The Veterinary Journal 198 (2013) 649–655

Contents lists available at ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Cluster randomised trial of the impact of biosecurity measures on poultry health in backyard flocks

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ARTICLE INFO

Article history:
Accepted 8 September 2013

Keywords:
Backyard poultry
Biosecurity
Cluster randomised trial
Avian influenza virus
Newcastle disease virus

ABSTRACT

In Cambodia, most poultry are raised in backyard flocks with a low level of biosecurity, which increases the risk of spread of infectious diseases. The aim of this study was to evaluate the effectiveness of a practical biosecurity intervention based on affordable basic measures. A cluster randomised trial was conducted in 18 villages in Cambodia from November 2009 to February 2011. Generalised estimating equations were used to test the association between the intervention and mortality rates in flocks of chickens and ducks. Mortality rates in chicken flocks in intervention villages (mean 6.3%, range 3.5–13.8%, per month) were significantly higher than in control villages (mean 4.5%, range 2.0–9.7%, per month; $P < 0.01$). Mortality rates in duck flocks in intervention villages (mean 4.1%, range 1.9–7.9%, per month) were significantly higher than in control villages (mean 2.8%, range 0.6–8.0%, per month; $P < 0.01$). Despite good compliance among poultry owners, the biosecurity intervention implemented in this study was not associated with improvements in poultry mortality rates. These findings suggest that basic biosecurity measures may not suffice to limit the spread of infectious diseases in backyard poultry flocks in Cambodia.

Introduction

In developing countries, backyard poultry rearing contributes to household incomes and home food consumption (VSF, 2005; Henning et al., 2006; Liao et al., 2009; Conan et al., 2012). Infectious diseases occur relatively frequently in backyard poultry flocks, since few or no biosecurity measures are usually implemented (Conan et al., 2012). Several major poultry diseases, such as Newcastle disease (ND), are enzootic in these flocks in Southeast Asia (Cameron et al., 1999), causing high mortality in poultry, with a direct impact on income generation (FAO, 2002). There is also a risk for food security and public health, for example from H5N1 highly pathogenic avian influenza (HPAI) virus (Lay et al., 2011; Theary et al., 2012; Chaka et al., 2013).

In Cambodia, backyard poultry represent 71% of the duck industry and 94% of the chicken industry (VSF, 2005). Mortality in backyard poultry flocks has been estimated at 30% (Ear, 2005). Mortality of poultry, particularly in the case of outbreaks of H5N1 HPAI, has a direct impact on the livelihood of villagers in rural Cambodia (Ear and Burgos Caceres, 2009).

The World Organization for Animal Health (OIE), the Food and Agriculture Organisation (FAO) and the World Health Organization (WHO) have suggested measures to control the spread of H5N1 HPAI virus and, by extension, other infectious agents, consisting of changes to husbandry practices among smallholders to improve the biosecurity of backyard poultry flocks (Chitnis, 2012). However, evidence of the feasibility and efficacy of these measures has not been demonstrated in extensive systems (Conan et al., 2012).

In 2006, Agronome et Vétérinaires Sans Frontières (AVSF), with the support of the FAO, carried out a sanitary management project in three villages in Cambodia. The findings suggested that the adoption of good management practices and hygiene improvement at the village level, without using vaccination, dramatically reduced mortality and morbidity of poultry (VSF-CICDA, 2007). However, the study was not randomised with a control group and the sample was not large enough to conclude that there had been a real impact. To confirm the latter finding, the effectiveness of low cost biosecurity interventions in backyard poultry flocks in Cambodia was evaluated in the present study.

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http://dx.doi.org/10.1016/j.tvjl.2013.09.010

Table 1
Morbidity, mortality and fatality rates of poultry flocks, Cambodia, November 2009–December 2010.

	Chickens (All ages)	Chicks (<1 month)	Ducks (all ages)	Ducklings (<1 month)
Number of households followed	732 (98%)	454 (61%)	655 (87%)	115 (15%)
Mean number of birds per household ± SD	24.1 ± 18.8	13.2 ± 9.7	16.3 ± 56.1	17.7 ± 54.3
Number of households with sick animals (%)	2344 (24.5%)	821 (13.8%)	724 (7.4%)	179 (12.9%)
Mean number of sick birds (0 excluded) ± SD	7.4 ± 8.2	7.0 ± 8.3	8.9 ± 19.7	11.5 ± 22.2
Mean morbidity rate ± SD	6.4 ± 15.9%	5.2 ± 16.4%	14.1 ± 3.6%	4.7 ± 17.1%
Number of households with dead animals (%)	2144 (22.4%)	757 (12.7%)	697 (9.6%)	176 (12.7%)
Mean number of dead birds (0 excluded) ± SD	6.6 ± 7.5	6.5 ± 7.9	8.5 ± 19.4	11.4 ± 22.3
Mean mortality rate ± SD	5.3 ± 14.5%	4.4 ± 14.7%	3.4 ± 13.6%	4.5 ± 16.6%
Mean fatality rate ± SD	82.2 ± 31.8%	85.3 ± 30.2%	92.6 ± 22.5%	95.9 ± 17.8%

SD, standard deviation.

Materials and methods

A cluster randomised trial was conducted using two sets of nine villages each in the Tram Kak and Samraong Districts in Takeo Province, south-eastern Cambodia. The protocol was approved by the Pasteur Institute in Paris (June 2009) and the National Veterinary Research Institute (NaVRI) (August 2009). A cascade training approach, using village teams to relay key biosecurity measures, was implemented in the nine intervention villages from December 2009 (Month 1, M1) to February 2010 (M3). The intervention consisted of an educational package, which focussed on implementing biosecurity measures relating to poultry health and husbandry, including cleaning yards and equipment, quarantine of newly introduced and sick animals and burning dead birds (Conan et al., 2013). The compliance of the villagers with the interventions was considered to be good, since 68% of the poultry owners in intervention villages changed poultry raising practices as a result of the cascade training vs. 22% in control villages ($P < 0.001$) (Conan et al., 2013). It was estimated that at least 39 households should be visited per village to observe a statistically significant reduction of 50% in poultry mortality (Hayes and Bennett, 1999). The village team interviewed the randomly selected household owners each month from November 2009 (M0) to December 2010 (M13) using a standardised questionnaire.

In the same 39 households, blood samples were collected from ducks on three occasions: November 2009 (M0, before the training), August 2010 (M9) and February 2011 (M15). Assuming an infection rate of 40% in the case of H5N1 HPAI or ND viruses in a duck flock, it was estimated that a sample of at least six birds would be needed to detect at least one seropositive animal (Conan et al., 2010). If the number of ducks was <6, blood samples were collected from all ducks. Blood was taken from the wing veins using a 4 mL syringe, using a new syringe and needle for each duck. The samples were placed on ice and sent daily to the NaVRI. Serological testing was performed on pooled samples from each household using haemagglutination inhibition tests for ND and H5 avian influenza viruses (OIE, 2012).

The main end-point of the trial was household mortality rates, considering one duck flock and one chicken flock per household. It was assumed that mortalities in chicken and duck flocks were most likely to be due to infectious agents (Halima et al., 2007; Mete et al., 2013). Mortality rate was defined as the number of dead poultry divided by the number of poultry per flock during a defined period. If the poultry owners reported deaths due to accidents or predators, the mortality rate of these flocks was defined as 0. To account for the likely positive intra-cluster correlation among poultry flocks within a village, a linear generalised estimated equation (GEE) with an exchangeable matrix structure was used. The influence of the intervention (taken as a binary variable) on trends of mortality rates was tested. Co-factors included in the model were chicken and duck flocks (categorical variables defined by quartile and median of number of animals), purchase of chickens or ducks (binary variable), trading with intermediaries ('middlemen'), visit to market, presence of fighting cocks or geese and observed changes in poultry raising practices, presumably due to the training (intervention). The factors 'trading with middlemen' and 'visit to market' were treated first as frequency variables. If these factors were not significant, they were introduced as binary variables. Except for the intervention variable, only variables with a P value <0.05 were retained in the model. Collinearity between retained variables was calculated.

For serology results, four different case definitions were tested for a flock recently infected by ND or H5N1 HPAI viruses using incremental criteria from one definition to another. Each new criterion brought additional evidence of the presence of one of the two viruses in the flock. Definition 1 relied on evidence of seroconversion, i.e. antibody titre >1:16 on the second sample, while the preceding pooled sample tested negative (OIE, 2012). Three other definitions were established to increase specificity. Definition 2 included Definition 1 plus the farmer not buying any poultry during the preceding 6 months. Definition 3 included Definition 2 plus the report of at least one dead chicken or duck during the preceding 6 months. Definition 4 included Definition 3 plus the report of neurological signs in chickens or ducks during the preceding 6 months. A Poisson GEE model was performed to compare each definition between intervention and control flocks at M9 and M15. All analyses were performed using Stata 11 (Statacorp).

Results

The 18 study villages comprised a total of 2343 households, with an average of 130 households per village (range 92–176 households per village), including an average of 132 households per intervention village and 128 households per control village (Wilcoxon test; $P = 0.5$). The initial census survey accounted for 1890 households, since 453 heads of households were not present during the visit. Of these 1890 households, 271 (14%) were excluded from the analysis because they did not raise poultry. During the period from November 2009 (M0) to December 2010 (M13), 9803 (99.7%) monthly survey questionnaires were collected out of the expected 9828. During the follow-up period, 21 intervention and 26 control households were excluded and replaced by

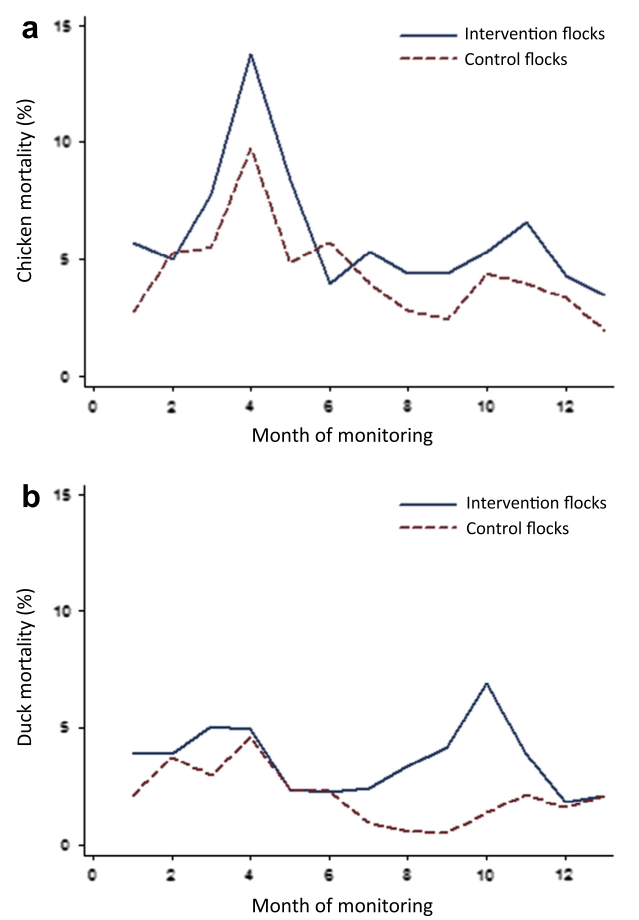

Fig. 1. Trends of (a) chicken and (b) duck flock mean mortality rates per month in intervention and control villages, Cambodia, December 2009 to December 2010.