



# Updates on parasite infection prevalence in the Joseon period based on parasitological studies of human coprolites isolated from archaeological sites in the cities of Euijeongbu, Gumi, and Wonju



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## Abstract

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Parasite infection rates estimated by examining ancient coprolites can provide insights into parasitism in Joseon society. Using newly discovered Joseon period cases is essential to regularly update the parasite infection rates and reinforce the reliability of our previous estimations. In the present study, we investigated parasite infections in Joseon coprolites newly isolated from the cities of Euijeongbu, Gumi, and Wonju. We then updated the overall parasite infection rates of Joseon period samples ( $n = 30$ ) as follows: 86.7% (26/30) for *Trichuris trichiura*, 56.7% (17/30) for *Ascaris lumbricoides*, 30.0% (9/30) for *Clonorchis sinensis*, and 30.0% (9/30) for *Paragonimus westermani*. The parasite infection rates in the Joseon society, estimated through coprolite examination, were very similar to those determined previously despite the addition of new cases to the existing data pool.

**Keywords:** Paleoparasitology, mummy, national survey statistics, Joseon, Korea

Studying ancient parasite eggs remaining in archaeological samples (e.g., coprolites) can reveal the infection pattern of specific parasites throughout history. Over the past decade, we performed parasitological investigations using feces (coprolite) samples from the mummies of the Joseon period. A series of such studies led to the identification of various parasite species [1]. These data provided an essential basis for estimating the parasite infection rate during the Joseon period. In brief, we compared the data obtained from parasitological studies on Joseon mummies ( $n = 24$ ) and those obtained from the South Korean national survey of 1971 [1]. The estimated parasite infection rates in Joseon mummies were 58.3% for *Ascaris lumbricoides*, 83.3% for *Trichuris trichiura*, 25% for *Clonorchis sinensis*, and 33.3% for *Paragonimus westermani* [1]. On the other hand, in the 1971 study, the infection prevalence was 54.9, 65.4, 4.6, and 0.09% for *A. lumbricoides*, *T. trichiura*, *C. sinensis*, and *P. westermani*, respectively. Thus, archaeoparasitological studies enable the estimation of changing patterns of parasitic infection rates in Korean people throughout history [1,2].

Our work on Joseon period samples has great academic significance. Therefore, this

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Conceptualization: Oh CS, Shin DH  
 Data curation: Oh CS, Shin DH, Seo M  
 Formal analysis: Oh CS  
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 Methodology: Chai JY, Seo M  
 Validation: Chai JY, Seo M  
 Visualization: Oh CS  
 Writing – original draft: Oh CS, Shin DH, Seo M  
 Writing – review & editing: Oh CS, Shin DH, Seo M

**Conflict of interest**

All authors declare no conflict of interest.

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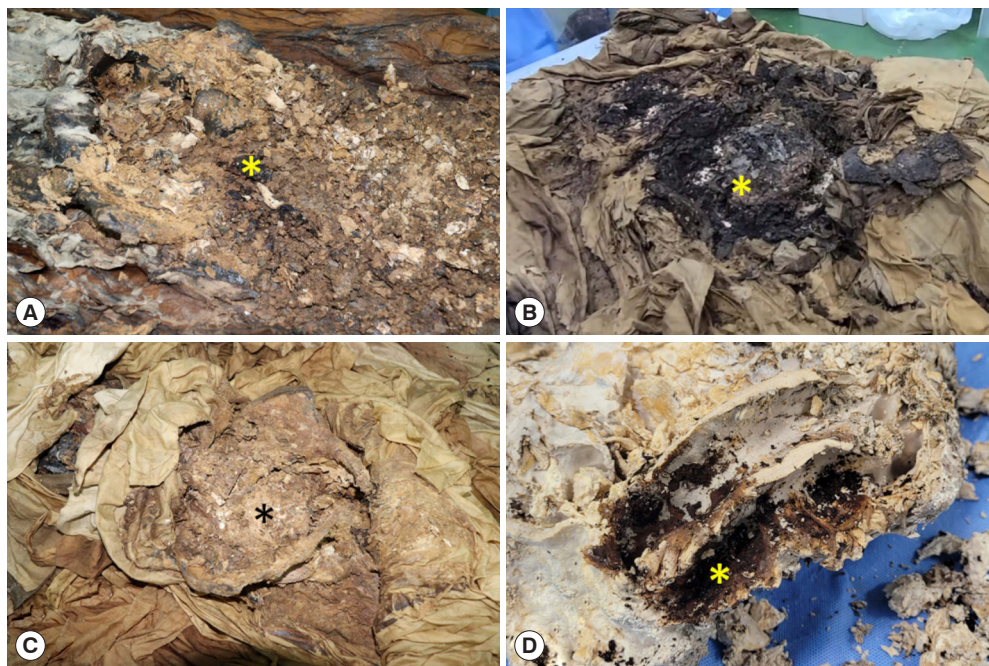
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kind of research needs to be pursued, especially because only 24 cases have been investigated so far. In this regard, we should thoroughly examine more coprolite samples from newly discovered Korean mummies. By updating the data with new Joseon period cases, we can more accurately estimate the parasite infection rate in premodern Korean society.

Recently, we examined parasites in the coprolites from 4 Joseon period individuals recovered during archaeological excavations in the cities of Euijeongbu (Gyeonggi-do), Gumi (Gyeongsangbuk-do), and Wonju (Gangwon-do) (Fig. 1). The archaeological information related to each case is summarized in Table 1.

Microscopic analyses were performed on coprolites or pelvic bone sediments collected from fully or half-mummified Joseon period human remains. Specimens (0.5–4 g) were rehydrated in trisodium phosphate solution (0.5%) [3,4]. They were filtered through a mesh, precipitated, and dissolved in a trisodium phosphate solution (0.5%, 20 ml). The solution was dropped on slides for observations under a BH-2 light microscope (Olympus, Tokyo, Japan). A total of 200  $\mu$ l was examined for each sample. The size of parasite eggs was measured for each species. The newly obtained data were then compared with those reported previously in the national survey from 1972 to 2019 [5,6].

Microscopic analyses revealed that mummy coprolites comprised the following variety of ancient parasite eggs: *T. trichiura* in Euijeongbu-1 and -2; *T. trichiura*, *A. lumbricoides*, and *C. sinensis* in Gumi-2; and *T. trichiura*, *A. lumbricoides*, *C. sinensis*, and *P. westermani* in Wonju6-1 (Fig. 2). Average egg sizes are presented in Table 1. Table 2 shows the present and previous data of parasitological examinations (total case number = 30). The overall



**Fig. 1.** Organic materials precipitated on the pelvic or abdominal regions of the 4 human remains examined in the present study. (A) Wonju6-1, (B) Euijeongbu-1, (C) Euijeongbu-2, and (D) Gumi-2 cases. \*Indicate the sampling location for the archaeoparasitological analysis.

positive infection rates of soil-transmitted helminths during the Joseon period were 86.7% (26/30) for *T. trichiura* and 56.7% (17/30) for *A. lumbricoides*. Regarding trematodes, *C. sinensis* and *P. westermani* infection rates were estimated to be 30.0% (9/30) and 30.0% (9/30), respectively. Compared with the Joseon period results ( $n = 24$ ) reported by Seo et al. [1], the estimated overall infection rate obtained in the present study is slightly different, albeit the difference is not significant.

Since limited information is available on parasite infection patterns in the Joseon period society, studies on Korean mummies are invaluable to parasitologists. Over the last few

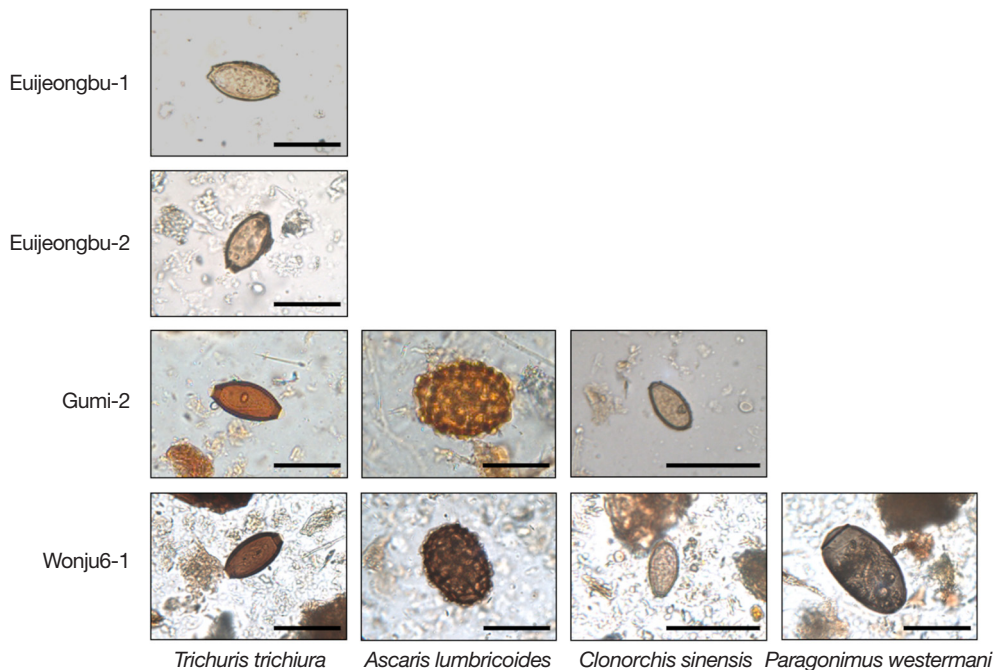
**Table 1.** The information on Joseon period human remains examined in this study and archaeoparasitological data

Cases	Year of excavation	Estimated date	Affiliations of archaeologists	Parasite eggs identified	Average dimensions (µm)	EPG <sup>a</sup>
Wonju6-1	2020	16-17C <sup>b</sup>	Nuri Institute for Archaeology	<i>T. trichiura</i>	54.4 × 25.1	666.7
				<i>A. lumbricoides</i>	69.5 × 53.5	1,040.0
				<i>C. sinensis</i>	27.5 × 15.0	146.7
				<i>P. westermani</i>	84.8 × 46.1	266.7
Uijeongbu-1	2021	18C <sup>c</sup>	Sudo Institute of Cultural Heritage	<i>T. trichiura</i>	49.2 × 24.2	339.0
Uijeongbu-2	2021	18C <sup>c</sup>	Sudo Institute of Cultural Heritage	<i>T. trichiura</i>	48.9 × 24.7	1,872.3
Gumi-2	2022	17C <sup>c</sup>	Sejong Research Institute of Cultural Heritage	<i>T. trichiura</i>	57.5 × 25.0	1,666.7
				<i>A. lumbricoides</i>	73.5 × 60.5	10,833.3
				<i>C. sinensis</i>	29.1 × 15.0	30,833.3

<sup>a</sup>Eggs per gram.

<sup>b</sup>Carbon dating.

<sup>c</sup>Archaeological evidences.



**Fig. 2.** Parasite eggs found in the feces of 4 mummified human remains (Euijeongbu-1, Euijeongbu-2, Gumi-2, and Wonju6-1). Scale bars, 50 µm.

**Table 2.** Archaeoparasitological results of Korean mummies<sup>a</sup>

No.	Cases	Archaeological Remarks	Location discovered	Estimated date	<i>Ascaris lumbricoides</i>	<i>Trichuris trichiura</i>	<i>Clonorchis sinensis</i>	<i>Paragonimus westermani</i>
1	Yongin	Female	Yongin, Gyeonggi-do	15-16C	+	+		+
2	Jinju	Male	Jinju, Gyeongsangnam-do	15-16C	+	+		+
3	Sapgyo	A male mummy found at the coastal country of Yellow Sea	Yesan, Chungcheongnam-do	16C		+	+	
4	Hadong-2	Female	Hadong, Gyeongsangnam-do	16-17C				+
5	Hadong-1	A female mummy from the coastal grave	Hadong, Gyeongsangnam-do	17C			+	
6	Sacheon	Female	Sacheon, Gyeongsangnam-do	1620-1630				
7	Gangneung	A male mummy of Gangneung Choi clan	Gangneung, Gangwon-do	1622		+		
8	Dangjin	Female	Dangjin, Chungcheongnam-do	1633	+			+
9	Mungyeong	A middle-aged female (1560s CE); Not married	Mungyeong, Gyeongsangbuk-do	1647		+	+	
10	Waegwan	Male	Chilgok, Gyeongsangbuk-do	1624-1685		+	+	
11	PJ SM	Female	Paju, Gyeonggi-do	1699	+	+		
12	Seocheon	Female	Yongin, Gyeonggi-do	17C	+	+		
13	Yangju	A child mummy	Yangju, Gyeonggi-do	17C	+	+	+	
14	SN 1-2	The tombs from the cemetery of Seoul people during Joseon Dynasty period; Urban people	Sinnae, Seoul	1605-1733		+		
15	SN3-7-1		Sinnae, Seoul	16-17C		+		
16	SN2-19-1		Sinnae, Seoul	1765 ± 10	+	+		
17	SN2-19-2		Sinnae, Seoul	1755 ± 10	+	+		
18	GJ1-2	Wife and husband buried together at the same grave (GJ1-2 is a husband)	Gongju, Chungcheongnam-do	17-18C	+	+		+
19	Hwasung	Rich <i>jungin</i> class individual	Hwasung, Gyeonggi-do	18C	+	+		+
20	Andong	Economically poor <i>yangban</i> ; A low-ranking official ( <i>chambong</i> )	Andong, Gyeongsangbuk-do	16C		+	+	
21	YG2-4	A housewife from a family of official	Yonggwang, Jeollanam-do	15-16C	+	+		+
22	YG2-6	Similar to YG2-4.	Yonggwang, Jeollanam-do	15-16C	+	+		+
23	Danlsung	A housewife from <i>yangban</i> family	Dalsung, Daegu	16-17C	+	+		
24	Junggye	Socioeconomic status looks very high; Urban people	Junggye, Seoul	16-17C	+	+		
25	Goryeong	A widow named Gwak; a freed female emancipated from slavery	Goryeong, Gyeongsangbuk-do	17C		+	+	
26	Gwangmyeong	Female	Gwangmyeong, Gyeonggi-do	17C	+	+		
27	Wonju6-1	Female	Wonju, Gangwon-do	16-17C	+	+	+	+
28	Uijeongbu-1	Male; Married Eunuch; Official in Joseon Dynasty government	Uijeongbu, Gyeonggi-do	18C		+		
29	Uijeongbu-2	The wife of Uijeongbu-1	Uijeongbu, Gyeonggi-do	18C		+		
30	Gumi-2	Male	Gumi, Gyeongsangnam-do	17C	+	+	+	

<sup>a</sup>Mummy parasitism results of (1)-(26) represent the existing corpus on Joseon mummy parasitism [1,8]. The current results are (27)-(30).

years, parasitological data on Joseon period mummy coprolites have been reported [2]. The results of the present study provide additional information to re-estimate the parasite infection rate in the Joseon society. Moreover, only a slight difference was observed between the present data and the last estimate of the Joseon period infection rate reported by Seo et al. [1]. Thus, we confirmed the changing pattern of parasite infection prevalence throughout the Joseon period to 21st century in Korea reported by Seo et al. [1]. Briefly, the infection prevalence of the trematodes *C. sinensis* and *P. westermani* was lower than that of the

nematodes *A. lumbricoides* and *T. trichiura*. The trematode infection rates obtained from the data of the 1971 study and those obtained from the Joseon period are very different (26.7 and 4.6% for *C. sinensis*, respectively, and 33.3% and 0.09% for *P. westermani*, respectively). In contrast, the nematode infection rates in the Joseon period (83.3% for *T. trichiura* and 60.0% for *A. lumbricoides*) remained almost the same until 1971 (65.4% for *T. trichiura* and 54.9% for *A. lumbricoides*) but were greatly decreased (0.2% for *T. trichiura* and 0.3% for *A. lumbricoides*) in 1992. Various hypotheses have been proposed to explain these historical changes in the rate of parasitic infection [7]; however, none explains it completely so far. Further research and discussion are needed to accurately comprehend this subject.

Analyzing parasite infection during the Joseon period and comparing it with the 20th century national survey data provide remarkable insights into historical parasitism in pre-modern Korean society that could not be obtained using conventional research. In this regard, periodical updates with newly discovered cases provide supplementary information that further reinforces the reliability of our data on Joseon parasite infection. The present study analyzed newly discovered mummy coprolites and confirmed the human parasite infection rates in the Joseon society estimated previously by examining mummy coprolites.

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