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Expansion of vertebral tuberculosis into Hokkaido: Implications for the population history of Ainu

Osamu Kondo ^{a,*}, Tomoya Aono ^b^a Department of Biological Sciences, Graduate School of Science, The University of Tokyo, 3-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan^b Date City Institute of Funkawan Culture, Tateyama-cho 21-5, Date City, Hokkaido 052-0031, Japan

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ABSTRACT

The initial expansion of human tuberculosis (TB) into Hokkaido has been confirmed by an archeological human skeleton from the site of Usu 4 in southwestern Hokkaido, Japan. The time of expansion is assumed at an early phase of the Ainu Culture period based on the burial dating to between 1640 and 1663 AD. Osteological lesions concentrated mainly on the vertebral column are described for both surface and inner trabecular morphology, and have been interpreted as osteolytic erosion and inflammatory reactive bone formation. Taking other paleopathological TB cases in and around Japan into consideration, the introduction of TB would have been routed through the Japanese archipelago into Hokkaido, which was coincident with the adoption of systematic agriculture such as dry-field plowing, not with animal (cattle) domestication. This subsistence shift must have helped to maintain a much denser population in the local community, thus keeping the TB bacillus among the host human groups. This new TB case reinforces the assumption of frequent bio-cultural interaction between the Ainu in Hokkaido (particularly in southwestern part of Hokkaido) and the mainland Japanese in (eastern) Honshu. It relates to issues of the population history of the Ainu, and discusses a plausible scenario.

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1. Introduction

1.1. Tuberculosis in human paleopathology

Human tuberculosis (TB) is an acute or chronic infectious disease caused by one of the species of *Mycobacterium*. *Mycobacterium bovis* is linked to tuberculosis transmitted to humans via cattle products, primarily contaminated milk. Direct transmission of tuberculosis between humans is caused by *Mycobacterium tuberculosis*, which most commonly affects the lungs by air transmission, and spreads into the body through the blood supply. Based on the infectious aspects of the pathogen, the distribution, antiquity, and epidemiology of tuberculosis have been studied by paleopathologists on skeletonized or mummified human remains. The spread and expansion of the disease is typically linked to an increase or change in human social complexity in the past, including domestication of animals and the development of agriculture, sedentism, urbanization, and human overcrowding (Ortner, 2003; McMichael, 2004; Hershkovitz et al., 2008).

Bone manifestation of tuberculosis is often seen in the vertebrae, including periosteal reactive regions and osteomyelitis. Severe cases of vertebral tuberculosis exhibit characteristic symptoms of deterioration of the vertebral body (Pott's disease), leading to compression fractures and gibbus formation as well as to severe bending of the vertebral column (Ortner, 2003; Roberts and Manchester, 2007). Such skeletal changes have been reported in Neolithic Italy at the beginning of the fourth millennium BC (Formicola et al., 1987; Canci et al., 1996). In addition, recent biomolecular studies have detected the ancient DNA of *Mycobacterium tuberculosis* complex in pre-dynastic (ca. 5000 BP) Egypt (Zink et al., 2001) and in Neolithic (ca. 9000 BP) Levant (Hershkovitz et al., 2008).

The expansion of tuberculosis into East Asia can be traced to the Neolithic, the late Longshan period in China (Pechenkina et al., 2007), and thereafter to the Iron Age in Siberia (4th century BC to 4th century AD) (Murphy et al., 2009) and to the 3rd/2nd century BC in western China (Fusegawa et al., 2003; Li et al., 2013). It appears to have reached the Japanese archipelago around the neolithic Yayoi period, almost contemporaneous with the TB expansion in the continental Asia. Several paleopathological cases of TB have been reported in Korea (Suzuki et al., 2008) and in Japan (Suzuki,

* Corresponding author.

E-mail address: kondo-o@bs.s.u-tokyo.ac.jp (O. Kondo).

1978; Suzuki and Inoue, 2007). The dissemination of tuberculosis into Japan has been discussed within the context of the population history of the Japanese (Suzuki, 2013). The popular “Dual structure model” dictates that a substantial migration of Northeast Asian groups through the Korean peninsula would have happened around this time and impacted both the genetic structure and the behavioral/cultural characteristics of the residents along the Japanese archipelago (Hanihara, 1991). Along with this migration, a few infectious diseases including TB would have been introduced, expanding into the southern half of Japan by the protohistoric Kofun period (ca. 250–600 AD) (Suzuki, 2013). However, TB does not appear to have reached northern Japan, particularly Hokkaido, until recent times (Suzuki, 1985).

We report here paleopathological evidence of vertebral tuberculosis from an adult Ainu skeleton uncovered from the site of Usu 4 in Date City, Hokkaido, which has been securely dated to between 1640 and 1663 AD based on tephra layers in the sediment (Aono and Mitani, 2009). The introduction of vertebral tuberculosis into Hokkaido can be explained in terms of the bio-cultural interaction between residents of Hokkaido (Ainu) and those of neighboring regions, including Honshu (mainland Japanese). Thus, it is worth discussing this event within the bio-cultural context of the population history of the Ainu.

1.2. Population history of Ainu

According to the “Dual structure model” for the population history of the Japanese archipelago, the Ainu people are considered to have descended mainly from the Jomon, the original aboriginal residents of Japan (Hanihara, 1991). Since morphological similarity between the Hokkaido Ainu and the Jomon has been repeatedly confirmed (Howells, 1966; Tuner, 1976; Yamaguchi, 1982; Dodo and Ishida, 1990; Kozintsev, 1992; Matsumura, 1994; Pietruszewsky, 1994; Dodo and Kawakubo, 2002; Ossenberg et al., 2006), direct genetic relationships between the Jomon in Hokkaido or Honshu and the Hokkaido Ainu, via the epi-Jomon people in Hokkaido, are highly plausible. However, geographical contexts around the formation process of the Ainu should remind us of additional influence from the mainland Japanese or other neighboring populations. Several previous studies have already suggested that the formation process of the Ainu population would have been influenced by both mainland Japanese and local/temporary residents of the Okhotsk Culture people (Ito, 1967; Yamaguchi, 1981; Kondo, 1995, 2013), the latter residing along the seashore of Okhotsk during 5th to 12th centuries AD. Recent quantitative genetic approaches for the cranial metric data (Kondo, 2005; Hanihara et al., 2008) and ancient DNA analyses (Sato et al., 2009; Adachi et al., 2011) have demonstrated a substantial influence of Okhotsk Culture people on the formation of the Ainu. On the other hand, the influence of the mainland Japanese on the Ainu has yet to be clarified or may be minor, although the prevalence of several non-metric traits for the local Ainu people along the Sea of Japan is similar to those of the eastern mainland Japanese (Dodo et al., 2012).

2. Materials and methods

2.1. Usu 4 and human skeletal remains of Ainu culture period

The site of Usu 4 is located at Date City, along the NE coast of Uchiura Bay (Funkawan), in SW part of Hokkaido (Fig. 1). The Funkawan area is known for the dense distribution of shell mounds, where many archeological sites dating from the Jomon to recent Ainu Culture period have been identified. Usu 4 is one of those sites. The site includes several different archeological contexts from Epi-Jomon, Satsumon and medieval/recent Ainu Culture period. The

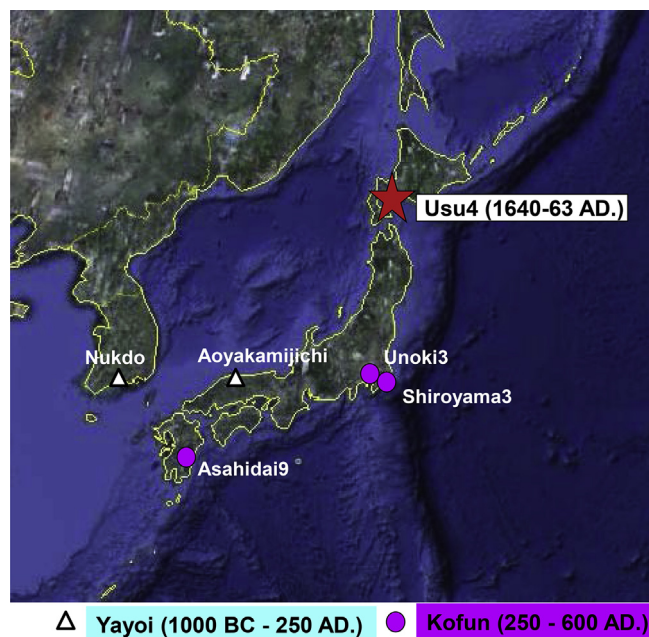


Fig. 1. Use 4 site and other archeological sites with tuberculosis human remains mentioned in the text.

accumulated layers are divided by three volcanic tephra layers: Usu-b tephra (Us-b) that was deposited in 1663 AD by the eruption of Mt. Usu; Komagatake-d (Ko-d) tephra that was deposited in 1640 AD; and the Hakutousan–Tomakomai (B–Tm) tephra that was deposited in early 10th century AD. These tephra layers help to identify the pits for ancient architecture such as burial pits and also help to assign dates for them (Fig. 2).

Excavation during 2006–07 uncovered 23 burial pits with human skeletons from the Ainu Culture period. Formation time for the burial pits was assigned to the following three periods due to vertical relationship of the detectable surface for each pit to the key tephra layers (Us-b and Ko-d): Period 1 is after the deposition of Us-b tephra, i.e., after 1663 AD; Period 2 is from 1640 to 1663 AD; and Period 3 is before Ko-d tephra, i.e., before 1640 AD (Table 1, Aono and Mitani, 2009). After restoration of the human skeletal remains, 23 individuals were identified, which include five subadults,

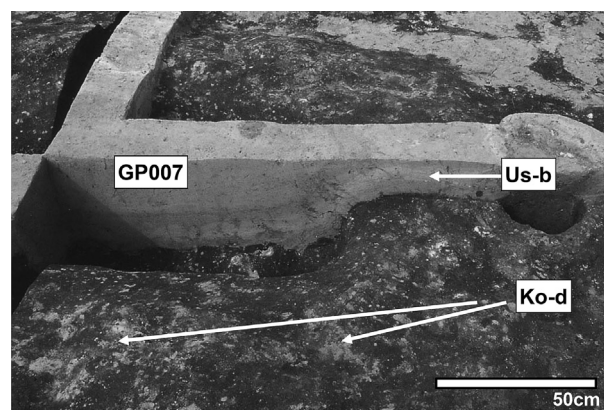


Fig. 2. Section of a grave pit (GP007), indicating the formation time before Us-b tephra in 1663 AD and after Ko-d tephra in 1640 AD.

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