Seroprevalence of *Mycobacterium avium* subspecies *paratuberculosis* in Korean Black Goats (*Capra hircus aegagrus*)

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ABSTRACT. In total, 582 sera from 116 black goat herds were analyzed by a commercially available ELISA kit to monitor the seroprevalence of *Mycobacterium avium* subspecies *paratuberculosis* (Mpt) in Korean black goats (*Capra hircus aegagrus*). The mean number of goats sampled per herd was 5.11, 4.66, and 5.38 for the northern, central, and southern regions of Korea, respectively. The apparent regional prevalence of Mpt was estimated at 18.2–38.2% and 4.6–15.3% for herds and goats, respectively. The Mpt-positive goats were predominantly detected in the south ($n=28$), compared to either the northern ($n=9$) or central ($n=11$) regions ($\chi^2=14.459$, $P<0.05$). Our findings indicate that Mpt is prevalent among the goat population, but regional variation exists.

KEY WORDS: goat, *Mycobacterium avium* subspecies *paratuberculosis*, seroprevalence.

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Paratuberculosis (Johne's disease) is a chronic infectious enteric disease of ruminants. It is seen primarily in cattle, sheep, and goats, and is caused by *Mycobacterium avium* subspecies *paratuberculosis* (Mpt). Mpt deleteriously affects the performance of dairy cattle by lowering milk production, and the economic losses caused by Mpt infection are estimated to be CND \$2,462 annually per 50-cow herd [2]. More importantly, Mpt is known to be associated with Crohn's disease in humans, and the evidence to support this possible causation of Crohn's disease is growing rapidly [1, 5, 8, 10]. Although Mpt has long been considered an economically important disease in cattle [3], it has gained little attention in goats due to their lower commercial value. Here, we report a preliminary study estimating the seroprevalence and regional distribution of Mpt in black goats (*Capra hircus aegagrus*) in Korea. The breed is mainly raised for meat and natural health supplements. In addition, vaccination against Mpt has not been implemented until now.

To test the seroprevalence of Mpt, 582 sera from 116 black goat herds were used. Regional veterinarians visited each farm and collected the blood from goats aged ≥ 1 year. The animals that were examined by the veterinarians had no clinical symptoms and the farms had never been cited for the disease. The sera obtained were kept at -20°C until tested. The sample size used in this study provided a 99.0% confidence level for an expected goat-level prevalence of $10.0 \pm 3.2\%$ and 95.0% confidence level for a herd-level prevalence of $25.0 \pm 7.9\%$, respectively (Win Episcope 2.0, CLIVE; Royal (Dick) School of Veterinary Studies, University of Edinburgh, Scotland). All samples were tested using a commercial ELISA kit, as recommended by the manufac-

turer (HerdChek[®] *Mycobacterium paratuberculosis* Test Kits, IDEXX Laboratories, ME, U.S.A.). Analytical procedures for ELISA in this study were identical to those outlined earlier for goats [9]. The absorbance reading in all ELISA plate wells was measured at 650 nm by an ELISA reader (Power Wave XS; Bio-Tek, VT, U.S.A.). ELISA optical density readings were transformed into positive (S/P) values. Using the same protocol and cutoff as for bovine sera, the ELISA for goat sera had 64% sensitivity and 100% specificity [9]. In this study, seropositive herds were defined as those having at least one goat that was positive for Mpt. Descriptive statistics were calculated to determine the apparent prevalence of Mpt at the individual and herd levels. Based on the apparent prevalence, the true goat- and herd-level prevalence were estimated (Survey Toolbox for Livestock Diseases, Version 1.03; Australian Centre for International Agricultural Research, Canberra, Australia), taking into account the ELISA sensitivity and specificity for goats, as described earlier [9]. The chi-square test was used to analyze the regional differences for the positive herds and goats ($P<0.05$). Mean goats sampled per herd between regions were subjected to one-way analysis of variance. Statistical significance among regions was determined by Duncan's new multiple range test [4], when the F value was significant at the 5% level.

The apparent Mpt seroprevalence in Korean black goats was calculated in three geographical regions, i.e., northern (Gyeonggi, Gangwon, Chungnam, and Chungbuk), central (Jeonbuk and Gyeongbuk), and southern (Jeonnam and Gyeongnam), respectively. Currently, goats are extensively raised in the south, rather than in either the northern or central regions, and the number of herds (goats) registered [6] are 10,896 (155,657), 8,261 (133,557), and 22,492 (237,298) for the northern, central, and southern regions, respectively; 54.0% of the total goat population were raised

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Table 1. Apparent and true prevalence of Mpt in Korean black goats (*Capra hircus aegagrus*)

Items	Regions			Total
	Northern	Central	Southern	
No. herds tested	38	44	34	116
No. goats tested	194	205	183	582
Mean goats sampled per herd (SD)	5.11 (± 2.17)	4.66 (± 2.15)	5.38 (± 2.40)	5.02 (± 2.31)
No. positive ^a				
Herds	8	8	13	29
Goats	9	11	28	48
Apparent prevalence (%)				
Herds (95% CI)	21.1 (8.2–34.0)	18.2 (6.8–29.6)	38.2 (21.9–54.5)	25.0 (17.2–38.2)
Goats (95% CI)	4.6 (1.7–7.5)	5.4 (2.3–8.5)	15.3 (10.0–20.6)	8.2 (6.0–10.4)
True prevalence (%)				
Herds (95% CI)	33.0 (25.1–40.9)	28.4 (21.5–35.4)	59.7 (49.6–69.6)	39.1 (34.3–43.9)
Goats (95% CI)	7.2 (5.4–9.0)	8.4 (6.6–10.3)	23.9 (20.7–27.1)	12.8 (11.5–14.2)

a) $\chi = 2.611$, $P > 0.05$ for herds; $\chi = 14.459$, $P < 0.05$ for goats.

in the southern region, whereas relatively low populations were recorded in the northern (26.2%) and central (19.8%) regions. This study employed 38, 44, and 34 herds from the northern, central, and southern regions, respectively. The mean number of goats sampled per herd was 5.11, 4.66, and 5.38 for the northern, central, and southern regions, respectively, without any significant differences in the number of goats sampled among the regions ($P > 0.05$).

Among a total of 116 herds tested, 29 had at least one goat that was seropositive for Mpt. The seropositive herds were most frequently observed in the southern region ($n=13$), as compared to the other regions. Nonetheless, the differences in the number of positive herds among the regions were not statistically significant ($\chi=2.611$, $P > 0.05$). The apparent herd-level prevalence in the northern, central, and southern regions was estimated at 21.1, 18.2, and 38.2%, respectively (Table 1). At the individual goat level, 48 of 582 sera tested were positive. The Mpt-positive goats were predominantly detected in the southern region, rather than in either the northern or central regions. Twenty-eight of 48 positive goats were geographically located in the southern region, whereas similar numbers of Mpt-positive goats were found in the northern ($n=9$) and central regions ($n=11$; Table 1). The statistically significant difference in the number of Mpt-positive goats between regions ($\chi=14.459$, $P < 0.05$) provides further evidence that the southern region is associated with most of the Mpt-positive goats detected. The apparent prevalence of Mpt-positive animals was 8.2% at the national level. In line with the herd-prevalence, Mpt was most prevalent in goats from the southern region (15.3%), followed by the central (5.4%) and northern (4.6%) regions (Table 1). The apparent prevalence was used to calculate the true prevalence. Using this measure, we may be able to estimate the number of truly infected goats. The true prevalence at the herd and goat lev-

els, based on the test characteristics, was estimated at 28.4–59.7% and 7.2–23.9%, respectively. The true herd and goat prevalence was 39.1 and 12.8%, respectively. Among 582 sera tested, 534 had a S/P value ≤ 0.24 . The S/P value of 23 sera ranged from 0.25 to 0.39. Twenty sera with a S/P value of 0.40 to 0.99 and five sera with a S/P value of ≥ 1.0 were observed (data not shown).

In Spain, Mainar-Jaime and Vázquez-Boland [7] found sheep-level prevalence of antibodies against Mpt of 11.7% using the agar gel immunodiffusion method. They concluded that possible risk factors for Mpt were all associated with intensive management. In addition, a herd size of 200 to 400 heads, and the presence of foreign breeds and their crosses, are significantly associated with seroprevalence. Unfortunately, our study did not monitor the various risk factors related to Mpt seroprevalence, as described earlier [7]. In this regard, it is difficult to explain which factor(s) are closely related to the higher seroprevalence in the southern region, as seen in this study. Nonetheless, our study clearly indicates that Mpt is prevalent in the goat population, with regional differences, and that measures for controlling the disease are needed. Further study should focus on explaining the risk factors associated with Mpt prevalence in the goat population.

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