

Prevalence of *Trichinella* spp. antibodies in wild boars (*Sus scrofa*) and domestic pigs in Korea

H.J. KIM¹, W.S. JEONG², E.M. KIM¹, S.G. YEO¹, D.J. AN³, H. YOON², E.J. KIM¹, C.K. PARK¹

¹College of Veterinary Medicine and Animal Disease Intervention Center, Kyungpook National University, Daegu, Republic of Korea

²Veterinary Epidemiology Division, Animal and Plant Quarantine Agency, Anyang, Republic of Korea

³Viral Disease Division, Animal and Plant Quarantine Agency, Anyang, Republic of Korea

ABSTRACT: Trichinellosis is a parasitic zoonosis that is of importance to public health; human trichinellosis usually occurs when improperly cooked pork or wild animal meat is consumed. The purpose of this study was to determine the nationwide seroprevalence of *Trichinella* infection in wild boar and domestic pig populations in Korea. Using ELISA, we detected no seropositivity among the serum samples of 2350 domestic pigs collected in 2013, indicating that the domestic cycles of *Trichinella* spp. have disappeared from the domestic pig population in Korea. In contrast, approximately 13% of the 434 wild boars hunted in 2013 were seropositive. Furthermore, the seroprevalence of six of the seven provinces was between 6.7% and 18.3%, indicating that *Trichinella* infection occurred in the wild boar population throughout the country. The results of this study suggest that *Trichinella* circulates in the wild boar population and could be transmitted from infected wild boars to other wildlife, domestic pigs, and humans in Korea. Therefore, we recommend continued surveillance of *Trichinella* infection prevalence in wild animals and an appropriate strategy to prevent human infection in Korea.

Keywords: *Trichinella* spp.; trichinellosis; seroprevalence; ELISA; wild boar; domestic pig

Trichinella spp. are the causative agents of trichinellosis, a parasitic zoonosis that results in economic losses and which poses an important public health hazard with respect to pig production and food safety (Gottstein et al. 2009). The major source of human infection worldwide is the domestic pig, and wild boars have played a significant role during outbreaks of human and swine *Trichinella* infection. Therefore, *Trichinella* infection represents a serious problem for the international trade of pigs and pork. Parasites of the genus *Trichinella* are present on all continents except Antarctica (Pozio 2007). Most *Trichinella* species, with the exception of *Trichinella spiralis*, mainly parasitise wild ani-

mals. Transmission from wild animals to domestic animals can occur when there is improper segregation of domestic animals and wildlife.

According to the International Commission on Trichinellosis, serological methods such as the enzyme-linked immunosorbent assay (ELISA) are not recommended as a substitute for meat inspection of individual carcasses (Gamble et al. 2000). However, ELISA is considered to be suitable for surveillance and epidemiological investigations of domestic animals and wildlife (Gamble et al. 2004).

In Korea, continuous outbreaks of human trichinellosis have been reported since 1997 (Sohn et al. 2000), and the sources of infection were deter-

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mined to be consumption of uncooked or poorly processed wild animal meat, including that of wild boars, badgers, and soft-shelled turtles (Sohn et al. 2000; Rhee et al. 2011; Lee et al. 2013). Although trichinellosis has great veterinary and public health importance, no nationwide surveillance study has been performed to determine the prevalence of the parasite in wild boars in Korea. Therefore, in this study, we conducted a nationwide serological survey on the prevalence of *Trichinella* spp. in wild boars and domestic pigs in Korea using ELISA.

MATERIAL AND METHODS

Sampling and data management. During the November–December 2013 hunting season, 434 serum samples were collected from wild boars hunted in eight provinces of the mainland area of Korea. Venous blood samples were collected from the wild boars immediately after hunting, preserved in blood collection tubes, transported from the field to the laboratory, and then stored at -20°C until serological analysis. We grouped the serum samples from the boars for all analyses according to the provinces from which they were collected.

An additional 2350 serum samples from domestic adult pigs (> 4 months old) were collected from seven pig-breeding farms and 69 pig-fattening farms that were distributed throughout the country. The breeding farms participated in the golden seed project (GSP) – the export promotion program for breeding pigs, which is supported by the Korean government.

Serological assay. The serum samples were analysed using a commercial ELISA test kit (PrioCheck *Trichinella* Ab; Prionics AG, Schlieren-Zurich, Switzerland) following the manufacturer's instructions, to detect antibodies against the excretory/secretory (E/S) antigens of *Trichinella* spp. in the serum samples of the tested pigs.

Statistics. Prevalence was calculated as the proportion of pigs that tested positive out of the total number tested, and 95% binomial confidence intervals were calculated. When the number of positive cases was zero, the likelihood estimator was calculated for the upper limit. The difference in prevalence among provinces was assessed with a chi-square test, using a significance level (alpha) of 0.05. The GraphPad Prism version 5.04 software package (GraphPad Software Inc., La Jolla, CA, USA) was used for the statistical analyses.

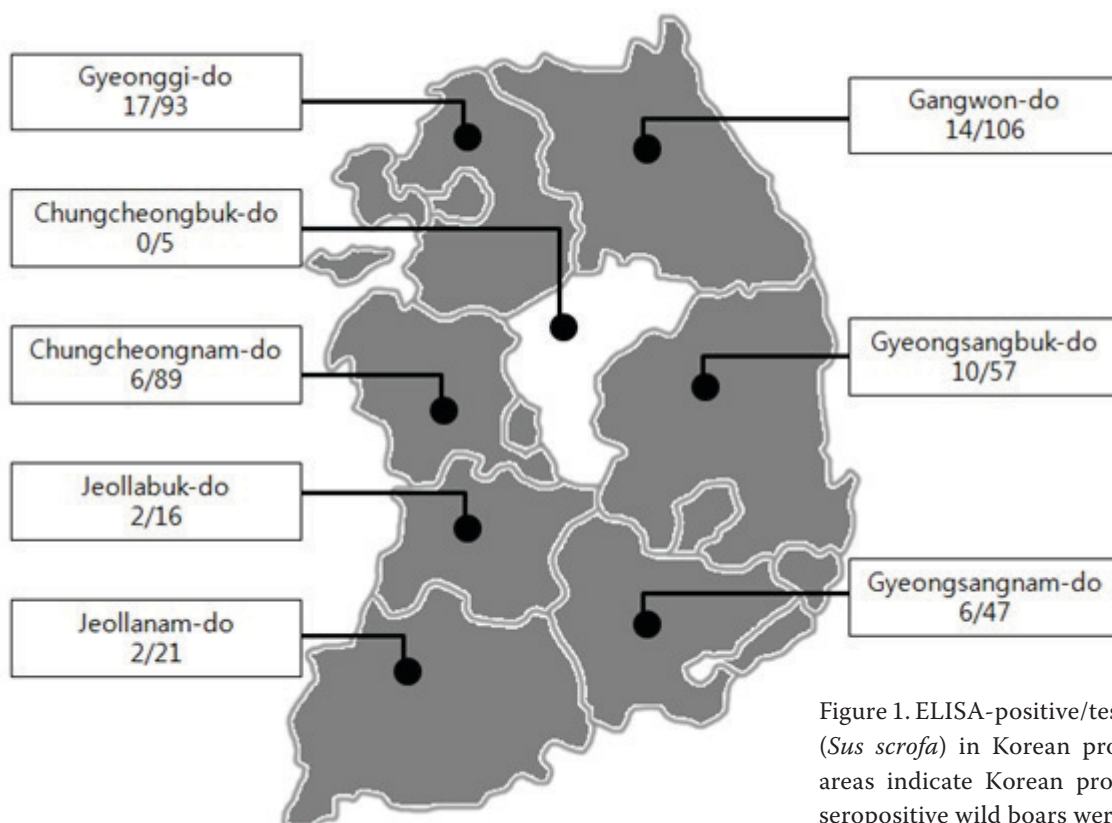


Figure 1. ELISA-positive/tested wild boar (*Sus scrofa*) in Korean provinces. Grey areas indicate Korean provinces where seropositive wild boars were detected.

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Table 1. Prevalence of *Trichinella* spp. antibodies in the serum samples of wild boar hunted in different provinces in Korea

| Province | Tested (<i>n</i>) | Positive (<i>n</i>) | Prevalence (%) | CI (%) |
|-------------------|---------------------|-----------------------|----------------|-----------|
| Gangwon-do | 106 | 14 | 13.2 | 6.8–19.7 |
| Gyeonggi-do | 93 | 17 | 18.3 | 10.4–26.1 |
| Chungcheongbuk-do | 5 | 0 | 0 | 0.0–31.9 |
| Chungcheongnam-do | 89 | 6 | 6.7 | 1.5–12.0 |
| Jeollabuk-do | 16 | 2 | 12.5 | 0.0–28.7 |
| Jeollanam-do | 21 | 2 | 9.5 | 0.0–22.1 |
| Gyeongsangbuk-do | 57 | 10 | 17.5 | 7.7–27.4 |
| Gyeongsangnam-do | 47 | 6 | 12.8 | 3.2–22.3 |
| Total | 434 | 57 | 13.1 | 10.0–16.3 |

CI = confidence interval

RESULTS

Of the 434 serum samples of wild boars examined, 57 (13.1%) harboured antibodies against *Trichinella* spp. (Table 1, Figure 1). Analysis of *Trichinella* spp. seroprevalence in the eight provinces of the country showed that the highest seroprevalence was in the Gyeonggi-do (18.3%) and Gyeongsangbuk-do (17.5%) provinces, and the lowest seroprevalence was observed in the Chungcheongbuk-do (0%) provinces. However, the difference in seroprevalence among provinces was not significantly different (Table 1).

In the case of domestic pigs, the serum samples of all 2350 pigs from seven breeding farms and 69 fattening farms were seronegative for *Trichinella* spp. However, the upper limit of the 95% confidence intervals estimated was 0.7% for breeding pig farms and 0.1% for fattening pig farms. The upper limit was higher when the number of tests was smaller (Table 2).

DISCUSSION

Trichinellosis is an important food-borne parasitic zoonosis that is widely distributed throughout the

world. Human trichinellosis has been reported in 55 (27.8%) countries (Pozio 2007) and is usually caused by consumption of raw or undercooked meat, especially pork and pork products. There are two cycles of distribution of *Trichinella* in the natural hosts: one is the domestic cycle in which the transmission involves swine herds that are fed uncooked pork scraps, carrion, garbage, or carcasses that are not promptly removed from the farm; the second is the sylvatic cycle, in which transmission occurs among wildlife hosts, including mammals, birds and reptiles (Pozio 2005). The domestic cycle and the sylvatic cycle can function either independently from each other or can also interact (Pozio 2007). With regard to the geographical distribution of the domestic cycle of trichinellosis, there have been no reports of infections on industrialised farms in Canada, the United States, and Western Europe. However, the domestic cycle still occurs on industrial farms in several countries of East-Central Europe and East Asia (Pozio 2007). In the countries with the domestic cycle, domestic pork and pork products remain the most important source of *Trichinella* infection in humans, especially when pigs are raised under free-ranging or backyard production conditions (Gottstein et al. 2009).

Table 2. Seroprevalence of *Trichinella* spp. in domestic pigs in Korea

| Farm | Number of farms | Number of pigs tested | Number of positive pigs | Prevalence (%) | CI (%) |
|----------------|-----------------|-----------------------|-------------------------|----------------|--------|
| Breeding farm | 7 | 280 | 0 | 0 | 0–0.7 |
| Fattening farm | 69 | 2070 | 0 | 0 | 0–0.1 |
| Total | 78 | 2350 | 0 | 0 | 0–0.1 |

CI = confidence interval

In the surveillance of trichinellosis, serological methods such as ELISA offer a sensitive and relatively specific tool for the detection of *Trichinella*-specific antibodies (Hassan et al. 2010). ELISA is the most commonly used method for the detection of *Trichinella* infection because it is economical and reliable and provides an acceptable balance of sensitivity and specificity. The sensitivity and specificity of the commercial ELISA kit used in this study were above 97% and 99.5%, respectively. The high sensitivity and specificity were achieved with a lower limit of detection than that of the routine artificial digestion test, suggesting that serological surveillance is a valuable alternative in surveillance for *Trichinella* spp. in pig production (Frey et al. 2009).

In Korea, two previous studies conducted since 2001 on trichinellosis surveillance showed that domestic pig farms are free from *Trichinella* infection (Wee et al. 2001; Jeong et al. 2004). In this study, seropositive results for *Trichinella* spp. were not obtained for the 2350 pig serum samples tested (Table 2), indicating that the domestic cycles of *Trichinella* have disappeared in Korea. However, several human trichinellosis cases have been documented since 1997 in Korea. All of the cases involved the consumption of wildlife meat, mainly wild boars (Kim et al. 2003; Hur et al. 2004; Rhee et al. 2011), wild badgers (Lee et al. 1999; Sohn et al. 2000), and soft-shelled turtles (Lee et al. 2013), indicating that the distribution of *Trichinella* in sylvatic cycles is present in Korea. Wild boars are presumed to be the major source of *Trichinella* infection in the sylvatic cycle in Korea. However, to date, no nationwide surveillance study aimed at characterising the prevalence of *Trichinella* infection in wild boars has been performed.

We therefore conducted a nationwide survey to determine the prevalence of *Trichinella* infection in wild boar populations in Korea. The results of ELISA antibody tests showed that approximately 13% of the 434 wild boars hunted in 2013 were seropositive (Table 1). The positive serological results suggest that the wild boars tested were previously infected with *Trichinella*. Furthermore, six of the seven (excluding Chungcheongbuk-do) provinces had seroprevalence rates between 6.7% and 18.3%, indicating that *Trichinella* infection occurred in wild boar populations throughout the country (Figure 1, Table 1). The results of this study suggest that *Trichinella* circulates in wild boar populations with relatively high

levels of infection and could be transmitted from infected wild boars to other wildlife, domestic pigs, and humans in Korea. Therefore, we recommend a continued surveillance of *Trichinella* infection in wild animals and an appropriate prevention strategy for human infection in Korea.

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Corresponding Author:

Choi-Kyu Park, Kyungpook National University, College of Veterinary Medicine and Animal Disease Intervention Center, Daegu 702-701, Republic of Korea

E-mail: parkck@knu.ac.kr
