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Short Communication

Intra-cluster correlation coefficients of 20 infections calculated from the results of cluster-sample surveys

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In developing countries, information on the prevalence of infections in the livestock population is generally obtained by means of cross-sectional surveys. Owing to the limited availability of sampling frames and high travel costs, it is usually impossible and impractical to select a simple random sample of animals from the population. The only solution for most surveys is to take a cluster sample, with herds or villages being randomly selected from a list and a defined number of animals then being randomly selected within each herd or village.

The desired precision of the survey result (i.e. the standard error (SE) of the prevalence estimate) is an important criterion for deciding on an appropriate sample size. However, for a given number of animals in the sample, the SE of a cluster sample is usually larger than the SE of a simple random sample. The increase in the SE resulting from cluster sampling, known as the design effect, D , is related to the average cluster size and the intra-cluster correlation coefficient, ρ , of the disease(s) of interest in the study population (Bennett et al., 1991). Unfortunately, D is rarely known before actually carrying out the survey because the value of ρ is unknown.

The purpose of this short communication is to report values of ρ for a range of infections derived from survey data available to the authors. The surveys were carried out in traditional livestock production systems in Colombia, Uruguay, Uganda, Zambia and Turkey.

The design effect of the cluster-sample surveys was estimated as:

$$D = SE_{\text{cluster sample}}^2 / SE_{\text{simple random sample}}^2 \quad (1)$$

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where the standard errors were calculated using the appropriate formulae (Bennett et al., 1991). ρ was then calculated as follows:

$$\rho = (D - 1) / (n - 1) \quad (2)$$

where n is the average cluster size (Bennett et al., 1991). The results are presented in Table 1. In the same survey, the average cluster size could vary between infections because not all samples were subjected all laboratory examinations.

Fourteen of 33 values of ρ lay between 0.05 and 0.10 and most (24/33) were below 0.20. This finding is in agreement with values reported by McDermott and Schukken (1994), where the upper estimate of ρ did not exceed 0.20 in 66 out of 70 investigations of diseases, infections or production parameters, and Deem et al. (1993), who reported results of $\rho \leq 0.20$ in 14 out of 18 calculations for five tick-borne parasites in three agroecological zones in coastal Kenya.

In this study, high values of ρ were found for reactors to highly contagious viral infections such as bovine viral diarrhoea (BVD), infectious bovine rhinotracheitis (IBR), infectious bursal disease (IBD) and Newcastle disease (ND). For IBR reactors, however, widely varying estimates of ρ were obtained. In two surveys the estimated values of ρ were 0.07, while for the third survey a value of 0.39 was calculated. In the first two studies, 102/104 and 81/82 clusters had reactors with an average prevalence within infected clusters of 33.6% and 39.8%, while in the third study only 60/90 clusters had reactors with an average prevalence within infected clusters of 47.6%. Thus, both the within-herd spread as well as the between-herd spread of infection are important in determining ρ . The latter can, therefore, be relatively low for highly contagious diseases in areas where inter-herd spread is high, e.g. by frequent mixing or contact at water sources.

Moderately contagious infections which normally do not achieve high within-herd prevalences, such as, for example, enzootic bovine leucosis (EBL) and bovine leptospiroses caused by non-bovine serovars of *Leptospira interrogans* had values of ρ between 0.08 and 0.12.

Values of ρ for vector-borne infections can be expected to be very variable, depending on the distribution, abundance and efficiency of the respective vector in the study area. In the study conducted in Uganda, infections with *Trypanosoma* spp. had values of ρ between 0.12 and 0.15, while in Colombia infection with *Trypanosoma vivax* had a ρ value of 0.06. Deem et al. (1993) reported marked differences in ρ for the same tick-borne infection in different agroecological zones.

The expected design effect of a cluster-sample survey can be calculated by rearranging Eq. (2) and inserting values for n and ρ . Although values of ρ could vary markedly from infection to infection, and, for the same infection, from setting to setting, they rarely exceeded 0.20. Thus, assuming a value of ρ of 0.20, the design effect of a cluster-sample survey with a sample of 10 animals per cluster is 2.8. The number of clusters, c , required is then given by (Bennett et al., 1991)

$$c = P(1 - P)D / SE^2 n \quad (3)$$

Thus, assuming a prevalence of 50%, sampling 27 clusters of ten animals should provide a prevalence estimate with a 95% confidence interval of $\pm 10\%$ for a wide range of infections.

Table 1
Summary information of survey data used for the calculation of the design effect, *D*, and the intra-cluster correlation coefficient, ρ , of selected infections of domestic animals

Infection	Species	Method of diagnosis	Prevalence		Clusters		<i>D</i>	ρ	Source
			% ^a	N	No.	Size			
Enzootic bovine leucosis	Cattle	Immunodiffusion	1.51	2907	104	28.0	3.52	0.09	Orjuela et al., 1991
		Enzyme immuno assay	11.75	945	81	11.7	2.11	0.10	Dhalwa, 1995
Infectious bovine rhinotracheitis	Cattle	Enzyme immuno assay	1.93	466	90	5.2	1.34	0.08	Barwinek et al., 1996
		Micro serum neutralisation	31.97	2852	104	27.4	2.76	0.07	Orjuela et al., 1991
		Enzyme immuno assay	47.88	969	82	11.8	1.71	0.07	Dhalwa, 1995
		Enzyme immuno assay	28.11	466	90	5.2	2.62	0.39	Barwinek et al., 1996
Bovine viral diarrhoea	Cattle	Micro serum neutralisation	6.30	2799	102	27.4	6.95	0.23	Orjuela et al., 1991
		Enzyme immuno assay	19.07	970	82	11.8	5.74	0.42	Dhalwa, 1995
		Enzyme immuno assay	69.74	466	90	5.2	2.76	0.42	Barwinek et al., 1996
Newcastle disease	Chicken	Haemagglutination inhibition	37.89	1470	253	5.8	1.89	0.18	Gumm, in prep.
Infectious bursal disease	Chicken	Immunodiffusion	41.56	1470	253	5.8	2.56	0.37	Gumm, in prep.
<i>Lepiospira hardjo</i>	Cattle	Micro-agglutination-lysis	38.55	2861	104	27.5	2.54	0.06	Orjuela et al., 1991
<i>Lepiospira icterohaemorrhagiae</i>	Cattle	Micro-agglutination-lysis	13.60	2861	104	27.5	4.24	0.12	Orjuela et al., 1991
<i>Lepiospira grippioxyphosa</i>	Cattle	Micro-agglutination-lysis	16.57	2861	104	27.5	3.91	0.11	Orjuela et al., 1991
<i>Lepiospira canicola</i>	Cattle	Micro-agglutination-lysis	5.38	2861	104	27.5	3.04	0.08	Orjuela et al., 1991
<i>Brucella abortus</i>	Cattle	Rose Bengal plate test	7.74	1512	104	14.5	2.18	0.09	Orjuela et al., 1991
<i>Brucella ovis</i>	Sheep	ELISA	11.71	1529	40	38.2	6.94	0.16	Mederos, 1993
<i>Anaplasma marginale</i>	Cattle	Immunodiffusion	10.99	1529	40	38.2	9.20	0.22	Mederos, 1993
<i>Trypanosoma vivax</i>	Cattle	Blood smear	3.78	2909	104	28.0	2.19	0.04	Orjuela et al., 1991
		Blood smear	4.32	1111	91	12.2	2.11	0.10	Dhalwa, 1995
<i>Trypanosoma congolense</i>	Cattle	Haematocrit centrifuge technique	2.75	2909	104	28.0	2.56	0.06	Orjuela et al., 1991
		Latex agglutination test	30.87	1111	91	12.2	2.68	0.15	Dhalwa, 1995
<i>Trypanosoma brucei</i>	Cattle	Latex agglutination test	23.94	1111	91	12.2	2.51	0.13	Dhalwa, 1995
		Latex agglutination test	24.39	1111	91	12.2	2.39	0.12	Dhalwa, 1995
<i>Eimeria</i> spp.	Cattle	McMaster slide technique	27.13	1010	104	9.7	2.53	0.18	Orjuela et al., 1991
		McMaster slide technique	15.63	1113	91	12.2	4.32	0.30	Dhalwa, 1995
<i>Strongyloides</i> spp.	Cattle	McMaster slide technique	12.08	1010	104	9.7	2.35	0.16	Orjuela et al., 1991
Trichostrongyles	Cattle	McMaster slide technique	4.04	1113	91	12.2	2.27	0.11	Dhalwa, 1995
		McMaster slide technique	69.01	1010	104	9.7	1.70	0.08	Orjuela et al., 1991
<i>Moniezia</i> spp.	Cattle	McMaster slide technique	48.43	1113	91	12.2	2.22	0.10	Dhalwa, 1995
		McMaster slide technique	3.07	1010	104	9.7	1.46	0.05	Orjuela et al., 1991
<i>Fasciola</i> spp.	Cattle	McMaster slide technique	15.90	1113	91	12.2	3.21	0.20	Dhalwa, 1995
		McMaster slide technique	6.92	1113	91	12.2	4.09	0.27	Dhalwa, 1995

^a Positive animals/tested animals.

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