Ascaris* sp., showing mammillated coat (Ain 156A(3)); C-D: *Dicrocoelium* sp., eggs (Ain 156–2, Ain 156A(3)); E: whipworm (*Trichuris* sp.). (Ain 156A(3)); F: concentration of eggs of intestinal parasites (number/ml). Scale 10  $\mu$ m.

water, sewage and cesspits in archaeological contexts (Smith, 2013). *Fannia scalaris* is primarily associated with semi-liquid faeces and urine often of humans and pigs since filiform processes are thought to allow flotation (Carruthers and Smith, 2020). These findings indicate that the environment was liquid to semi-liquid and rich in salts from urine and faeces, allowing perfect organic preservation conditions. As water-level fluctuations cannot be excluded, the associated decay of fragile seeds, fruits and palynomorphs should be considered.

Archaeobotanical analysis reveals dominance of food plants and occasional presence of wild herbs (Supplementary Data 2). The assemblages are dominated by non-digested remains of figs, cherries and plums, which are typical of latrine assemblages (Greig, 1981) and owes most likely to preferential preservation due to their robust, woody structures (Smith, 2013). Food remains from latrines represent only part of the original diet (e.g. Jacomet and Kreuz, 1999). The components were fragmented during food preparation, dissolved by secretions of the gastrointestinal tract, or degraded after the deposition by oxidation and coprophagy. Many plants lack the archaeobotanical record because the fleshy parts of the fruits are eaten before the seeds ripen, or if roots and

rhizomes are eaten. In addition, puparia of fly species indicate occasional disposal of decaying corpses and kitchen waste. *Drosophila* sp. documents vegetable or fruit waste, *Lucilia caesar* and *Calliphora vomitoria* – carrion. The latter one, rural bluebottle, is a carrion feeder, usually associated with cadavers in the early stages of decay or with decaying meat and/or food waste (Carruthers and Smith, 2020).

Beside human faeces and kitchen waste, the medieval latrines in Europe were used as rubbish pit for disposal of garbage from fields, garden or stable (e.g. Greig, 1981; Jacomet and Kreuz, 1999; Bosi et al., 2011). Although the occasional presence of wild herb species (Supplementary Data 2) questions the deposition of hay or weeds in the latrine, spores of *Tilletia caries*, a common parasite of wheat, rye and other grasses, causing common bunt, suggest deposition of infected grasses and/or inedible cereals. Taxonomically rich assemblage of coprophilous fungal spores (Supplementary Data 4) indicates deposition of dung or decayed plant material, because the aggressive chemical environment of the latrine would not allow fungal growth in situ (Schlütz and Shumilovskikh, 2017). Presence of bark and wood fragments speak for occasional deposition of wooden waste, while ceramic

fragments speak for kitchen rubbish. Taken together, the finds indicate that the cesspit contains human faeces together with kitchen waste, dung and other rubbish.

Interpretation of pollen in this cesspit is less straightforward. It has been demonstrated that the pollen content in cesspits generally results from the intentional or unintentional ingestion with food plants, plant-based drinks, drinking water and rubbish thrown in the cesspits, while atmospheric pollen deposition can be assumed to have been minimal or almost zero in the closed environment (Greig, 1981; Kalis et al., 2005, 2019; Brown et al., 2017; Deforce, 2010, 2017; De Cupere et al., 2022). However, pollen can only rarely be used as direct indicators of food and diet. For example, dominance of Cerealia-type in cesspit of Ainos can possibly result from cereal-based food, rubbish from cereal processing, dung or hay containing wild grasses with Cerealia-type pollen (Beug, 2004). *Zea mays* can indicate maize plantations in surroundings or digestion of corn. Pollen of *Castanea*, *Corylus*, *Juglans*, *Olea* and *Vitis* might indicate horticulture in Ainos or wild trees around, being indirect indicators of food range. Pollen from insect-pollinated plants could originate from honey but also from weeds or cultivated plants.

#### 4.3. Food and diet evidenced from the cesspit at Ainos in their historical context

The knowledge on the Ottoman culinary tradition is largely based on historical materials like travel books, medical books, poems, paintings and cooking books, rather than on ceramics and archaeobotanical studies (e.g. Işin, 2018; Vroom, 2023). Due to a lack of similar context to the Ottoman latrine of Ainos, we discuss our findings in historical context by comparison of the data to different sources (Table 2). Vroom (2023) analysed the ingredients listed from a 19th-century Turkish cookbook containing 253 recipes. The cooking book includes 120 ingredients with the 10 most-used being salt, butter, pepper, onions, sugar, eggs, mutton, flour, lemons and cinnamon (Vroom, 2023). A compilation of food consumption habits in Ottoman culinary culture from travel books (Ağaoğlu et al., 2022) shows a wide variety of plant and animal products used in the Ottoman cuisine. Grisebach (1841) did not provide details about the culinary habits of the Enez population but described small gardens with pomegranates, fig and olive trees and other noble southern fruits, as well as wheat and vegetable fields and pastures with horses and camels in the vicinity. Archaeobotanical studies only rarely cover the Ottoman period. Dry-preserved material was investigated from hearth samples at Kaman-Kalehöyük, Central Anatolia (Fairbairn, 2006), and from burnt areas and the ground floor at the Komana excavation, north-central Türkiye (Pişkin and Tatbul, 2015). In both studies, the assemblages demonstrate unintentionally discarded kitchen remains. These data cannot be directly compared to the findings from cesspit, reflecting remains after a digestion. We should also keep in mind that a single cesspit from Ainos might not be representative for the entire city. An evaluation of the results will hopefully be possible in the future, when new data from similar contexts become available.

As expected, the spectrum of foods from the latrine in Ainos is much smaller than reported by travellers or culinarian books (Table 2). However, our data provide unique details on diet of latrine users. A charred grain of *Triticum aestivum/durum* possibly reached the latrine with the kitchen waste, indicating the consumption of bread wheat. Wheat in form of bread, boiled grain, bulgur or soup is well attested in the Greek cities of the Ottoman Empire (Balta, 1992) and was commonly used, as evidenced by historical (Işin, 2018) and archaeological data (Fairbairn, 2006; Pişkin and Tatbul, 2015). Another possible starch provider is foxtail millet (*Setaria* sp.). It has three species in Türkiye – cultivated *S. italica* and wild *S. viridis* and *S. verticillata* – occurring in archaeological contexts of the Iron Age and the Roman period (Nesbitt and Summers, 1988). Poor preservation in the Ainos latrine hampers the identification to the species level. However, the use of Italian millet (*S. italica*) is documented in written sources since Roman times. It was

used as admixture to bread or beans, which were usually eaten by the poor (Spurr, 1983). Coming from the America, maize (*Zea mays*) enters and rapidly established in the regional cuisine as early as in the 17th century, especially in the mountainous Black Sea region (Işin, 2018). The pollen data (Supplementary Data 4) show that also in Ainos local cultivation of maize took place from the beginning of the introduction of these new products.

The position of the harbour of Ainos at the forefront of New World food expansion is underlined by finds of chili pepper (*Capsicum annuum*) in the cesspit assemblages already in the 17th-18th centuries. Its seeds appear already in the lowest sample Ain 156A(1), confirming the dating of the pit filling to post-Columbian times. *Capsicum annuum* originates from South America; it was introduced in Europe in the 16th century. It was consumed in the Ottoman Empire as part of the Mesoamerican food complex, having reached south-eastern Europe by way of Portuguese Africa, India, and the Ottoman Empire in the aftermath of the Columbian voyages. The Ottoman Empire, especially Anatolia, adopted a wide range of American crops and foods such as peppers, squashes, maize and beans, which were more popular in the Balkans than in Iberia (Andrews, 1993). The influence of the Ottoman Empire in expansion of new exotic foods is reflected by names e.g. ‘Turkish wheat’ for maize, ‘Turkish gourd’ for pumpkin, ‘Turkish beans’ for *Phaseolus* species (Işin, 2018). The harbour of Ainos seems to have been one of the hubs for the establishment and spread of new cultivated species.

A wide variety of vegetables and fruits were traditionally eaten raw in the Ottoman Empire (Işin, 2018). In the cesspit of Ainos cucumber is evidenced in one sample, most likely due to taphonomical reasons. In contrast, diverse fruits are presented by figs (*Ficus carica*), grapes (*Vitis vinifera*), cherries (*Prunus avium*, *P. cerasus*), plums (*Prunus domestica*), apples (*Malus* sp.), apricots (*Prunus armeniaca*), Cornelian cherry (*Cornus mas*), white mulberries (*Morus alba*) and pomegranates (*Punica granatum*). Watermelon (*Citrullus lanatus*), melon (*Cucumis melo*) and walnuts (*Juglans regia*) were also on the table. All these fruits were most likely grown in own gardens as reported Grisebach (1841), which is in line with the developed horticulture known in the Ottoman Empire (Işin, 2018). In addition, wild fruits like blackberry (*Rubus fruticosus*) and dewberry (*Rubus caesius*) were part of the rich fruit diet.

Oil plants are represented by a single olive (*Olea europaea*) endocarp and a pollen grain. With its sub-Mediterranean climate, Enez has olives in its gardens, but no big plantations. This might be a reason of the poor presence of fruits. The use of olive oil possibly imported through the harbour is nevertheless indirectly attested by the fragments of oil ewers and of big ceramic containers. Seeds of purslane (*Portulaca oleracea*) do not allow to differentiate between cultivated and wild forms. Both can be used for food in form of salad or cooked like spinach (Kučan, 1995), while seeds can be eaten occasionally. White goosefoot (*Chenopodium album*) belongs to potentially used wild edible plants. The record of herbs and spices is very limited to mint (*Mentha* sp.) and coriander (*Coriandrum sativum*). The latter is also documented for Central Anatolia (Fairbairn, 2006). Also, sweets in form of honey or honey products are suggested by pollen of insect-pollinated plants.

Seafood finds point to the special character of the diet in Ainos, where the Greek population was largely dominant in Ottoman times. The users of the latrine consumed high amount of fish, indicated by numerous finds of fish scales and bones. The small size of the fish remains suggests different anchovies; however, identification is required for a proper evaluation of the fish in the diet. Shells found by archaeological excavation indicate consumption of oysters. Seafood was probably regularly consumed by the fishermen of Ainos since Antiquity, although marine products are not typical for the Ottoman culinary traditions (Ağaoğlu et al., 2022; Vroom, 2023). Işin (2018) connects the variety of seafood in the Ottoman cuisine from the 15th century to the increased Byzantine influence after the conquest of Constantinople in 1453. From animal products consumed in the house, there is only indirect evidence of consumption of meat by fly puparia of carrion feeders and of liver by eggs of lancet liver fluke. The appearance of its eggs in the

**Table 2**

Comparison of Ottoman culinary culture from travel books (Ağaoğlu et al., 2022; Grisebach, 1841), Turkish culinary book (Vroom, 2023), archaeobotanical data of Ottoman period (Fairbairn, 2006; Pişkin and Tatbul, 2015) to the finds of this study from the latrine in Ainos. Abbreviations: BM – botanical macroremains, F – fly pupa, P – pollen, IP – eggs of intestinal parasites, ZM – zoological macroremains.

		Ağaoğlu et al. (2022)	Grisebach (1841)	Vroom (2023)	Fairbairn (2006)	Pişkin and Tatbul (2015)	This study
<b>Bread and grains</b>							
<i>Hordeum vulgare</i>	Barley	+			BM	BM	
<i>Oryza sativa</i>	Rice	+		+			
<i>Panicum miliaceum</i>	Millet	+			BM		
<i>Secale cereale</i>	Rye	+			BM	BM	
<i>Setaria</i> sp.	Foxtail millet						BM
<i>Triticum aestivum/durum</i>	Wheat	+	+	+(flour)	BM	BM	BM
<i>Zea mays</i>	Maize	+					P
<b>Legumes</b>							
<i>Cicer arietinum</i>	Chickpea				BM		
<i>Lens culinaris</i>	Lentils	+			BM	BM	
<i>Pisum sativum</i>	Peas	+					
<i>Vicia ervilia</i>	Ervil				BM		
<i>Vicia faba</i>	Broad beans	+					
<b>Vegetables, oil plants and salad</b>							
<i>Abelmoschus esculentus</i>	Okra	+					
<i>Allium cepa</i>	Onion	+		+			
<i>Allium sativum</i>	Garlic	+		+			
<i>Beta vulgaris</i>	Beet	+					
<i>Brassica oleracea</i>	Cabbage	+					
<i>Brassica oleracea</i>	Cauliflower	+					
<i>Brassica rapa</i>	Turnip	+					
<i>Capsicum annuum</i>	Chili pepper	+					BM
<i>Cucumis sativus</i>	Cucumber	+					BM
<i>Cucurbita</i> sp.	Pumpkin	+					
<i>Foeniculum vulgare</i>	Fennel	+					
<i>Lactuca sativa</i>	Lettuce	+					
<i>Olea europaea</i>	Olive	+	+				BM, P
<i>Portulaca oleracea</i>	Purslane						BM
<i>Raphanus sativus</i>	Radish	+					
<i>Solanum lycopersicum</i>	Tomato	+					
<i>Spinacia oleracea</i>	Spinach	+					
<b>Fruits and berries</b>							
<i>Citrullus lanatus</i>	Watermelon	+					BM
<i>Citrus × limon</i>	Lemon			+			
<i>Cornus mas</i>	Cornel cherry						BM
<i>Cucumis melo</i>	Melon	+			BM		BM
<i>Ficus carica</i>	Fig	+	+		BM		BM
<i>Malus</i> sp.	Apple	+			BM		
<i>Morus</i> sp.	Mulberry	+					BM
<i>Prunus armeniaca</i>	Apricot	+					BM
<i>Prunus avium/cerasus</i>	Cherry	+					BM
<i>Prunus persica</i>	Peach	+					
<i>Prunus domestica</i>	Plum	+					BM
<i>Punica granatum</i>	Pomegranate	+	+				BM
<i>Pyrus</i> sp.	Pear	+			BM		
<i>Rubus caesius</i>	Dewberry						BM
<i>Rubus fruticosus</i>	Blackberry						BM
<i>Vaccinium oxycoccus</i>	Cranberry	+					
<i>Vitis vinifera</i>	Grape vine	+			BM	BM	BM, P
<b>Nuts</b>							
<i>Castanea</i>	Chessnut						P
<i>Corylus</i> sp.	Hazelnut	+		+			P
<i>Juglans regia</i>	Walnut	+					BM, P
<b>Spices, herbs and salt</b>							
<i>Brassica nigra/Sinapis alba</i>	Mustard	+					
<i>Cinnamomum</i> sp.	Cinnamon			+			
<i>Coriandrum sativum</i>	Coriander				BM		BM
<i>Crocus sativus</i>	Saffron			+			
<i>Cuminum cyminum</i>	Cumin	+		+			
<i>Laurus nobilis</i>	Bay leaves			+			
<i>Mentha</i> sp.	Mint	+		+			BM
<i>Metroxylon sagu</i>	Sago			+			
<i>Myristica</i> sp.	Nutmeg			+			
<i>Myrtus communis</i>	Myrtle leaves			+			
<i>Origanum majorana</i>	Marjoram			+			
<i>Petroselinum crispum</i>	Parsley			+			
<i>Papaver</i> sp.	Poppy seed	+					
<i>Piper nigrum</i>	Black pepper			+			
<i>Thymus</i> sp.	Thyme	+		+			

(continued on next page)

Table 2 (continued)

		Agaoğlu et al. (2022)	Grisebach (1841)	Vroom (2023)	Fairbairn (2006)	Pişkin and Tatbul (2015)	This study
<i>Vitis vinifera</i>	Vine leaves			+			
–	Salt	+		+			
<b>Animal products</b>							
–	Cheese, yogurt, butter	+		+			
–	Eggs	+		+			
–	Fish		+				ZM
–	Liver						IP
–	Meat (mutton, chicken, turkey)	+		+			F
–	Milk	+					
–	Oyster						ZM
<b>Drinks</b>							
<i>Coffea</i> sp.	Coffee	+		+			
–	Water	+					
–	Raki	+					
<b>Sweets</b>							
<i>Ceratonia siliqua</i>	Carob	+					
–	Halva	+					
–	Honey desserts	+					(P)
–	Sugar			+			

17th century suggests the ingestion of contaminated herbivore livers. The practice of eating fried liver (tava ciğer) is famous among the Turkish population in the Edirne region to this day. Here we should mention that the main focus of this study lays on results of archaeobotanical and palynological analyses. Future identification of insect imago, bone fragments and fish remains would definitely broaden our picture of the diet of the latrine users. Overall, the data highlight a wide variety of products and supposedly a rich diet, indicating possibly good health of the people using the latrine.

#### 4.4. Hygiene and disease in Ainos

Grisebach (1841), who travelled in the Balkans in 1839, noted that Ainos was one of the cleanest and best built cities he visited in the Ottoman Empire. Perhaps the use of latrines has contributed to such a praise impression. People used latrines in the houses for collecting of excrement and kitchen waste in a specific place. Furthermore, the inhabitants of the house used sand, broken molluscs and charcoal (s. 3.2.1 and Supplementary Data 4), possibly against smell and/or flies (Smith, 2013). The sample Ain 156A(2), consisting of calcareous material, possibly represents an artificial layer of lime to improve hygiene or odour.

The use of latrines did not protect the inhabitants of the house from intestinal parasites in the form of helminths and protozoa that cause diarrhoea. Parasitological evidence reveals that they were infected by whipworm (*Trichuris*), roundworm (*Ascaris*) and *Giardia duodenalis*. All three species are characterised by a faecal-oral transmission, indicating contamination of food or water with faecal material (Garcia, 2016; Lardín and Pacheco, 2015). This may indicate that the drinking water supply was contaminated by faeces, that flies spread faeces onto food, or that human faeces were used as a crop fertiliser (Jones, 2012).

If we consider which of the parasites found in this population was likely to have had the greatest health impact (Mitchell, 2023), this would be the *Giardia*. Giardiasis causes diarrhoea, abdominal cramps, malabsorption and weight loss. Most who die from *Giardia* are children, but in those who survive a proportion can experience stunted growth, reduced intelligence and failure to thrive (Halliez and Buret, 2013; Ryan et al., 2019). Whipworm and roundworm infections can lead to malnutrition, anaemia and stunted growth in children with severe infections, but those with mild infections are asymptomatic and these helminths do not often cause death (Brooker, 2010).

Previous parasite research in Türkiye has found whipworm dating back to the Chalcolithic period at Çatalhöyük (Ledger et al., 2019). Roundworm, whipworm and *Giardia duodenalis* have been identified at

Roman period sites such as Sagalassos, Ephesus, Elaia/Pergamon and Sardis (Ledger et al., 2018; Shumilovskikh et al., 2016; Williams et al., 2017). The earliest known evidence for *Giardia* in the world comes from the Middle East, in two cesspits in Iron Age Jerusalem from the 7th to 6th centuries BCE (Mitchell et al., 2023). The only other example of an Ottoman latrine that has undergone parasite analysis is located in Acre, Israel, and dates to the early 1800s. The cesspit sediment contained evidence for roundworm, whipworm, fish tapeworm (*Dibothriocephalus* sp.), beef or pork tapeworm (*Taenia* sp.), lancet liver fluke (*Dicrocoelium* sp.) and two protozoa that cause diarrhoea and dysentery, *Giardia* and *Entamoeba* (Eskew et al., 2019). The Acre cesspit shows a broader range of parasites than does the latrine at Ainos, with Acre including zoonotic parasites that infect humans after they eat undercooked meat and fish (Ledger and Mitchell, 2022). In contrast to the users of the Acre toilet, for the users of the Ainos cesspit, inadequate sanitation was responsible for all the intestinal parasites.

## 5. Conclusions

The interdisciplinary research on the Ottoman cesspit in Ainos provides rare evidence for the everyday life of its users. The latrine was probably built in the 17th century in a densely populated neighbourhood and remained in use until the late 19th century, being closed before the abandonment of the house, probably at the beginning of the 20th century. Deposition of human faeces occurred together with kitchen waste, dung and possibly other rubbish. A broad diet with bread, vegetables, fruits, nuts, spices, meat, fish and honey is evidenced by the archaeobotanical and palynological data. The high number of seeds of chili pepper (*Capsicum annum*) indicates its use in the Ottoman Ainos. Together with maize (*Zea mays*), it highlights the special role of the harbour of Ainos in the establishment and possible further expansion of new foods from the New World. Although sanitation in the Ottoman Empire was better than in many regions of Europe, latrine users were affected by helminthiasis (*Ascaris* and *Trichuris*) and giardiasis (*Giardia duodenalis*). Inadequate sanitation was responsible for all the intestinal parasites.

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### CRedit authorship contribution statement

**Lyudmila Shumilovskikh:** Writing – original draft, Investigation, Conceptualization, Visualization. **Anca Dan:** Writing – original draft, Visualization, Investigation, Funding acquisition. **Piers D Mitchell:** Writing – review & editing, Investigation. **Tianyi Wang:** Investigation. **W. Marijn van der Meij:** Investigation. **Jean-Baptiste Houal:** Investigation. **Sait Başaran:** Investigation. **Türker Arslan:** Investigation. **Ercan Erkul:** Writing – review & editing, Visualization, Investigation. **Simon Fischer:** Investigation. **Wolfgang Rabbel:** Writing – review & editing, Visualization, Investigation, Funding acquisition. **Felix Reize:** Investigation. **Helmut Brückner:** Writing – review & editing, Visualization, Investigation.

### Declaration 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.

### Data availability

[Supplementary files](#)

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### Appendix A. Supplementary material

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