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Epidemiological characteristics of bovine brucellosis in Korea, 2000~2004

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Abstract : This paper describes the epidemiological characteristics of bovine brucellosis in Korea during January 2000~September 2004, which encompasses the period when the incidence of bovine brucellosis increased abruptly. Data from the National Animal Infectious Disease Data Management System were used for this study. A range of epidemiological measures was calculated including annual herd and animal incidence. During the study period, there were 1,183 outbreaks on 638 farms. In beef cattle, annual herd incidence increased from 0.2 (2000) to 11.5 (2004, to September) outbreaks per 10,000 and annual animal incidence varied between 3.4 (2000) and 105.8 (2004, to September) per 100,000, respectively. On 401 (62.9%) infected farms during this period, infection was eradicated without recurrence. Recurrence of infection was significantly higher on farms where abortion was reported (53.3%), compared to farms where it was not (30.0%). On beef cattle farms, infection was introduced most frequently through purchased cattle (46.2%). Based on the results of this study, the establishment and spread of brucellosis in the Korean beef cattle population were mainly due to incomplete or inappropriate treatment of aborted materials and the movement of infected cattle.

Keywords : bovine brucellosis, epidemiology, incidence, Korea

Introduction

Bovine brucellosis remains a serious animal and public health issue in the Republic of Korea, despite long-term eradication efforts. Prior to 2000, infection was only detected sporadically in beef cattle, and these animals were not included in the official control program. Since 2000, however, brucellosis in beef animals has been detected with increasing frequency [7]. Accordingly, new systems have been implemented to strengthen brucellosis surveillance in this livestock sector, which included testing and certification for cattle traded in livestock markets and annual serological testing for all female beef cattle older than 12 months in cities and provinces where positive rate has exceeded 5% [7]. A National Animal Infectious Disease Data Management System (AIMS; Animal, Plant and Fisheries Quarantine and Inspection Agency, Korea) was established in 2002 in Korea, providing real-time information on national animal disease incidence and related data from epidemiological investigation on the infected herd by veterinary public officers working for Local Veterinary Services. These data include some descriptions on the herd size, type and size of farmhouse, type of herd, purchase source and frequency, presence of other animals in the farm, distance from neighboring farms and their history of infection with *Brucella abortus*, type of service used (artificial insemination or natural), and type of labor used (hired or family members).

Earlier studies have presented overviews of brucellosis in cattle in Korea. Wee *et al.* [7] reported the prevalence of bovine brucellosis from early 1950s to 2005 and discussed some factors that have contributed to the establishment and spread of brucellosis in Korean beef

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cattle population. Lee *et al.* [3] conducted a critical evaluation of surveillance and control efforts for bovine brucellosis during 2000~2006. As yet, however, the epidemiological characteristic of bovine brucellosis in Korea has not been reported clearly. Epidemiological analyses provide insights into the national policies on disease incidence. The objective of this study was, therefore, to offer the epidemiological data on bovine brucellosis in Korea during January 2000~September 2004, which encompasses the period when the incidence of bovine brucellosis increased abruptly.

Materials and Methods

Data collection

Data on bovine brucellosis were collected from the database AIMS. The accuracy of these data were confirmed using data collected by Local Veterinary Service Laboratories and monthly reports on animal diseases maintained by the Ministry for Food, Agriculture, Forestry and Fisheries, Korea [4].

Data analysis

Analyses were conducted on all brucellosis cases during January 2000~September 2004 ('the period of interest'). A farm was considered to be a new outbreak case if it was reported as brucellosis-affected farm for the first time during the period of interest and otherwise, a recurrent outbreak case. Farms were considered infected throughout each outbreak (which included the period from the time of initial detection to subsequent clearance). Following initial detection of infection in a herd, cattle concerned epidemiologically are tested for brucellosis on two (prior to 2000) or three (subsequently) occasions before subsequent clearance. Required interval between tests varied a little over the years (50~70 days in 2006, but 30~60 days prior to and after this). From 2006, the first of these tests was conducted within 10 days of initial detection. Further, from 2007, the third test is conducted 6 months after the detection of the last case in an infected herd. Therefore, infected cattle were associated with either a new or recurrent outbreak.

We calculated the number of infected farms and cattle, by year and outbreak type (new and recurrent). The annual herd and animal incidence rates were also calculated, the former solely pertained to farms with new outbreaks and the latter to all animal cases. The frequency of recurrence was determined based on the total number of farms with outbreaks that were classed as recurrent. We also calculated the time from initial diagnosis to first recurrence in those farms where recurrent infection was detected. We determined the causes for initial diagnostic investigation, by farm type and year. We calculated the percentage of farms reporting abortion(s), and also determine the association between reported abortion and both farm type and recurrence of infection using chi-square tests. The cause for initial introduction of infection was summarized based on the following categories: purchased cattle, neighborhood spread (outbreak on neighboring farms, no

Table 1. The number of herds and cattle infected with brucellosis in Korea during January 2000 to September 2004 ('the period of interest'), by year and case type

Classification	Total	2000	2001	2002	2003	2004 (to Sep.)
Number (%) of farm outbreaks						
Total	*1,183*	*294*	*146*	*121*	*172*	*450*
New outbreaks	638 (53.9)	153 (52.0)	60 (41.1)	43 (35.5)	74 (43.0)	308 (68.4)
Recurrent outbreaks	545 (46.1)	141 (48.0)	86 (58.9)	78 (64.5)	98 (57.0)	142 (31.6)
Number (%) of infected cattle						
Total	*6,955*	*1,375*	*806*	*982*	*1,088*	*2,704*
In association with farms with new outbreak*	3,800 (54.6)	665 (48.4)	311 (38.6)	392 (39.9)	552 (50.7)	1,880 (69.5)
In association with farms with recurrent outbreak	3,155 (45.4)	710 (51.6)	495 (61.4)	590 (60.1)	536 (49.3)	824 (30.5)

*The farms were considered a new farm case if reported with brucellosis for the first time during the period of interest.

Table 2. The annual incidence of brucellosis in herd and individual levels in Korea during January 2000~September 2004

Year	Herd incidence* (per 10,000 herds)			Animal incidence† (per 100,000 animals)		
	Total	Dairy	Beef	Total	Dairy	Beef
2000	4.5	107.4	0.2	58.7	242.2	3.4
2001	2.2	43.5	0.1	39.3	135.3	4.7
2002	1.8	32.1	0.2	49.3	140.6	14.9
2003	3.7	44.1	1.3	55.4	92.0	41.5
2004 (to Sep.)	15.4	89.8	11.5	126.6	193.1	105.8

*Herd incidence includes only new farm outbreaks during this period. †Animal incidence includes all infected animals. Data of the total number of herds and cattle (in total, by dairy and beef) were derived from statistical yearbooks of Ministry for Food, Agriculture, Forestry and Fisheries, Korea [4].

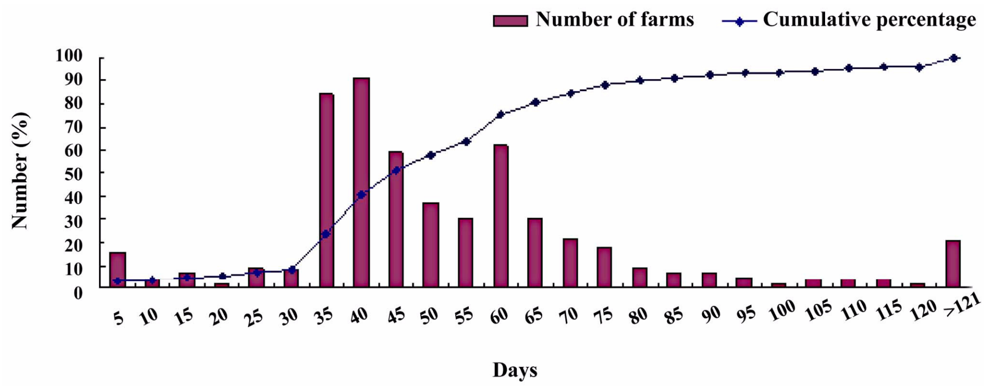

Fig. 1. The number and cumulative percentage of farms by time (days) from clearance of the initial outbreak to subsequent recurrence, on the 237 farms where an outbreak recurred at least once.

cattle purchased), residual infection (recurrence of infection on a farm that had previous infection prior to January 2000, no other factors linked with introduction, including cattle purchasing) or unknown (no purchased cattle, no neighborhood spread, no within-herd transmission). Analyses were conducted with SPSS (ver. 11.0; SPSS Corporation, USA) and SAS (ver. 8.1; SAS Institute, USA).

Results

The number of herds and cattle affected by brucellosis in Korea during January 2000 to September 2004, by year and case type, is presented in Table 1. During this period, there were 1,183 separate outbreaks (6,955 infected cattle) on 638 different farms, including 3,800 and 3,155 cattle associated with 638 new and 545 recurrent outbreaks, respectively. Annual herd incidence varied between 32.1 (2002) and 107.4 (2000) per 10,000 in dairy herds, and 0.2 (2000) and 11.5 (2004, to September) per 10,000 in beef herds. Annual animal incidence varied between 92.0 (2003) and 242.2 (2000) per 100,000 in dairy cattle and 3.4 (2000) and 105.8 (2004, to September) per 100,000 in beef cattle (Table 2). The frequency of recurred outbreaks in 638 farms in Korea during January 2000~September 2004 was also analyzed. Brucellosis was eradicated without recurrence on 401 (62.9%) infected farms, while the rest of farms (237/638, 37.1%) had at least one occurrence. The number of farms with recurred outbreak was 120 (18.8%) of one time recurrence, 47 (7.4%) of twice, 22 (3.4%) of three times, 21 (3.3%) of four times, 10 (1.6%) of five times, 6 (0.9%) of six times, 6 (0.9%) of seven times, and 5 (0.87%) of more than eight times, respectively. The time periods between clearance from the initial outbreak and subsequent recurrence on the remaining 237 farms are presented in Fig. 1.

The reason for initial diagnostic investigation, by year, is presented in Table 3. In total, 341 (88.6%) out of the 385 infected dairy cattle farms were initially detected as

Table 3. The cause for initial diagnostic investigation on 638 infected farms in Korea during January 2000~September 2004, by year and farm type

Farm type, year	Total	Causes for initial diagnostic investigation (number of farms)				
		Routine serological screening	Non-routine diagnostic investigation	Follow-up survey	Farmer-requested testing certification	Unknown
Dairy cattle						
Total	385	341	14	1	–	29
2000	148	130	2	–	–	16
2001	57	52	5	–	–	ñ
2002	39	35	1	–	–	3
2003	50	47	2	–	–	1
2004 (to Sep.)	91	77	4	1	–	9
Beef cattle						
Total	253	31	109	27	67	19
2000	5	–	3	–	–	2
2001	3	–	2	–	–	1
2002	4	–	4	–	–	ñ
2003	24	–	20	2	–	2
2004 (to Sep.)	217	31	80	25	67	14
Total	638	372	123	28	67	48

Table 4. Probable route of introduction of infection on 638 farms infected with brucellosis in Korea during January 2000~September 2004, by farm and outbreak type

Farm type	Total	Probable route of introduction of infection (Number of farms, %)			
		Purchased cattle	Neighborhood spread	Residual infection	Unknown
Total	638	295 (46.2)	78 (12.2)	40 (6.3)	225 (35.3)
Farm					
Dairy cattle	385	110 (28.6)	64 (16.6)	37 (9.6)	174 (45.2)
Beef cattle	253	185 (73.1)	14 (5.5)	3 (1.2)	51 (20.2)
Outbreak					
New	401	186 (63.1)	36 (46.2)	22 (55.0)	157 (69.8)
Recurrent	237	109 (36.9)	42 (53.8)	18 (45.0)	68 (30.2)

brucellosis-affected during routine serological screening. Whereas, infection on 176 (70.0%) out of the 253 infected beef cattle farms was initially detected as a consequence of a non-routine diagnostic investigation (43.1%) or farmer-requested testing certification (26.4%). Abortion was reported on 195 (30.6%) of the 638 infected farms, including 24.7% and 39.5% dairy and beef farms, respectively. Recurrence of infection was significantly higher on farms where abortion was reported (53.3%) compared to farms where it was not (30.0%) (Relative risk 2.7, 95% confidence interval 1.9~3.8; $p < 0.0001$). Mean frequencies of recurrence on farms with and without abortion were 1.21 (SD: 1.78) and 0.70 (SD: 1.55), respectively ($p < 0.05$).

Table 4 presents the probable introduction routes of infection on 638 brucellosis-infected farms in Korea during the study period, by farm type. On 413 farms where probable causes for introduction could be deduced, brucellosis was introduced by purchased cattle (46.2%) or neighborhood spread (12.2%). On beef cattle farms, infection was introduced most frequently through purchased cattle.

Discussion

Since initial introduction in 1955, brucellosis has predominantly been a disease of the Korean dairy section. It only emerged as an important infection in Korean native (beef) cattle during 2003~2004; prior to this, cases in beef animals were only reported sporadically. Reasons for the abrupt surge in brucellosis incidence in beef cattle in 2004 have been the subject of detailed investigation [3, 7], and can largely be attributed to increased surveillance effort. At this time, a number of new regulations were introduced requiring mandatory testing of beef cattle prior to trade in livestock markets, and of beef cattle farms in high prevalence areas. Although the increase in beef cattle reactors is closely aligned to an increase in surveillance effort, it is likely that this increase is a genuine reflection of the recent establishment and spread of brucellosis in the Korean beef cattle population [3]. Other factors contributing to this increase included a general lack of understanding, among beef farmers, about brucellosis. There were examples of aborted fetal material being left for extended periods, and of incomplete or inappropriate disinfection following abortion. It is noteworthy that human brucellosis cases were rare prior to the sudden increase of brucellosis in beef cattle. Indeed, most reported human cases (72.7%, 8/11) were reported in association with infected Korean native beef cattle [6]. Once this link was observed, health education and safe livestock practices for the prevention and control of bovine brucellosis, particularly among farmers and related workers, were emphasized to increase public awareness of brucellosis.

Brucellosis can be transmitted either horizontally, following the introduction of acutely or latently infected animals into a herd, or vertically, following *in utero* transmission to calves from infected dams [1]. The most common route of transmission is reported to be contact with an aborted fetus or contaminated placenta [1]. *B. abortus* in aborted fetuses and fetal membranes, and also in uterine discharges from infected cattle, may remain infective for several months [2]. Logically, repeated infection within a herd may be associated with the ability of *Brucella* to persist outside the mammalian hosts under suitable conditions. In the current study, recurrence risk was 2.7 times higher on farms reporting abortion compared with farms where abortion was not reported or where the abortion status was unknown. In a case-control study on bovine brucellosis in Korea reported by Yoon *et al.* [8], there was a 10-fold increase in brucellosis incidence on farms that habitually left aborted material untreated, compared with farms where this material was properly disinfected. Accordingly, the potential for transmission can be substantially reduced if farmers are aware of the importance of early recognition of abortion and proper treatment of aborted materials. In Korea, artificial insemination is mostly used for dairy cattle, whereas natural mating is usually preferred for beef cattle. Even when artificial insemination is used, additional natural mating is often conducted for the purpose of increasing fertilization rate in beef herds. These practices may have contributed to transmission of infection in infected herds.

In this study, the introduction of cattle was found to be the most common reason for introduction of infection, particularly on beef cattle farms. In Korea, most of beef and dairy farms are small with less than 50 animals. Further, animal movement occurs more commonly in beef, compared with dairy herds in Korea. Frequent contact with other herds through the movement of purchased cattle may increase risk of introducing infected cattle [2]. In a previous study on risk factors for bovine brucellosis in Korea, Yoon *et al.* [8] reported a two-fold increase in infection risk associated with the purchase of cattle at least once yearly compared with no cattle purchased. As a consequence, the Korean government has introduced new systems to prevent disease spread via movement of infected animals, including mandatory testing, since June 2004, of cows and bulls prior to trade [7]. Currently, test-positive herds are placed under movement restriction and subjected to repeat tests on at least 2 occasions between days 30 and 60 after the initial test. Movement restriction of animals in a herd can be lifted only after confirmation of all animals are negative in the two consecutive tests. Our finding that recurrent cases were detected most commonly at days 31~40 and 56~60 indicates that cattle-retesting in test-positive herds was mostly conducted during those days. If the re-examination was conducted twice at intervals of 30-day or 60-day, movement restriction of cattle in the test-positive herds may be lifted a minimum of 60 days and a maximum of 120 days after the initial test, respectively. Given the variable incubation period for brucellosis, ranging between 53 to 251 days [5], this testing interval will not detect all of the additional cases, noting the potential for a relatively long incubation period in some infected herds. Therefore, the current study results have highlighted the need to extend the period of movement restriction, and of the retest interval in test-positive herds, to 120 days. This will facilitate an increase in the rate of detection, and a reduction in the risk of recurrence. This study also prompted a revision of existing regulations to include mandatory re-testing of herds 6 months after the detection of the last known infected case.

Based on the results of this study, the recent establishment and spread of brucellosis in the Korean beef cattle population were mainly due to incomplete or inappropriate treatment of aborted materials and the movement of infected cattle. There was a general lack of understanding about brucellosis among Korean beef farmers, leading to a concurrent increase in human cases, particularly among beef farmers and related workers. Education and information should be emphasized to increase public awareness of the disease. These study results have prompted some revision to the national control program, specifically an extension to the period of movement restriction and of the retest interval in test-positive herds.

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References

1. **Carvalho Neta AV, Mol JPS, Xavier MN, Paixo TA, Lage AP, Santos RL.** Pathogenesis of bovine brucellosis. Vet J 2010, **184**, 146-155.
2. **Crawford RP, Huber JD, Adams BS.** Epidemiology and surveillance. In: Nielsen K, Duncan JR (eds.). Animal Brucellosis. 1st ed. pp. 131-151, CRC Press, Florida, 1990.
3. **Lee BY, Higgins IM, Moon OK, Clegg TA, McGrath G, Collins DM, Park JY, Yoon HC, Lee SJ, More SJ.** Surveillance and control of bovine brucellosis in the Republic of Korea during 2000-2006. Prev Vet Med 2009, **90**, 66-79.
4. **Ministry for Food, Agriculture, Forestry and Fisheries (MIFAFF)**. Bovine tuberculosis. Monthly report on notifiable diseases (livestock and poultry). In: Agriculture and Forestry Statistical Yearbook, 1960-2007. MIFAFF, Gwacheon, 2008.
5. **Nicoletti P.** The epidemiology of bovine brucellosis. Adv Vet Sci Comp Med 1980, **24**, 69-98.
6. **Park MY, Lee CS, Choi YS, Park SJ, Lee JS, Lee HB.** A sporadic outbreak of human brucellosis in Korea. J Korean Med Sci 2005, 20, 941-946.
7. **Wee SH, Nam HM, Kim CH.** Emergence of brucellosis in cattle in the Republic of Korea. Vet Rec 2008, **162**, 556-557.
8. **Yoon HC, Nam HM, Kim CH, Park CK, Kang MI, Wee SH**. Risk factors for bovine brucellosis in Korea: A case control study. Korean J Vet Public Health 2006, **30**, 77-87.