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The pattern of ancient parasite egg contamination in the private residence, alley, ditch and streambed soils of Old Seoul City, the Capital of Joseon Dynasty

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ABSTRACT

We report on our most recent archaeoparasitological examination of soil samples from 15th to 19th century Old Seoul City in Korea. The sediments were taken from the area in front of the Joseon Dynasty *Jongmyo Shrine*, which was situated at the juncture of a private residence, alley, side gutter and stream. The soils exhibited signs of serious parasitic contamination suggesting that the Old Seoul City inhabitants were particularly vulnerable to infection. The numbers of parasite eggs in the Joseon strata differed according to the sector: *Trichuris* and *Ascaris* eggs were found in the streambed, alley, and side gutter samples; none were discovered in the samples from the private house. We speculated that people tried to make their houses and workplaces clean, though resigned to unavoidably contaminated streets, alleys, and streams. The results of the present study offer, for the first time, a clear and detailed snapshot of contemporary Old Seoul City inhabitants' lives.

1. Introduction

Pioneering researchers have shown that archaeoparasitological studies of historical towns and cities, especially the discovery and examination of parasite eggs in soil samples, can provide invaluable knowledge of the parasitic infection patterns and of everyday life in historical societies (Monckton, 1995; Bouchet et al., 2003; Matsui et al., 2003; Fernandes et al., 2005; da Rocha et al., 2006; Mitchell et al., 2008; Reinhard and Araujo, 2008). Pre-modern cities in many parts of the world seem to have been similarly affected, which we would expect to have predisposed the inhabitants to contracting intestinal parasites (Easton, 1964; Taylor, 2005).

When Old Seoul City (Korean: *Hanseong*) was founded in the late 14th century as the capital of the Joseon Dynasty (1392–1910), its districts and streets were meticulously designed to impart an air of dignity befitting its status as the Kingdom's political and cultural center. Historical documents indicate that the city's population was as large as 200,000 by the mid-17th century, making it, one of the most populous cities in the world at that time (Shin et al., 2011). Thankfully, despite serious damage to the historical districts incurred under Japanese occupation (1910–1945), the subsequent Korean War and Korea's tumultuous 20th-century modernization, the original urban layout remained preserved underground (Fig. 1A) These remains have been examined or restored during recent archaeological projects, which included a series of archaeoparasitological studies. Our studies have indicated that the inhabitants were most likely heavily infected by soil-transmitted parasites, as reflected the unhygienic conditions prevailing there and throughout the world at that time (Shin et al., 2011).

Nonetheless, the archaeoparasitological examinations conducted to date are not sufficient to reveal any detailed picture of Joseon society and its parasitic infection patterns. These data afford views only of main-street and stream areas; high-population-density precincts, where common people from all walks of life interacted in large numbers have been relatively neglected. In this regard, we were fortunate to have an opportunity to examine soil samples from the marketplace in front of *Jongmyo Shrine*, which was a very busy intersection of Joseon society.

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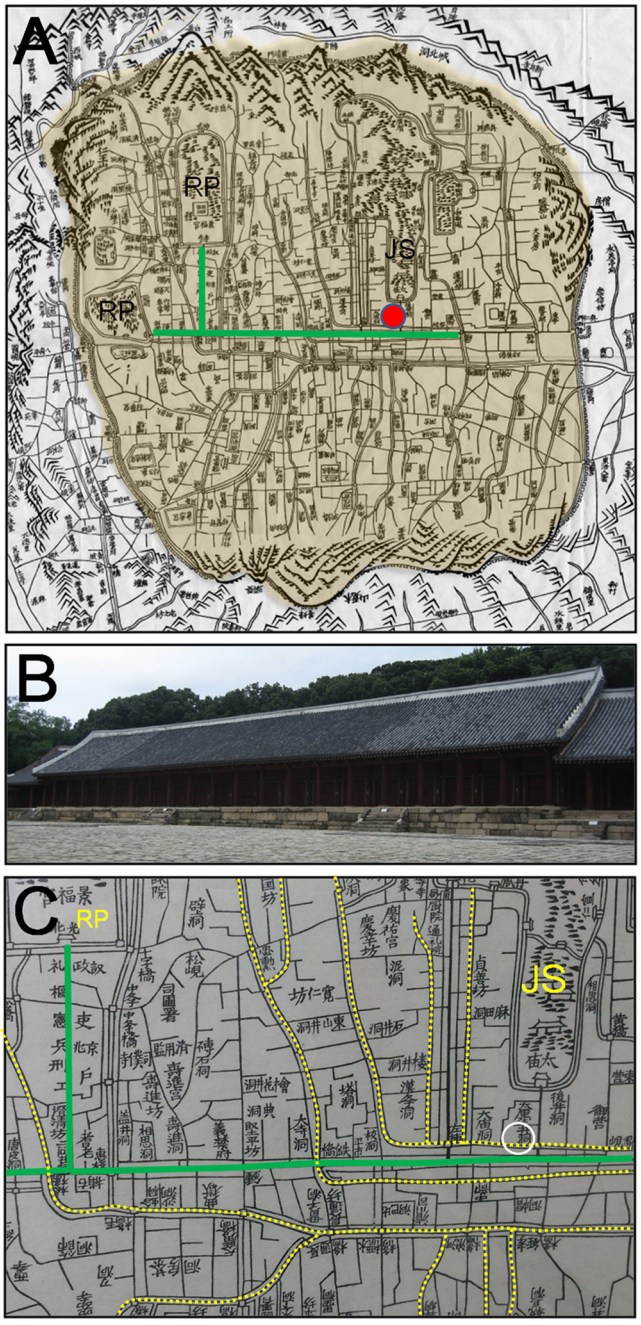

Fig. 1. (A) The Old Seoul City map (Suseonjeondo in Korean) published in 1824. City area is shaded in gray. Red round indicates the place where the current archaeological investigation was done. Main street was marked by green line. JS, Jongmyo Shrine; RP, Royal Palace. (B) The Jongmyo Shrine, the symbol of Joseon dynasty heritage. (C) Magnified image of main street area of Old Seoul City. Yellow dotted lines are streams. White blank circle is for the area where the current archaeological investigation was undertaken. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

2. Materials and methods

Jongmyo Shrine (a UNESCO World Heritage site) was a royal shrine where the kings of the Joseon Dynasty took part in religious ceremonies, and is a tangible symbol of Korea's dynastic heritage (Fig. 1B). The shrine is located on what was a bustling thoroughfare at the center of Old Seoul City, where there were many private houses and offices (Fig. 1C). Recently, archaeologists have investigated the area in front of the shrine and identified an alley, gutter, private house and stream (Choi et al., 2012). Here, in cooperation with the Seoul Museum of History, archaeologists collected 46 samples (Table 1) from a range of soil strata (Fig. 2A–C).

To minimize potential contamination, lab members collected them wearing protective gloves, a head cap, sterilized gown and mask. Since our samplings were conducted on soils left exposed at open-air sites, the surface soils within a 1 meter radius of the site were also collected as negative control. Archaeologists estimated the date of each geological layer using time-sensitive cultural materials. The streambed samples ($n = 22$), were classified as either pre- or post-17th century. The samples from alley strata ($n = 11$), a gutter running along the side of the alley ($n = 6$) (Supplementary Data 1 and 2), and the private residence ($n = 7$) appear to be 17th–19th century soil precipitates.Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijpp.2013.04.002.

The soil samples were rehydrated in a 0.5% trisodium phosphate solution (Van Cleave and Ross, 1947; Callen and Cameron, 1960) and shaken on a daily basis for one week to ensure re-hydration of the parasite eggs. The rehydrated samples were filtered through several layers of gauze and then precipitated for one day, after which the upper turbid layer was discarded. The precipitates were then dissolved in 10% neutral-buffered formalin preparatory to being pipetted onto microscopic slides. We searched the slides under light microscopy (Olympus, Japan) for the presence of eggs.

3. Results

Our microscopic examinations showed that there were not any parasite eggs in the negative control samples from the surface soil, ruling out the possible false positivity induced by accidental introduction of surface soil into the layers we investigated. However, in the streambed samples of 15th to 19th century, we found *Trichuris* and *Ascaris* eggs (20 of 22 samples) (Fig. 3, Supplementary Data 3). We also examined the samples from alley strata and gutter of the alley. In alley strata, we observed *Trichuris* eggs only in the 18th century layer (Fig. 4 A and B) while *Ascaris* and *Trichuris* eggs were discovered in every 17th–19th century alley-gutter sample (Fig. 4 C–F). However, there were no parasite eggs in the samples from the private house (Supplementary Data 2). The average sizes and eggs per grams (EPG) are summarized in Table 1.Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijpp.2013.04.002.

4. Discussion and conclusions

The marketplace in front of *Jongmyo Shrine* was first opened in 1413. Given the shrine's civic and religious significance, only relatively clean commodities, such as clothing, were sold in the shops there. According to historical records, a drainage canal or stream (*Hoedong*|*Jesengdongcheon*) was created in the 15th century to lessen the risk of city flooding during the rainy season (National Institute of Korean History, 1970). Contemporary maps of Old Seoul City show the front of the marketplace facing the main street (Chongno), with the *Hoedong*|*Jesengdongcheon* stream flowing from west to east in the rear, and with private houses occupying the opposite bank (Fig. 1C). The city layouts on these maps and descriptions in the written records have been confirmed by modern archaeological excavations (Fig. 2A).

The population of Old Seoul City, one of the largest cities in the world, oscillated between 100,000 and 200,000 throughout the 15th-to-19th centuries (Shin et al., 2011). As with other populous urban centers (Davies, 2005; Sterner, 2008), night soils posed acute sanitary problems. According to historical records, feces remained on the streets until, they were eventually swept away by