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Serologic Survey of Alaska Wildlife for Microbial Pathogens

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Research Performance Report
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This is a progress report on continuing research. Information may be refined at a later date.

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RESEARCH PROGRESS REPORT

STATE: Alaska **STUDY:** 18.71

COOPERATOR: None

GRANT: W-27-4

STUDY TITLE: Serologic Survey of Alaska Wildlife for Microbial Pathogens

AUTHOR: Randall L Zarnke

PERIOD: 1 July 2000–30 June 2001

SUMMARY

During this grant period, I accomplished the following work:

- Processed and cataloged approximately 1500 serum samples
- Shipped approximately 1000 serum samples to various labs for testing
- Entered and analyzed test results
- Relayed test results to submitters
- Wrote hard copy and CD version of 25-year summary of serologic survey
- Wrote and submitted manuscript (Brucella serology in caribou, wolves, and bears) to Journal of Wildlife Diseases and worked on 5 other manuscripts for JWD

Under the study title "Serologic Survey for Microbial Pathogens," a formal manuscript has been submitted to the *Journal of Wildlife Diseases*. A copy of this manuscript (Appendix) constitutes the progress report for this reporting period.

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APPENDIX Geographic pattern of serum antibody prevalence for *Brucella* spp. in caribou, grizzly bears, and wolves from Alaska, 1975–1998 (modified format submitted to *Journal of Wildlife Diseases*)

RH: ZARNKE AND VER HOEF — SERUM ANTIBODY PREVALENCE OF BRUCELLA SPP. IN CARIBOU, GRIZZLY BEARS, AND WOLVES

GEOGRAPHIC PATTERN OF SERUM ANTIBODY PREVALENCE FOR BRUCELLA SPP. IN CARIBOU, GRIZZLY BEARS, AND WOLVES FROM ALASKA, 1975–1998

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ABSTRACT: Blood samples were collected from 2635 caribou (Rangifer tarandus groenlandicus), 1934 grizzly bears (Ursus arctos), and 930 wolves (Canis lupus) from throughout mainland Alaska during 1975–1998. Sera were tested for evidence of exposure to Brucella spp. Serum antibody prevalences were highest in the northwestern region of the state. In any specific area, prevalences for caribou and wolves were of a similar magnitude, whereas prevalence for bears in the same area was two to three times higher.

Key words: Alaska, Brucella spp., caribou, grizzly bear, wolf.

INTRODUCTION

Brucellosis is a bacterial disease with worldwide distribution (Tessaro, 1986). Several species comprise the genus Brucella. Each species has a preferred host range (Witter, 1981). Reindeer and caribou (Rangifer tarandus groenlandicus) are the preferred reservoir hosts for Brucella suis biovar IV (Forbes, 1991). Infection localizes primarily in joints and the reproductive tract (Dieterich and Morton, 1987). Other tissues can also be infected (Tessaro and Forbes, 1986). Clinical signs of disease include orchitis in males, abortion in females, and bursitis in both sexes (Forbes, 1991).

Caribou are widely distributed throughout mainland Alaska (Valkenburg, 1998). They live in herds that range in size from a few hundred animals to a few hundred thousand (Valkenburg et al., 1996). Size of individual herds can vary considerably due to the effects of predation, quantity and quality of available food, and weather (Adams et al., 1998). Infectious and parasitic diseases also play a role in population dynamics (Dieterich, 1980).

Wolves (Canis lupus) and grizzly bears (Ursus arctos) are the two primary terrestrial predator species in Alaska. Both species prey extensively on caribou where they are sympatric (Valkenburg et al., 1996). The predation process provides ample opportunity for transmission of diseases and parasites from caribou to predators (Neiland, 1970).

The objective of the current study was to determine geographic pattern of Brucella sp. antibody prevalence in caribou, wolves, and grizzly bears in Alaska.

METHODS

Caribou, wolves, and grizzly bears were captured by personnel of the Alaska Department of Fish and Game, U.S. Fish and Wildlife Service, and National Park Service. Several individual animals (primarily bears) were captured more than once. For the purpose of this study, each capture was considered as a separate event. Blood samples were collected and stored at either ambient or refrigerated temperatures for 12–36 hours. Sera were removed and stored temporarily at –15 C. Long-term storage was at –55 C for 1–10 years until the time of testing.

Sera were tested for evidence of exposure to Brucella spp. by means of the standard plate test (SPT) (U.S. Department of Agriculture, undated) and buffered Brucella antigen (BBA) test (Angus and Barton, 1983). Prior to 1990, tests were conducted at the U.S. Department of Agriculture's National Veterinary Services Laboratory in Ames, Iowa. After 1990, tests were conducted at the University of Alaska's Institute of Arctic Biology in Fairbanks, Alaska.

Sera that caused agglutination in the SPT at a dilution ≥1:50 were considered indicative of previous natural exposure. The BBA test was evaluated as simply either positive or negative. Results from the two tests were jointly evaluated to arrive at a final determination for each sample.

To aid in managing wildlife, the landmass of Alaska is divided into 26 Game Management Units (GMU). These areas are based on major physiographic features such as mountain ranges and major river drainages. Several of the larger GMU's are further divided into subunits. Obviously, wildlife species such as caribou, wolves and bears do not necessarily restrict their movements within these boundaries. However, it is convenient to report the results for the GMU where an animal is captured. In addition, this approach provides a meaningful representation for geographic patterns of antibody prevalence.

A Bayesian hierarchical model (Clayton and Kaldor 1987; Devine et al., 1994; Bernardinelli et al., 1995; Waller et al., 1997; Xia et al., 1997) was used to estimate area-specific prevalences for all three species. Let N_{ij} be the number of samples from the *i*th area (for all GMU's listed in Table 1); $i = 1,2,\ldots, 26$, for the *j*th species; $j = 1$ (caribou), 2 (wolf), or 3 (grizzly bear). Let x_{ij} be the number of positive titers in the *i*th area. Assume that positive titers are binomially distributed,

$$x_{ij} \mid p_{ij}, N_{ij} \sim Bin(N_{ij}, p_{ij}),$$

where

$$logit(p_{ij} \mid \alpha_j, b_i) = \mu + \alpha_j + b_i .$$

This is the usual logistic regression situation, except that b_i is a random effect that is spatially autocorrelated with its neighbors. For the fixed effects, α_1 was assigned a value of 0. A normal distribution $\alpha_j \sim N(0,10000)$ was used for j = 2,3. An improper flat prior was given to μ. The autocorrelation among the $\{b_i\}$ follows a conditional autoregressive (CAR) model (see, e.g., Cressie, 1993:p. 407). Any two GMUs that shared a border were defined as neighbors. A normally distributed CAR model is defined where $b_i \mid \bar{b}_i, \phi, n_i$ is normally distributed $N(\bar{b}_i, \phi / n_i)$, where $\bar{b}_i$ is the mean of the neighboring values for the *i*th GMU and n_i is the number of neighbors. The variance parameter was given a gamma distribution, $\phi \sim Gam(0.001, 0.001)$.

The statistical software package WinBUGS was used to obtain a sample from the posterior distribution for ϕ, b_i, α_j and μ, and functions of these parameters. For example, the posterior distribution of

$$100 \times \exp(\mu + \alpha_i + b_j) / [1 + \exp(\mu + \alpha_i + b_j)]$$

provides an estimate of the prevalences (in %) in the *j*th GMU for the *i*th species. These values are known as "smoothed" rates. The mean of the sample from the posterior distribution was used to estimate the smoothed rates, and the standard deviation of the sample gives the standard error of the smoothed rates (Besag et al., 1991; Besag and Kooperberg, 1995). The posterior sample was obtained using Marker Chain Monte Carlo methods, with a "burn-in" of 4,000 iterations. The sample was drawn from the next 50,000 iterations.

RESULTS

Serum antibody prevalences for caribou, wolves and bears were highest in the northern portion of the state (Table 1 and Fig. 1). Within any particular GMU, the relative magnitude of observed prevalences for caribou and wolves are similar. Prevalence for bears is substantially higher than for the other two species. A graphic representation of the "smoothed" rate for all three species is also presented in Figure 1.

DISCUSSION

The "smoothed" rate for all three species (Fig. 1) confirms that antibody prevalence is highest in the northwest portion of the state. In some cases, the raw rates for an individual species may provide a somewhat biased picture of geographic distribution. Animals captured on the boundary of GMU "A" may actually spend most of their time in adjacent GMU "B." In addition, only a few animals of this species may have been captured in GMU "A." Therefore, these few animals have a large influence on the overall prevalence attributed to GMU "A." The best examples of this phenomenon in the current study are:

(a) the 100% prevalence (1/1) for caribou in GMU 20F and
(b) the 40% prevalence (2/5) for bears in GMU 25 (Table 1).

Therefore, the "smoothed" rates provide a better overall representation of the geographic distribution of Brucella sp. exposure. Multiple samples from a few animals may have exerted a small bias on the reported prevalence.

Bears and wolves are exposed to Brucella spp. while preying on infected caribou (Neiland, 1975; Neiland and Miller, 1981). For most GMUs, prevalences in bears are substantially higher than those for caribou and wolves (Table 1). These higher prevalences may be due to the longer average lifespan of bears compared to the other two species. During this longer life, bears have a greater potential for consuming an infected caribou.

Historically, brucellosis has been considered to be present in caribou herds throughout Alaska (Neiland et al., 1968). The observed serum antibody prevalence for caribou from the southern half of the state is essentially 0% (Table 1). One interpretation of this data is that the disease is absent from this region. Observed prevalences for bears from all regions (including the southern half of the state) are higher than prevalences for caribou. This data suggests that bears are being exposed to Brucella sp. in the southern portion of the state. Presumably, the source of that exposure would be infected caribou. No other species serve as an effective large-scale reservoir for transmission to predators and scavengers. Thus, it appears that the disease may be present in most (if not all) caribou herds, but at very low levels in the southern portion of the state. Perhaps sampling intensity was simply incapable of detecting this very low frequency of infection in these southerly herds. An alternative explanation would be that the disease does not occur in caribou herds from the southern portion of the state and the positive serologic test results for bears and wolves from this region are incorrect.

Numerous free-ranging, semi-domestic reindeer herds live in GMU 22 on the Seward Peninsula (Fig. 1). Brucellosis is enzootic in these herds (Dieterich and Morton, 1987). The Western Arctic caribou herd has a large home range, covering portions of GMU's 21, 22, 23 and 26A (Fig. 1). During the winter, the Western Arctic herd migrates to the southwestern portion of its range. At that time, there is often opportunity for contact between Seward Peninsula reindeer and caribou from the Western Arctic herd. Reindeer may have been the original reservoir for transmission of brucellosis to other arctic species (Davydov, 1965). Alternatively, perhaps the disease has always been enzootic in free-ranging caribou (Huntley et al., 1963). The current study provides no evidence to confirm or refute either theory.

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LITERATURE CITED

ADAMS, L. G., AND B. W. DALE. 1998. Reproductive performance of female Alaskan caribou. Journal of Wildlife Management 62: 1184–1195.

ANGUS, R. D., AND C. E. BARTON. 1983. The production and evaluation of a buffered plate antigen for use in a presumptive test for brucellosis. Third international symposium on

brucellosis, Algiers, Algeria, 1983. Developments in Biological Standardization 56: 349–356.

BERNARDINELLI, L., D. CLAYTON, AND C. MONTOMOLI. 1995. Bayesian estimates of disease maps: How important are priors? Statistics in Medicine 14: 2411–2431.

BESAG, J., AND C. L. KOOPERBERG. 1995. On conditional and intrinsic autoregressions. Biometrika 82: 733–746.

———, J. YORK, AND A. MOLLIE. 1991. Bayesian image restoration, with two applications in spatial statistics. Annals of the Institute of Statistical Mathematics 43: 1–59 (with discussion).

CLAYTON, D., AND J. KALDOR. 1987. Empirical Bayes estimates of age-standardized relative risks for use in disease mapping. Biometrics 43: 671–681.

CRESSIE, N. A. C. 1993. Statistics for Spatial Data, Revised Edition. John Wiley and Sons, New York. 900 pp.

DAVYDOV, N. N. 1965. La brucellose du renne dans le Grand Nord. Bulletin de Office International des Epizooties 63: 1005–1014.

DEVINE, O. J., M. E. HALLORAN, AND T. A. LOUIS. 1994. Empirical Bayes methods for stabilizing incidence rates prior to mapping. Epidemiology 5: 622–630.

DIETERICH, R. A. 1980. Current status of reindeer/caribou diseases in Alaska. In Proceedings of the second international reindeer/caribou symposium, Røros, Norway, 1979. E. Reimers, E. Gaare, and S. Skjenneberg (eds.). Direktoratet for vilt og ferskvannsfisk, Trondheim. pp. 438–441.

———, AND J. K. MORTON. 1987. Effects of live Brucella abortus strain 19 vaccine on reindeer later challenge exposed with Brucella suis type 4. Rangifer 7: 33–36.

FORBES, L. B. 1991. Isolates of Brucella suis biovar 4 from animals and humans in Canada, 1982–1990. Canadian Veterinary Journal 32: 686–688.

HUNTLEY, B. E., R. N. PHILIP, AND J. E. MAYNARD. 1963. Survey of brucellosis in Alaska. Journal of Infectious Diseases 112: 100–106.

NEILAND, K. A. 1970. Rangiferine brucellosis in Alaskan canids. Journal of Wildlife Diseases 6: 136–139.

——— 1975. Further observations on rangiferine brucellosis in Alaskan carnivores. Journal of Wildlife Diseases 11: 45–53.

———, AND L. G. MILLER. 1981. Experimental Brucella suis type 4 infections in domestic and wild Alaskan carnivores. Journal of Wildlife Diseases 17: 183–189.

———, J. A. KING, B. E. HUNTLEY, AND R. O. SKOOG. 1968. The diseases and parasites of Alaskan wildlife populations, Part I. Bulletin of the Wildlife Disease Association 4: 27–36.

TESSARO, S. V. 1986. The existing and potential importance of brucellosis and tuberculosis in Canadian wildlife: A review. Canadian Veterinary Journal 27: 119–124.

———, AND L. B. FORBES. 1986. Brucella suis biotype 4: A case of granulomatous nephritis in a barren ground caribou (Rangifer tarandus groenlandicus L.) with a review of the distribution of rangiferine brucellosis in Canada. Journal of Wildlife Diseases 22: 479–483.

U.S. DEPARTMENT OF AGRICULTURE (USDA). Undated. National Animal Disease Laboratory Diagnostic Reagents Manuals 65D, E, F. National Animal Disease Laboratory, Ames, Iowa. 57 pp.

VALKENBURG, P. 1998. Herd size, distribution, harvest, management issues, and research priorities relevant to caribou herds in Alaska. Seventh North American caribou conference, Thunder Bay, Ontario, Canada, 19–21 August 1996. Rangifer 10: 125–129.

———, J. L. DAVIS, J. M. VER HOEF, R. D. BOERTJE, M. E. MCNAY, R. M. EAGAN, D. J. REED, C. L. GARDNER, AND R. W. TOBEY. 1996. Population decline in the Delta caribou herd with reference to other Alaskan herds. Sixth North American caribou workshop, Prince George, British Columbia, Canada, 1–4 March 1994. Rangifer 9: 53–62.

WALLER, L. A., B. P. CARLIN, H. XIA, AND A. E. GELFAND. 1997. Hierarchical spatio-temporal mapping of disease rates. Journal of the American Statistical Association 92: 607–617.

WITTER, J. F. 1981. Brucellosis. In Infectious diseases of wild animals. Second edition. J. W. Davis, L. H. Karstad, and D. O. Trainer (eds.). Iowa State University Press, Ames, Iowa, USA, pp. 280–287.

XIA, H., B. CARLIN, AND L. A. WALLER. 1997. Hierarchical models for mapping Ohio lung cancer rates. Environmetrics 8: 107–120.

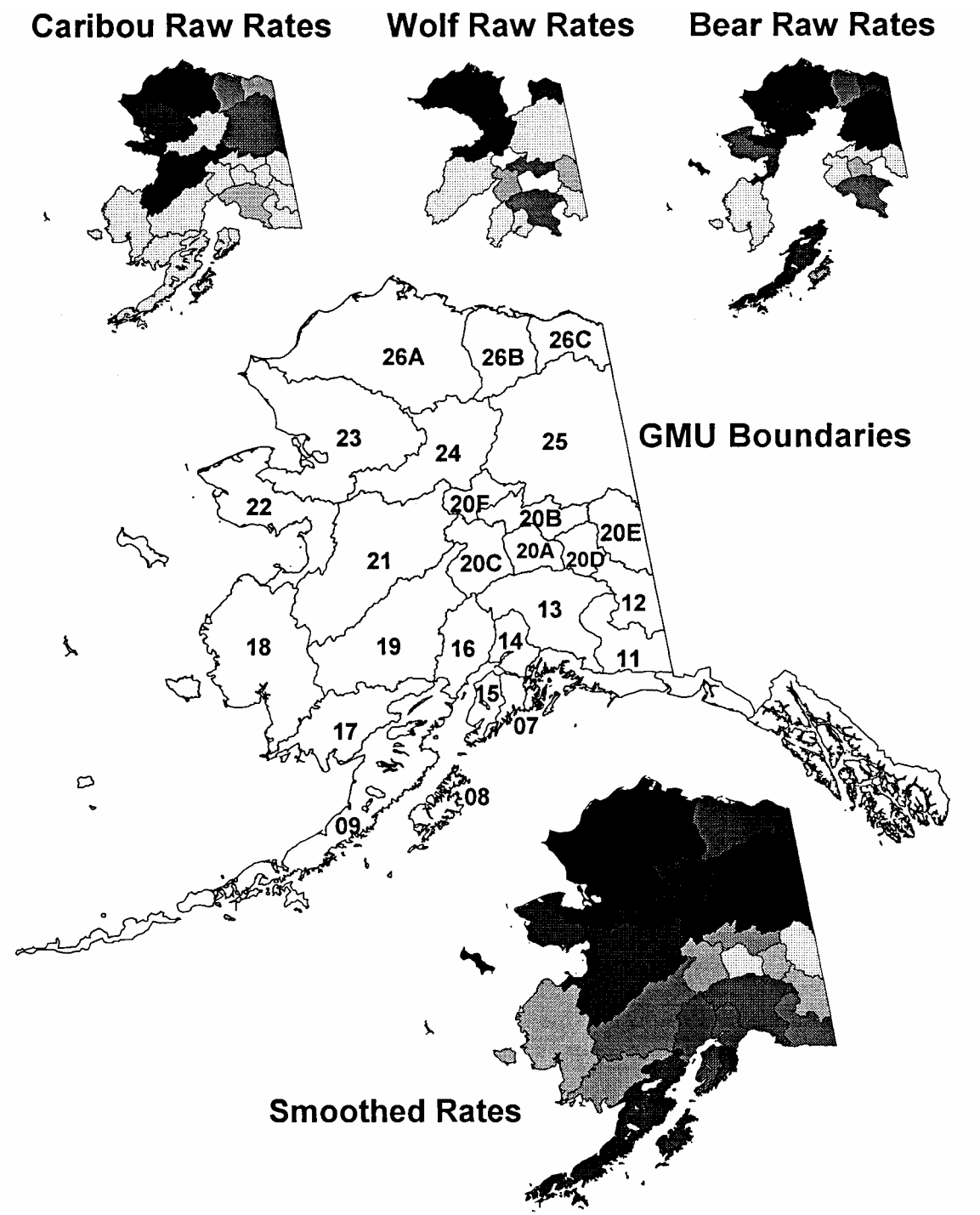

Figure 1 Location-specific serum antibody prevalence for Brucella sp. in caribou (*Rangifer tarandus*), wolf (*Canis lupus*), and grizzly bear (*Ursus arctos*) from Alaska (darker shading indicates higher prevalence)

TABLE 1 Serum antibody prevalence for Brucella sp. in caribou (*Rangifer tarandus groenlandicus*), wolf (*Canis lupus*), and grizzly bear (*Ursus arctos*) from Alaska, 1975–2000

	Caribou					Wolf					Grizzly Bear				
GMU[a]	Sample size	Number positive[b]	% Prevalence	% Smooth rate[c]	Standard error[d]	Sample size	Number positive[b]	% Prevalence	% Smooth rate[c]	Standard error[d]	Sample size	Number positive[b]	% Prevalence	% Smooth rate[c]	Standard error[d]
07	13	0	0.0	1.1	0.98				2.4	2.22				5.1	4.13
08	3	0	0.0	1.3	0.38				2.8	1.04	232	14	6.0	6.0	1.50
09	337	0	0.0	1.9	0.48				4.3	1.46	126	19	15.1	8.9	1.97
11	19	0	0.0	0.8	0.85				1.9	1.90				4.0	3.66
12	77	0	0.0	0.5	0.39	11	0	0	1.1	0.89				2.5	1.84
13	214	0	0.0	1.0	0.29	75	1	1.3	2.2	0.76	156	12	7.7	4.7	1.26
14				1.0	0.77	11	0	0	2.1	1.71				4.5	3.34
15	22	0	0.0	1.1	0.86				2.6	2.00				5.4	3.72
16				0.9	0.65	7	0	0	2.1	1.47				4.6	2.86
17	87	0	0.0	0.7	0.54				1.7	1.26				3.6	2.50
18	3	0	0.0	0.6	0.37				1.3	0.84	63	0	0	2.8	1.69
19	44	0	0.0	0.9	0.62				1.9	1.43				4.1	2.82
20A	126	0	0.0	0.5	0.18				1.1	0.45	270	6	2.2	2.3	0.80
20B	3	0	0.0	0.7	0.33	239	3	1.3	1.5	0.63	1	0	0	3.4	1.54
20C	105	0	0.0	0.6	0.29	201	2	1.0	1.4	0.60	5	0	0	3.2	1.38
20D	97	0	0.0	0.5	0.35				1.1	0.81				2.5	1.66
20E	162	0	0.0	0.4	0.23	195	1	0.5	0.9	0.47	9	0	0.0	2.0	1.10
20F	1	1	100.0	3.4	3.58				7.2	6.59				13.9	10.04
21	53	5	9.4	2.8	1.20	31	0	0	6.1	2.63				12.6	4.77
22				2.8	0.97				6.2	2.43	76	10	13.2	12.6	3.50
23	541	38	7.0	5.5	0.79				11.9	2.99	203	39	19.2	22.7	2.49
24	20	0	0.0	3.2	1.34	54	4	7.4	6.9	2.59				14.2	5.06
25	103	5	4.9	3.7	1.47	1	0	0	8.1	3.64	5	2	40.0	16.0	5.59
26A	182	13	7.1	6.0	0.97	60	15	25.0	12.7	2.88	366	80	21.9	24.2	2.06
26B	327	8	2.4	2.6	0.67				5.9	2.00	50	6	12.0	12.1	2.84
26C	98	1	1.0	2.8	0.55	45	1	2.2	6.2	1.64	372	50	13.4	12.5	1.61

[a] Game Management Unit.
[b] Results of standard plate test and buffered *Brucella* antigen tests.
[c] Estimated prevalence based on the observed prevalence, model effects, and effects from neighboring areas.
[d] Standard errors of the estimated prevalence (smooth rates).