doi: 10.17221/8105-VETMED

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

H.J. Kim[1], W.S. Jeong[2], E.M. Kim[1], S.G. Yeo[1], D.J. An[3], H. Yoon[2], E.J. Kim[1], C.K. Park[1]

[1]College of Veterinary Medicine and Animal Disease Intervention Center, Kyungpook National University, Daegu, Republic of Korea
[2]Veterinary Epidemiology Division, Animal and Plant Quarantine Agency, Anyang, Republic of Korea
[3]Viral 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 animals. 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-

This study was carried out with the support of the Technology Development Program for Bio-industry (Project No. 311007-5), the Cooperative Research Program for Agricultural Science and Technology Development (Project No. 009410), the Golden Seed Project (Project No. PJ009921) and Rural Development Administration (RDA), Ministry of Agriculture, Food and Rural Affairs (MAFRA), Republic of Korea.

doi: 10.17221/8105-VETMED

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.

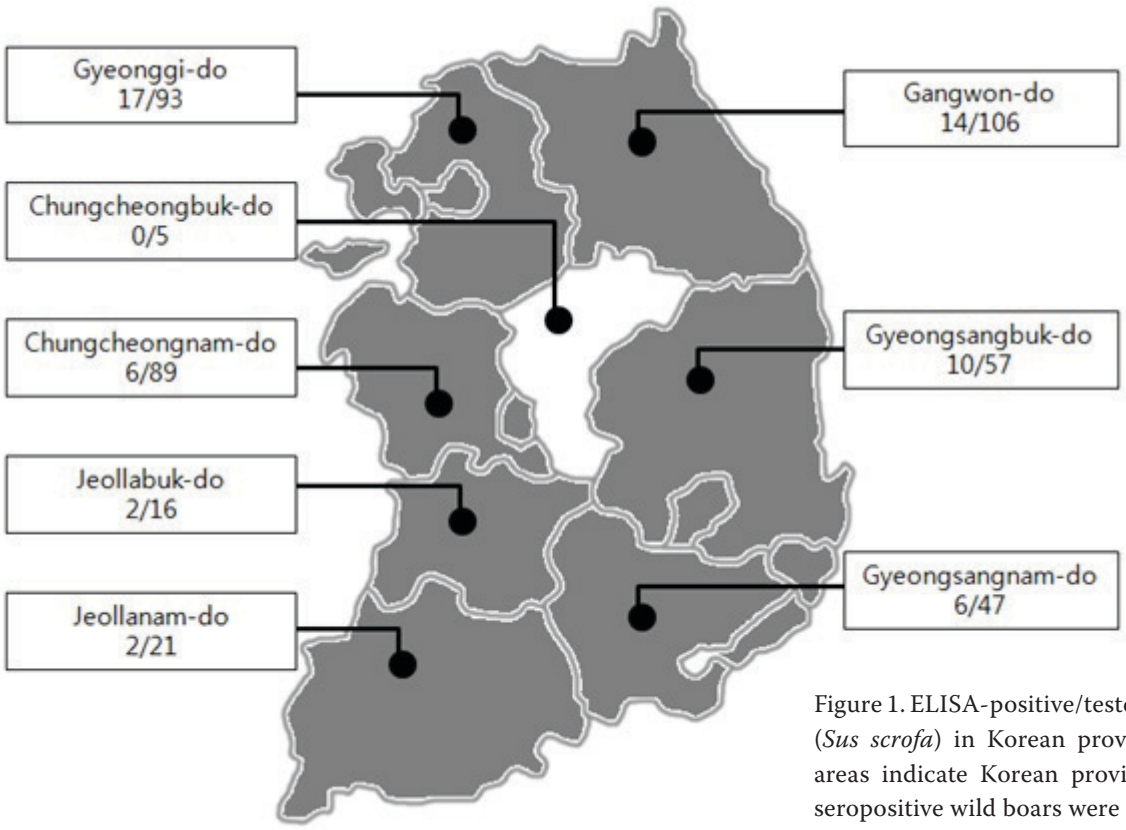

Figure 1. ELISA-positive/tested wild boar (*Sus scrofa*) in Korean provinces. Grey areas indicate Korean provinces where seropositive wild boars were detected.

doi: 10.17221/8105-VETMED

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

Province	Tested (*n*)	Positive (*n*)	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 a 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

doi: 10.17221/8105-VETMED

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.

REFERENCES

Frey CF, Buholzer P, Beck R, Marinculic A, Raeber AJ, Gottstein B, Schuppers ME (2009): Evaluation of a new commercial enzyme-linked immunosorbent assay for the detection of porcine antibodies against Trichinella spp. Journal of Veterinary Diagnostic Investigation 21, 692–697.

Gamble HR, Bessonov AS, Cuperlovic K, Gajadhar AA, van Knapen F, Noeckler K, Schenone H, Zhu X (2000): International Commission on Trichinellosis: recommendations on methods for the control of Trichinella in domestic and wild animals intended for human consumption. Veterinary Parasitology 93, 393–408.

Gamble HR, Pozio E, Bruschi F, Nockler K, Kapel CMO, Gajadhar AA (2004): International Commission on Trichinellosis: recommendations on the use of serological tests for the detection of Trichinella infection in animals and man. Parasite 11, 3–13.

Gottstein B, Pozio E, Noeckler K (2009): Epidemiology, diagnosis, treatment, and control of Trichinellosis. Clinical Microbiology Reviews 22, 127–145.

Hassan SE, El-Moghazy FM, Toaleb NI (2010): Comparison of two antigens for diagnosis of Trichinellosis in pigs. World Applied Sciences Journal 8, 457–461.

Hur GY, Hwang BY, Lee JG, Lee MG, Cheong HJ, Cho SW, Joo KH (2004): An outbreak of trichinellosis caused by ingestion of raw wild boar. Korean Journal of Medicine 67, 917–922.

Jeong WS, Kang SW, Jang H, Wee SH, Lee HS, Park YJ, Joo YS, Kim IM (2004): Inspection of trichinellosis in slaughtered pigs and imported pigs using ESP-ELISA and artificial digestion method. Korean Journal of Veterinary Public Health 28, 29–33.

Kim E, Pyun RH, Park JH, Kim KH, Choi I, Park HH, Lee YH, Yong TS, Hong SK (2003): Family outbreak of Trichinosis after eating a raw meat of wild swine. Infection and Chemotherapy 35, 180–184.

Lee HC, Kim JS, Oh HY, Kim JH, Kim HG, Lee MS, Kim WJ, Kim HT (1999): A case of Trichinosis caused by eating a wild badger. Korean Journal of Medicine 56, 134–138.

Lee SR, Yoo SH, Kim HS, Lee SH, Seo M (2013): Trichinosis caused by ingestion of raw soft-shelled turtle meat in Korea. Korean Journal of Parasitology 51, 219–221.

doi: 10.17221/8105-VETMED

Pozio E (2005): The broad spectrum of Trichinella hosts: from cold- to warm-blooded animals. Veterinary Parasitology 132, 3–11.

Pozio E (2007): World distribution of Trichinella spp. infections in animals and humans. Veterinary Parasitology 149, 3–21.

Rhee JY, Hong ST, Lee HJ, Seo M, Kim SB (2011): The fifth outbreak of Trichinosis in Korea. Korean Journal of Parasitology 49, 405–408.

Sohn WM, Kim HM, Chung DI, Yee ST (2000): The first human case of Trichinella spiralis infection in Korea. Korean Journal of Parasitology 38, 111–115.

Wee SH, Lee CG, Joo HD, Kang YB (2001): Enzyme-linked immunosorbent assay for detection of Trichinella spiralis antibodies and the surveillance of selected pig breeding farms in the Republic of Korea. Korean Journal of Parasitology 49, 405–408.

Received: 2014–07–03
Accepted after corrections: 2015–03–17

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