Preventive Veterinary Medicine 126 (2016) 54–65

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

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

A case–control study to estimate the effects of acute clinical infection with the Schmallenberg virus on milk yield, fertility and veterinary costs in Swiss dairy herds

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ARTICLE INFO

Article history:
Received 5 October 2015
Received in revised form 22 January 2016
Accepted 25 January 2016

Keywords:
Schmallenberg virus
Dairy cattle
Clinical signs
Financial losses
Switzerland

ABSTRACT

Schmallenberg virus (SBV) was first detected in Switzerland in July 2012 and many Swiss dairy farmers reported acute clinical signs in dairy cattle during the spread of the virus until December 2012. The objectives of the present study were to investigate the effects of an acute infection with SBV on milk yield, fertility and veterinary costs in dairy farms with clinical signs of SBV infection (case farms), and to compare those farms to a matched control group of dairy farms in which cattle did not show clinical signs of SBV infection.

Herd size was significantly ($p < 0.001$) larger in case farms (33 cows, $n = 77$) than in control farms (25 cows, $n = 84$). Within case herds, 14.8% (median) of the cows showed acute clinical signs. Managers from case farms indicated to have observed a higher abortion rate during the year with SBV (6.5%) than in the previous year (3.7%). Analysis of fertility parameters based on veterinary bills and data from the breeding associations showed no significant differences between case and control farms. The general veterinary costs per cow from July to December 2012 were significantly higher ($p = 0.02$) in case (CHF 19.80; EUR 16.50) than in control farms (CHF 15.90; EUR 13.25). No differences in milk yield were found between groups, but there was a significant decrease in milk production in case farms in the second half year in 2012 compared to the same period in 2011 ($p < 0.001$) and 2013 ($p = 0.009$). The average daily milk yield per cow (both groups together) was +0.73 kg higher ($p = 0.03$) in the second half year 2011 and +0.52 kg ($p = 0.12$) in the second half year 2013 compared to the same half year 2012. Fifty-seven percent of the cows with acute clinical signs ($n = 461$) were treated by a veterinarian.

The average calculated loss after SBV infection for a standardized farm was CHF 1606 (EUR 1338), which can be considered as low at the national level, but the losses were subject to great fluctuations between farms, so that individual farms could have very high losses (>CHF 10,000, EUR 8333).

1. Introduction

In the summer of 2011, a new disease entity was reported in dairy cattle in North Rhine-Westphalia, Germany, and in the Netherlands. The short-lived acute clinical signs in adult cattle included fever, drop in milk production, and watery diarrhea (ProMed-Mail, 2011). In November 2011, a novel virus was isolated from a blood sample of a cow with acute clinical signs of this new disease entity. This new virus, belonging to the genus Orthobunyavirus of the family Bunyaviridae (Simbu serogroup), was designated as Schmallenberg virus (SBV) after the city in Germany where the affected cow originated from. Members of the Simbu serogroup had not been detected in Europe before (Hoffmann et al., 2012). In the following months, farmers in the Netherlands observed an outbreak of malformations in lambs, and SBV RNA was detected in brain tissue from 22 out of 54 examined lambs, as well as in malformed calves and kids. The main malformations were arthrogryposis, ankylosis, torticollis, scoliosis, kyphosis, brachygnathia inferior, hydrocephalus, and hydranencephaly (Van den Brom et al., 2012; Bilk et al., 2012; Herder et al., 2012).

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http://dx.doi.org/10.1016/j.prevetmed.2016.01.021
0167-5877/

Susceptible species include wild and domestic ruminants, and the virus is transmitted by biting midges, especially Culicoides (Elbers et al., 2012; Linden et al., 2012; Goffredo et al., 2013). In infected animals, viremia lasts only for three to five days, and antibodies can be detected two weeks after infection (Wernike et al., 2013). While malformations have been reported in newborn calves, lambs, and kids, with the highest incidence in lambs (Afonso et al., 2014), acute clinical signs were mainly observed in adult cows (European Food Safety Authority, 2012a).

In Switzerland, veterinarians and farmers had been instructed in February 2012 to submit malformed and dead calves for testing for Schmallenberg virus and specific antibodies. In order to ensure early virus detection, testing was extended to adult cattle with fever, diarrhea, and reduced milk production in June 2012 (Schorer et al., 2012; Balmer et al., 2014). Since the first virus detection in mid-July 2012 in cows on two different farms in the canton of Berne (Schorer et al., 2012), SBV spread rapidly throughout Switzerland; as of December 2012, the herd seroprevalence had reached 99.5% compared to 19.7% in July 2012. Some farmers observed the typical clinical signs of acute infection in adult cattle, but animals were mainly found to have seroconverted without showing clinical signs of acute infection (Balmer et al., 2014). In 2012, several other countries reported cases of SBV infection, and all of Europe had been infected by the end of the year (Doceul et al., 2013).

The rapid spread of SBV and the presence of malformations in newborn ruminants have induced extensive research activity on this new infectious disease. At first, many studies were focused on virus detection and epidemiology of the disease, mainly based on seroprevalence studies (Elbers et al., 2012; Bouwstra et al., 2013). Further studies then addressed the impact of SBV infection on fertility, milk production and animal welfare, and revealed substantial losses in affected farms (Martinelle et al., 2012; Veldhuis et al., 2014b).

The aims of the present study were to estimate the effects of an acute infection with SBV on animal health, fertility and milk production in farms with clinically affected dairy cows, and to compare these parameters with those of matched farms where the animals had not been observed to be clinically ill. A further aim was to assess the financial losses resulting from reduced milk production, reduced fertility, and calf death or malformations, and to calculate the therapy costs associated with the acute phase of the disease in farms with clinically affected animals. For this purpose, selected production parameters relative to milk yield and fertility were compared over time, i.e. for the time periods immediately before, during and after the outbreak of acute SBV infection in the summer and fall of 2012.

2. Materials and methods

2.1. Farm selection and sample size

The present study was designed as a matched case–control study. Case farms were selected from a list of the Swiss reference laboratory for viral diseases (Institute of Virology and Immunology, IVI, Mittelhäusern, Berne) which had analyzed all samples from animals suspected of being infected with SBV in Switzerland in 2012. A dairy farm was regarded as a case farm if at least one cow in the herd had been observed with at least two clinical signs suspicious of SBV infection (fever, diarrhea, decreased milk yield) in the summer or fall of 2012, and had been confirmed as positive by ELISA or RT-qPCR for SBV RNA in 2012. If abortions had been the main clinical sign in a case herd, at least two cows had to have aborted and shown at least one other classical clinical sign of acute SBV infection in 2012 in addition of being ELISA or RT-qPCR positive. The managers of potential case farms were first contacted by phone and invited to participate in the project. They were briefly interviewed by the investigator to verify that all inclusion criteria were fulfilled, and they were asked to provide an overview of farm characteristics and of the observed clinical signs. When the farm manager agreed to participate, the local veterinarian was asked to identify potential control farms. These had to fulfill the following criteria to be matched to case farms: close location (maximal distance: 10 km), similar average milk yield, housing system, and breed, no suspicious clinical signs of SBV in adult cattle in the summer and fall 2012, and no noticeably elevated occurrence of abortions in 2012.

A sample size of 76 case and 76 control farms was calculated using WinEpiscope 2.0 software (Thrusfield et al., 2001) in order to detect a difference in mean milk production between case and control farms of 0.25 times the standard deviation with 80% power and 90% confidence (one-tailed test). This sample size was large enough to allow the detection of differences in the mean incidence of stillbirth between case and control farms with the same power and confidence if 0.5% of control farms and 7% of case farms had stillbirths. A total of 175 farmers were recruited between October 2012 and April 2013, and results from 161 (77 case and 84 control) farms were included in the analyses. Fourteen farmers (7 per group) were lost to follow-up during the study because of changes in the farm structure or because they were not willing to make the effort of providing the requested data.

2.2. Farm visits and questionnaire

Case and control farms were visited once between May and December 2013, and a questionnaire was filled in, which included questions about general farm characteristics (geographic localization, herd size, housing system, animals, welfare label, milk yield, milking system, feeding, disease control measures, fertility), the farmers' knowledge about SBV (epidemiology, clinical signs), and questions to investigate possible risk factors for the occurrence of acute clinical signs of SBV infection (climate, housing, pasturing, summer alpine pasturing, animal movement, breeding methods—artificial insemination vs. mating-, insect control, presence of standing water around the farm, density of wild ruminants on the premises). The questionnaire had been previously tested with four farmers. For case farms, additional questions were asked about the clinical signs observed for each affected cow, as well as the farmers' self-estimated loss of production (reduced milk yield, abortion, stillbirths, reduced reproductive efficiency—number of inseminations per cow-, culling), and treatment costs due to acute disease following SBV infection.

2.3. Data collection

In addition to the questionnaire, veterinary bills, veterinary treatment records, and data from the respective Swiss breeding associations (swissherdbook, Braunvieh, and Holstein) were collected for the time frame between January 2011 and December 2013 to assess the impact of SBV infection on veterinary costs, milk yield, and fertility. Data for milk yield and fertility were missing for 19 farms (7 case and 12 control farms) which were not members of a breeding association.

All farmers gave written permission for accessing their data on the Swiss animal movement database (Tierverkehrsdatenbank, TVD) and the breeding associations' databases. The TVD was used to complete missing data regarding calving dates.

2.4. Serology and necropsies

During the farm visits in 2013, blood samples were collected from five cows per herd. Schmallenberg virus is known to produce a high within-herd prevalence in infected herds (Elbers et al., 2012), thus the sample size was chosen to detect a 50% within-herd prevalence with a 95% probability, assuming a herd size up to 100 cows and a test sensitivity of 95%. Sample size was calculated with the software Survey Toolbox (Cameron, 1999). In farms with traditional mountain grazing, five additional animals which had spent the summer 2012 on alpine pastures also underwent blood sampling. In case farms, cows that had shown acute clinical signs in 2012 were sampled preferentially. In control farms, sampled cows were selected randomly. If blood results from five animals from the previous year were available (with at least one animal positive by ELISA or RT-qPCR), no further animals were tested in 2013, except for herds with mountain grazing. All blood samples were analyzed for antibodies against SBV by use of a monophasic ELISA (ID Screen® Schmallenberg virus Indirect ELISA kit, Grabels, France) at the IVI.

Participating farmers were instructed to contact the study team in case of an abortion or stillbirth between January and December 2013 in order to perform a complete necropsy on the fetuses or calves at the Institute for Animal Pathology in Berne. Data of these examinations formed the basis to evaluate the incidence of abortion, stillbirth and malformation in calves, and to compare the incidence between groups. The fetus, placenta, and blood from the dam were submitted for necropsy by veterinarians or were collected by the investigator during a farm visit. To exclude other causes for abortion or stillbirth, abomasum, lung, liver, brain, body cavity fluid (abdomen or thorax) or ear tissue of the calves, as well as placenta and blood from the dams were examined for brucellosis, coxiellosis, neosporosis, bovine virus diarrhea, and infectious bovine rhinotracheitis. Samples from the brain stem and body cavity liquid of the fetuses were examined for the presence of SBV RNA or antibodies by RT-qPCR (Bilk et al., 2012) and ELISA, respectively, as described above. Blood from the dams was also tested for SBV antibodies by ELISA.

2.5. Data analysis

The definitions of the parameters used to investigate potential correlations with acute clinical SBV infection and the time periods analyzed for each parameter are listed in Table 1. The data for abortion, stillbirth, and milk yield reduction during acute SBV infection as well as other parameters assessed by use of the questionnaire must be considered as the best available estimates (by the farmers) in the absence of accurate quantitative data in the majority of farms. A standardized herd size of 33 cows (median number of cows in case farms) was used to calculate the financial losses in farms with clinically affected animals. The figures for total monthly veterinary costs, treatment costs for acute SBV infection per case farm, percentage of cows with dystocia requesting veterinary assistance, percentage of cows with retained fetal membranes, and percentage of cows requesting intrauterine treatment were calculated based on treatment records and veterinary bills. Calculations regarding milk yield and theoretical bulk tank milk somatic cell count (SCC, calculated as described previously (Bennedsgaard et al., 2003)) were based on the monthly test day milk records (data from one test day per cow per month) from the breeding associations. Data regarding calvings (calving intervals) and artificial inseminations (percentage of cows with >1 insemination per successful pregnancy) were also based on the records from the breeding associations. Only data from the swissherdbook and Braunvieh breeding associations were available for the analysis of the calving intervals. Data recorded on a monthly basis were pooled into five time periods for further analyses: Period 1 = July to December 2011; Period 2 = January to June 2012; Period 3 = July to December 2012 (acute phase and spread of SBV infection through Switzerland); Period 4 = January to June 2013 (six months following the spread of SBV infection); Period 5 = July to December 2013. Comparisons for milk yield and SCC were only conducted for the Periods 1, 3, and 5, as differences due to seasonal factors (winter housing and feeding vs. summer pasture) were expected for Periods 2 and 4.

The fertility parameters assessed in the questionnaire (abortion rate, stillbirth rate, percentage of cows with retained fetal membranes, malformation rate, preterm birth rate, and average number of inseminations per cow for a successful gestation) were calculated for the same time periods. Periods 3 and 4 were pooled for parameters which were potentially affected for a longer period of time than the six months of the acute phase of SBV infection (dystocia, reduced fertility).

All data except those obtained from the breeding associations were checked for completeness, accuracy, and plausibility, and descriptive statistics and univariable screening were performed with NCSS 9 (Hintze, 2013). Analyses of monthly data from the breeding associations were performed with the software STATA (StataCorp, 2013). Multivariable analysis was conducted with SAS 9.3 (SAS Institute Inc., 2009).

In the statistical analyses, two different comparisons were made. Case farms were compared to control farms, and the time periods before, during and after SBV infection were compared within case and control farms, respectively. Univariable screening was performed for both comparisons with appropriate paired tests. The McNemar's test was used for categorical variables, and the Wilcoxon signed-rank test for ordinal variables. For continuous variables, Shapiro–Wilk *W* test and normality plots were used to evaluate normality. If data were normally distributed, a paired *t*-test was used for screening. In case of non-normal distribution, variables were log-transformed to obtain normality (natural log, LN), or the Wilcoxon signed-rank test was applied after unsuccessful transformation.

For comparison between groups, all matched pairs with data for the selected parameter were included, and all farms with data for all time periods were included to compare the periods within each group. All potential confounding variables were reviewed for possible correlations by use of Spearman or Pearson correlation coefficient. Herd size (number of cows) and farm size (in ha) had a correlation coefficient >0.7, therefore only herd size was used for further analyses.

Outcomes with a p-value < 0.2 in the univariable analysis indicating either an association between farm group and the respective outcome or a potential effect of the time period were further analyzed in mixed regression models. For this multivariable analysis, random intercept ordinal logistic regression or linear mixed models were used, depending on the type of outcome. Because the study was a matched-pairs design, both types of model accounted for the dependency between case and control farms by including the number of the matched pairs as a random effect with an independent correlation structure. The time period was included as a repeated effect. The percentage of variance accounted for by the random effect (intraclass correlation coefficient, ICC) was calculated from the covariance parameter estimates given in the model output. Subject-specific rather than population-average models were used because we considered that, for calculating the losses caused by SBV, the effect on the individual farms in the study would be more relevant than the population-average effect.

The abortion rate estimated by the farmers was grouped into four ordinal categories: 0%, >0–5%, >5–10%, and >10%. A multivariable ordinal logistic regression model was then built with SAS Proc GLIMMIX (SAS Institute Inc., 2009). The classification of the farm as case or control and the time period (mainly Period 3 vs. Period 1 and Period 5) were analyzed as the main factors of interest. In addition, the interaction between being a case farm and the time period was also included in the model since it was hypothesized that only case farms would have more abortions in the Periods 3 and/or 4 than in the previous year. Because the case and control farms were not perfectly matched for farm size, distance, housing

Table 1
Overview of relevant health and production parameters used to estimate the costs and losses associated with an acute Schmallenberg virus (SBV) infection in dairy farms.

Group	Classification of parameters	Parameter	Definition	Observation periods[a]
Case farms	Financial losses due to acute SBV infection	Abortion	Number of abortions per standardized case farm[b] (estimated by farmers)	Period 3
		Stillbirth	Number of stillbirths per standardized case farm (estimated by farmers)	Periods 3 + 4
		Reduced milk yield	Reduction in kg per standardized case farm during the acute phase of disease (estimated by farmers)	Period 3
		Veterinary treatments in the acute phase of SBV infection	Treatment costs for clinically affected cows in CHF per standardized case farm (included only costs for cows unequivocally identified by name or ear tag number on the veterinary bills or treatment records, and which fulfilled the case definition; numerical data from the veterinary bills)	Period 3
Case and control farms	Veterinary costs		Median value in CHF of monthly veterinary costs per cow and farm (costs for treatments of calves were not included; if a clear separation of costs for cows and calves was not possible, the farms were excluded from this analysis)	Period 1
				Period 2
				Period 3
				Period 4
				Period 5
	Losses due to reduced fertility	Dystocia requesting veterinary assistance for calving	% of affected cows per farm	Periods 1 + 2
				Periods 3 + 4
				Period 5 (×2)
		Retained fetal membranes	% of affected cows per farm	Periods 1 + 2
				Periods 3 + 4
				Period 5 (×2)
		Intrauterine treatment	% of affected cows per farm	Periods 1 + 2
				Periods 3 + 4
				Period 5 (×2)
		Calving interval	Median value in days for each farm	Period A
				Period B
	Losses due to reduced milk yield and quality	Milk yield	Median value in kg per day, cow and farm	Period 1
				Period 2
				Period 3
				Period 4
				Period 5
		SCC[c]	Median value in cells × 1000/ml per farm	Period 1
				Period 2
				Period 3
				Period 4
				Period 5

[a] Period 1 = July to December 2011; Period 2 = January to June 2012; Period 3 = July to December 2012 (acute phase and spread of SBV infection through Switzerland); Period 4 = January to June 2013 (six months following the spread of SBV infection); Period 5 = July to December 2013; Period 5 (×2) = Period 5 included only 6 months, thus the number of events in period 5 were multiplied by two for comparison with the other 2 periods (1 + 2 and 3 + 4) which included 12 months each; Period A = 2 calvings between January 2010 and July 2012 = prior to the apparition of SBV; Period B = 2 calvings between July 2012 and March 2014 = after the spread of SBV.
[b] Standardized case farm = 33 cows (median number of cows in case farms).
[c] SCC = theoretical bulk tank somatic cell count.

type, welfare label, breed, and potential for wildlife contact, these variables were included in the models as potential confounders.

For the linear and normally distributed outcomes milk yield, LN of SCC, LN of calving interval, and LN of veterinary costs, mixed linear regression models were fitted with SAS Proc MIXED (SAS Institute Inc., 2009). In a stepwise backward selection procedure, confounders were eliminated from the models if they were neither statistically significant ($p > 0.05$) nor changing any of the other estimates by more than 20%.

The average market price in 2012, CHF 0.58 (EUR 0.48) per kilogram of industrial milk (Federal Office for Agriculture (FOAG), 2013) was used for the calculation of the costs of reduced milk yield during acute SBV infection. The average weekly market price (July to December 2012) for veal calves with a body weight of 65 kg, corresponding to the average weight of calves sold for fattening, was obtained from the official Swiss Farmers' Union (Anon. 2015). This resulted in an estimate of the loss associated with a stillbirth of CHF 335 (EUR 279). The average loss due to an abortion was estimated to be CHF 872 (EUR 727) (Etter and Genoni, 2005). For each clinically affected cow, the total losses due to SBV were calculated as the sum of losses due to abortions, stillbirths, reduced milk yield, and veterinary treatment costs. These sums were standardized for a herd size of 33 cows, and finally, the average sum over all case farms was built to express the total losses in case farms. The loss of an extended calving interval was estimated at CHF 4 per day which applies for Swiss farms (Herd Health Unit, Clinic for Ruminants of the University of Berne, personal communication).

The project had been reviewed and approved by the Swiss Federal Food Safety and Veterinary Office, all farmers had given written informed consent to participate in the study (questionnaire and data regarding animal health and financial losses), and the blood sampling procedure had been approved by the Committee for Animal Welfare and Protection in Berne (authorization number BE 99/12).

3. Results

3.1. Farms and sample size

The 161 farms included in the study were distributed in the main dairy areas of Switzerland, with 41% in the western part, 22.4% in the central part, 18.6% in the eastern part, and 18% in the northern part of the country. A description of the farms and a comparison between case and control farms are shown in Table 2.

Data from 77 case farms, 84 control farms, and 77 matched pairs were available for analysis of variables from the questionnaire (a total of 54 questions were tested). Seventy-three case farms, 78 control farms, and 70 pairs had complete data for the analysis of veterinary costs and fertility parameters obtained from the veterinary bills (dystocia requiring veterinary assistance, retained fetal membranes, intrauterine treatments). Analyses of data from the breeding associations could be performed with 70 cases, 72 controls, and 63 pairs; 53 control and 52 case farms as well as 47 pairs were included in the analysis of calving intervals.

3.2. Results of the analyses of questionnaire answers

Questions with significant differences in response between case and control groups based on the opinions of the farmers are listed in Table 3. Farm managers from case farms knew more about the disease caused by SBV and estimated the effects of SBV to have been more serious than farm managers from control farms. The estimated median within-herd prevalence of acute clinical signs in case farms was 14.8%.

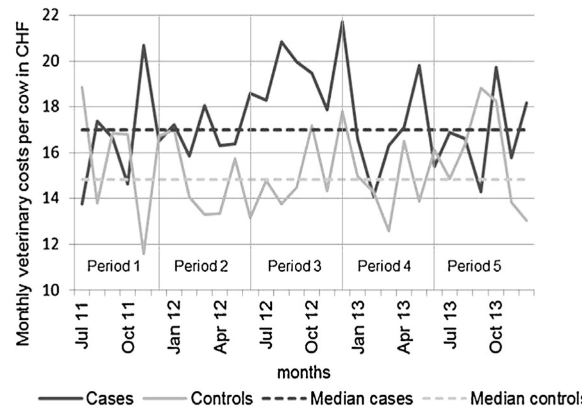

Fig. 1. Monthly median veterinary costs per cow in Swiss francs (CHF) in farms with (case farms) and without (control farms) clinical signs of acute Schmallenberg virus infection in dairy cows. See Table 1 for legends regarding observation periods.

Comparing the time periods within control farms, there were no significant differences in estimations regarding fertility parameters. In contrast, the median number of inseminations per cow, abortion rate, and stillbirth rate were estimated to have been significantly higher in the Periods 3 and 4 than in the previous year (Periods 1 + 2) in case farms (1.8 vs. 2.0, 3.5% vs. 6.7%, and 4.3% vs. 5.7%, respectively). The percentages of cows with retained fetal membranes, of calves with malformations, and of weak calves at birth, as well as the preterm birth rate were also estimated to have been higher in the year with SBV, but the differences were not significant and/or the occurrence of these events was rare in both time periods.

3.3. Monthly veterinary costs per cow

The median veterinary costs per cow and month are shown in Fig. 1 and Table 4. The median veterinary costs over the entire study period (July 2011 to December 2013) were significantly higher ($p = 0.001$) in case farms than in control farms, with a monthly value of CHF 17 (EUR 14) and CHF 15 (EUR 13) per cow, respectively. In the individual analysis of the different observation periods, the median costs per cow and month in Period 3 were CHF 3.90 (EUR 3.20) higher in case farms than in control farms ($p = 0.02$), but the differences between case and control farms were not significant in the other four time periods. Within case farms, the median costs were CHF 3.20 (EUR 2.65) higher in Period 3 compared to Period 5 ($p < 0.001$), whereas the difference between Periods 1 and 3 was not significant ($p = 0.07$). No significant difference was found when comparing Period 3 with the Periods 2 and 4. The veterinary costs did not vary significantly over time within the control group.

The multivariable model for veterinary costs showed findings similar to those of the univariable analysis (Table 5). The LN of veterinary costs was 0.2 higher in case farms than in control farms ($p < 0.0001$). The monthly veterinary costs per cow were also lower in the Periods 1, 2, 4, and 5, compared to Period 3, but the differences were not significant. Farms with tie-stalls had significantly ($p = 0.009$) higher veterinary costs (median = CHF 19, EUR 15.65) than farms with free-stalls (median = CHF 15, EUR 12.35). Larger herd size was associated with higher veterinary costs, higher milk yield, and higher SCC, but these effects were mostly of limited magnitude. In the regression model, the matched pairs accounted for 33% of the variance in veterinary costs, 51% of the variance in milk yield, and 29% of the variance in LN of SCC, respectively.

Table 2
Overview of farm characteristics and comparison of case and control farms.

Factor	Cases	Controls	p-value[a]
Number of farms per group (n = 161)	77	84	
Breed in % (n = 161)[b]			
BS (only BS or mixed herds with OB)	26.0	21.4	
HF (only HF or mixed herds with RH or BS)	27.3	26.2	
RH (only RH or mixed herds with SF)	29.9	32.1	
SF	10.4	13.1	
Other breeds	6.5	7.1	0.91
Farm size in hectares (n = 154)			
Median (IQR[c])	29 (20–40)	25 (18–30.5)	0.01
Number of cows (n = 154)			
Median (IQR[c])	33 (22.5–50.5)	25 (19–38)	< 0.001
Housing system in % (n = 161)			
Tie-stall	46.8	50.0	0.49
Free-stall	53.3	50.0	
Milk production in kg/lactation (n = 150)			
Mean (±SD[d])	7914 (±1233)	7569 (±1068)	0.03

[a] p-value = result of group comparison (case vs. control) regarding the parameters listed; significance level set at $p \leq 0.05$.
[b] BS = Brown Swiss, OB = Original Brown, HF = Holstein Friesian, SF = Swiss Fleckvieh.
[c] IQR = interquartile range.
[d] SD = standard deviation.

Table 3
Comparison of case and control farms for variables from the questionnaire (self-estimation by the farmers for different observations during the SBV outbreak in Switzerland).

Variable	Number of pairs	Categories	Cases (%)	Controls (%)	p-value
Seeked more information about SBV	77	No	10.4	40.3	<0.001
		Yes, a little	67.5	55.8	
		Yes, a lot	22.1	3.9	
Knowledge of the clinical signs of SBV[a]	77	1 symptom	0	11.7	<0.001
		2 symptoms	2.6	22.1	
		3 symptoms	18.2	22.1	
		4 symptoms	79.2	44.2	
Estimation of the relevance of SBV infection in dairy cows	77	No opinion	1.3	2.6	0.01
		Low	23.4	39.0	
		Moderate	48.1	44.2	
		High	27.3	14.3	
Comparison of the estimated herd fertility before and after SBV[b]	77	Unchanged or better	50.7	75.3	<0.001
		Decreased	49.4	24.7	
Density of wild ruminants around the farm	77	High	55.8	33.4	0.02
		Low or moderate	44.2	63.6	
			Median (IQR)	Median (IQR)	
Estimated rate of retained fetal membranes in % of cows	69	Periods 3 + 4	11.8 (7.9–18.8)	10.0 (6.4–16.3)	0.02
Estimated abortion rate in % of cows	71	Periods 1 + 2	3.7 (0–6.7)	0 (0–5.3)	0.05
	73	Periods 3 + 4	6.5 (1.4–11.8)	2.4 (0–5.6)	<0.001
Malformed calves in % of calved cows	76	Periods 3 + 4	0 (0–1.2)	0 (0–0)	0.01

[a] Farmers were asked to identify the four main clinical signs of acute SBV infection (fever, diarrhea, milk loss, and abortion) from a list of disease symptoms.
[b] Estimation of fertility before the appearance of SBV in Switzerland and afterwards. See Table 1 for legends.

3.4. Losses due to reduced fertility

The median of the fertility parameters in case and control farms are presented in Table 4. The data revealed no difference in the frequency of dystocia requiring veterinary assistance, neither between the two groups nor among the different time periods, and there was no evidence for a possible effect of SBV on the incidence of retained fetal membranes or the number of cows requiring intrauterine treatment. Furthermore, no significant differences were found regarding calving intervals and the number of cows with >1 insemination per successful pregnancy. For calving interval, the matched pairs accounted for 16% of the variance (Table 5).

The distribution of case and control farms in categories based on abortion rate is shown in Table 6. For the estimated abortion rate, the final multivariable hierarchical ordinal logistic regression model only contained the farm status as case or control, the time periods, and the interaction between farm status and time periods as significant variables. Case farms had fewer abortions in the Periods 1 and 2 compared to the Periods 3 and 4 (OR = 0.57, 95% CI = 0.43–0.74), whereas there was no significant difference among the time periods for control farms. In addition, case farms had a higher overall abortion rate compared to control farms (OR = 3.4, 95% CI = 2.6–4.4). The covariance parameter estimate for the random effect pair number was 0.97 with a standard error of 0.30. This

Table 4
Comparison of veterinary costs, fertility disturbances and milk loss due to SBV infection in case and control farms based on information from veterinary bills and breeding associations.

Variable	Observation periods	Case farms: median (IQR)	Control farms: median (IQR)
Monthly veterinary costs per cow in CHF	1	16.7 (8.4–29.6)	16.5 (7.0–30.2)
	2	17.0 (8.7–27.1)	14.0 (7.9–25.7)
	3 (SBV infection)	19.8 (10.6–30.7)[a]	15.9 (6.9–27.0)[a]
	4	16.0 (9.8–26.5)	14.6 (6.8–27.7)
	5	16.6 (9.0–27.6)	15.5 (7.4–27.1)
Dystocia requiring veterinary assistance in % of calvings per farm	1 + 2	4.3 (1.3–10)	4.5 (0–8.6)
	3 + 4	4.5 (1.2–9.6)	5.3 (0–9.1)
	5 (×2)	3.2 (0–10.3)	3.6 (0–9.4)
Cows requiring intrauterine treatment in % per farm	1 + 2	14.8 (6.7–33.7)	13.3 (5.3–28.4)
	3 + 4	15.0 (4.9–33.9)	11.1 (5.3–27.0)[c]
	5 (×2)	13.3 (0–27.3)	12.1 (0–24.0)[c]
Incidence of retained fetal membranes in % per farm	1 + 2	10.0 (4.3–15.6)	8.8 (4.3–14.8)
	3 + 4	8.8 (3.8–14.8)	7.8 (4.4–11.5)
	5 (×2)	8 (0–16.8)	8 (0–14.3)
Calving interval	A	377 (368–392)	379 (370–395)
	B	384 (372–393)	381 (368–393)
% of cows with >1 insemination	1	41.7 (28.6–60.0)	33.3 (22.2–50.0)
	2	48.8 (33.3–60.7)	50.0 (37.5–60.0)
	3	44.4 (30.8–60.0)	50.0 (28.6–66.7)
	4	50.0 (31.7–61.3)	50.0 (33.3–66.7)
	5	50.0 (0–100)	42.9 (0–100)
Daily milk yield per cow in kg	1	25.0 (19.5–31.5)[b]	23.6 (18.3–29.8)
	2	26.4 (21.1–33.3)	25.2 (20.0–31.3)
	3	24.3 (18.9–30.7)[b]	23.3 (18.0–29.1)
	4	25.4 (20.0–32.0)	24.1 (19.0–30.2)
	5	24.8 (19.4–31.3)[b]	23.7 (18.4–30.2)
SCC per farm in thousand/ml	1	75 (35–165)[a]	68 (32–149)[a,c]
	2	64 (30-137)	60 (28–134)
	3	74 (35–164)[a]	66 (32–144)[a,c]
	4	64 (29–138)	58 (27–131)
	5	69 (33–147)	67 (31–140)

[a] Significant differences between case and control groups ($p \leq 0.05$).
[b] Significant differences between Period 3 and Periods 1 and 5 within case farms ($p \leq 0.05$).
[c] Significant differences between the different time periods within control farms ($p \leq 0.05$). See Table 1 for legends.

corresponds to 23% of the variance accounted for by the matched pairs.

3.5. Losses due to reduced milk yield and quality

The median daily milk yield per cow and the median SCC per farm are listed in Table 4.

Despite large fluctuations in monthly milk yields, the curves of the two groups followed the same general pattern with a decrease in average milk production in both groups during Period 3 (Fig. 2), and no significant differences were found between groups. The median daily milk yield per cow in case farms was 0.7 kg and 0.5 kg lower in Period 3 compared to Period 1 ($p < 0.001$) and Period 5 ($p = 0.009$), respectively. In control farms, no significant differences were found among the time Periods 1, 3, and 5.

The linear regression model showed that milk yield was significantly higher in Period 1 than Period 3, but the difference between periods 3 and 5 was not significant (Table 5). The average daily milk yield per cow was higher in the Periods 1 (+0.73 kg) and 5 (+0.52 kg) compared to Period 3.

Data for SCC showed that case farms had in general higher values over the entire study period, and SSC were subject to large fluctuations. The median values were significantly increased by 7000 and 8000 cells/ml in case farms as compared to control farms in the Periods 1 and 3 ($p = 0.04$ and $p = 0.001$, respectively). Within groups, data did not differ among the different time periods in case farms, but the value in control farms was significantly lower in Period 3 than in Period 1 ($p = 0.005$).

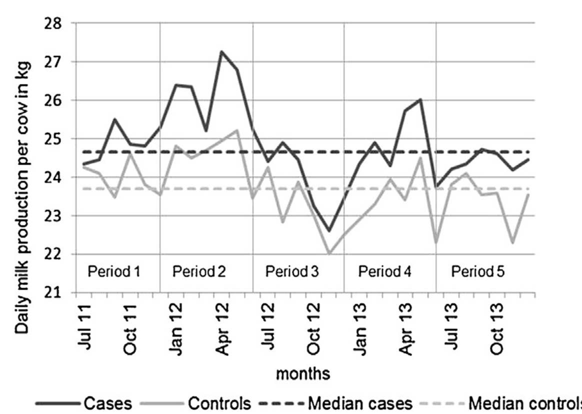

Fig. 2. Median daily milk production per cow in farms with (case farms) and without (control farms) clinical signs of acute Schmallenberg virus infection. See Table 1 for legends regarding observation periods.

The regression model supported the findings of the univariable analysis in that control farms had a significantly lower SCC in comparison with case farms ($p = 0.002$; Table 5). An increasing number of cows on the farms was associated with significantly higher cell counts. Results indicated that there was no significant difference regarding SCC between the second half year in 2011 and 2012 and between 2012 and 2013, respectively.

Table 5
Results of the mixed linear regression models for factors affecting veterinary costs, calving interval, milk yield and SCC during the SBV outbreak in Switzerland.

Outcome	Effects	Categories	Parameter estimate	Standard error	*p*-value	Overall *p*-value (F statistics)
LN[a] (veterinary costs per cow)	Observation periods	Period 3	Reference	–	–	0.760
		Period 1	−0.07	0.07	0.283	
		Period 2	−0.06	0.07	0.420	
		Period 4	−0.01	0.07	0.818	
		Period 5	−0.002	0.65	0.972	
	Group	Control	Reference	–	–	<0.001
		Case	0.23	0.046	<0.0001	
	Housing system	Free-stall	Reference	–	–	0.009
		Tie-stall	0.19	0.07	0.009	
	Herd size	Number of cows	0.02	0.002	<0.0001	<0.001
LN[a] (calving interval)	Observation periods	Period B	Reference	–	–	0.826
		Period A	−0.01	0.01	0.165	
	Group	Case	Reference	–	–	0.005
		Control	−0.003	0.01	0.621	
	Housing system	Free-stall	Reference	–	–	0.028
		Tie-stall	0.015	0.01	0.064	
Milk yield	Observation periods	Period 3	Reference	–	–	<0.001
		Period 1	0.73	0.34	0.029	
		Period 2	1.76	0.34	<0.001	
		Period 4	0.77	0.33	0.021	
		Period 5	0.52	0.33	0.122	
	Group	Case	Reference	–	–	0.530
		Control	0.14	0.23	0.531	
	Herd size	Number of cows	0.10	0.01	<0.001	<0.001
LN[a] (SCC)	Observation periods	Period 3	Reference	–	–	<0.001
		Period 1	0.06	0.048	0.232	
		Period 2	−0.11	0.048	0.025	
		Period 4	−0.09	0.048	0.058	
		Period 5	−0.02	0.048	0.692	
	Group	Case	Reference	–	–	0.002
		Control	−0.10	0.03	0.002	
	Herd size	Number of cows	0.003	0.001	0.028	0.028

See Table 1 for legends.
[a] LN = natural logarithm.

Table 6
Abortion rates in case and control herds prior to and during the outbreak of SBV infection in Switzerland.

Group	Time period	Abortion rate 0% Farm distribution in % of farms (number of farms)	>0–5%	>5–10%	>10%	Unknown
Cases	1 + 2	31.2 (24)	26 (20)	33.8 (26)	3.9 (3)	5.2 (4)
	3 + 4	20.8 (16)	20.8 (16)	26 (20)	28.6 (22)	3.9 (3)
Controls	1 + 2	53.3 (41)	19.5 (15)	23.4 (18)	1.3 (1)	3.6 (2)
	3 + 4	45.5 (35)	24.7 (19)	23.4 (18)	5.2 (4)	1.3 (1)

See Table 1 for legends regarding observation periods.

Table 7
Average estimated costs and financial losses related to acute SBV infection in case farms (in Swiss francs, CHF).

Event	Mean	±SD	Median	IQR	Min-max
Abortion	650 (EUR 542)	±1036 (EUR 863)	0	0–1047 (EUR 0–873)	0–5756 (EUR 0–4797)
Stillbirth	127 (EUR 106)	±284 (EUR 237)	0	0–55 (EUR 0–46)	0–1382 (EUR 0–1152)
Reduced milk yield	291 (EUR 159)	±306 (EUR 255)	191 (EUR 159)	103–357 (EUR 86–298)	0–1486 (EUR 0–1238)
Costs of therapy	538 (EUR 448)	±713 (EUR 594)	312 (EUR 260)	126-682 (EUR 105–568)	0–4636 (EUR 0–3863)
Total	1606 (EUR 1338)		503 (EUR 419)		

3.6. Estimation of financial losses

Table 7 shows the theoretical financial losses in standardized farms with acute clinical signs of SBV infection. The mean abortion rate within case farms in Period 3 was 2.3% and reached a maximum of 20% in individual herds. More than two abortions were observed between July and December 2012 (Period 3) in 10% of case farms. The stillbirth rate in case farms during Periods 3 and 4 was lower than the abortion rate, with a mean value of 1.2%. At least one stillbirth was observed in 24.7% of case farms, and in one farm 12.5% of the calves (3 out of 24) were born dead.

The reduction in milk yield lasted seven days (median) and corresponded to a median value of 100 kg milk per cow. The reported median duration of 7 days was used for further calculations related to reduced milk production. Two hundred and sixty-five out of 461 cows fulfilling the case definitions were treated by a veterinarian during the acute phase of disease. The median costs of therapy per cow were CHF 138 (EUR 115).

The average calculated loss (sum of the mean costs for abortion, stillbirth, reduced milk yield and therapy) for a standardized farm due to acute SBV infection based on the farmers' estimates in case farms was CHF 1606 (EUR 1338). The managers of case farms were asked to estimate the total costs of acute SVB infection for their farm, and the median reported value for a standardized farm was CHF 3948 (EUR 3290).

3.7. Results of serology and necropsies

All participating farms had at least one animal tested positive for SBV in 2012 (ELISA or RT-qPCR) or 2013 (ELISA), except for two control farms where none of the tested animals were positive for SBV-antibodies.

Thirty-three calves were necropsied between January and December 2013, including two sets of twin calves which were each counted as one case. Of these, four aborted calves came from case farms which later dropped out of the study. The remaining 29 calves represented approximately 0.6% of all calvings in 2013 in the 161 study farms. Eight calves (six abortions and two stillbirths) from six control farms and 21 calves (13 abortions, seven stillbirths, and one calf which had been euthanized a few hours after birth due to neurological symptoms) from 12 case farms were submitted for necropsy. Six calves from case farms showed malformations: one was a schistosoma reflexum, other malformations included arthrogryposis ($n = 2$), brachygnathia inferior ($n = 2$), prognathia inferior ($n = 1$), scoliosis ($n = 1$), and brachyuria ($n = 1$). Precolostral SBV antibodies were detected in three calves (one with typical malformations), but none of the necropsied calves was tested positive for SBV RNA. *Neospora caninum* was the most frequent infectious agent found ($n = 4$) and no causative agent was identified in 66.7% of the calves ($n = 22$). Because of the small number of calves examined, no statistical analyses were performed within groups or to compare the case and control groups.

4. Discussion

The investigation of the effects of acute SBV infection on milk production, fertility, and veterinary costs in Switzerland revealed significant associations between acute SBV infection and milk yield, abortion rate, and veterinary costs, but no effects were detected regarding other fertility parameters such as calving difficulties, retained placenta, or number of inseminations for the next pregnancy. Although these results are likely slightly underestimated due to the retrospective nature of the study and to the fact that some data were only available on a monthly basis while acute infection had been reported to last only 3–5 days (Wernike et al., 2013), the calculated costs of acute SBV infection appeared to be limited in Swiss dairy farms. However, the losses associated with clinical signs of infection showed a high variability among farms and could be high for individual farmers.

In 2012, disease awareness regarding SBV was high in Switzerland, so that only 3.7% of the managers of control farms had never heard of the disease prior to the study. The managers of case farms, having observed acute clinical signs, had actively sought information about the disease and were better informed than the managers of control farms.

The time period of greatest interest for the assessment of the effects of acute SBV infection was defined as being from July to December 2012 (Period 3), as Swiss farmers reported acute clinical signs of SBV infection in cows from July to November 2012. The reference periods for analyses over time within groups were mainly the second semester 2011 and 2013 in order to exclude effects of seasonality.

Fifty-eight percent of the cows with acute clinical signs of SBV infection were treated in the present study. In contrast, in a study in Belgium where veterinarians were asked about treatments of affected cows, only 11 out of 27 participating veterinarians indicated that they had treated animals with SBV infection, and the average treatment costs per cow were EUR 107 (Martinelle et al., 2012). The high percentage of animals treated in the present study suggests that the high value of individual animals in Switzerland may have warranted early notification of veterinarians and requests for the treatment of sick animals. The treatment costs per cow were comparable between Belgium and Switzerland. In suckling cow herds in European countries, treatment was reported to be needed in 10% of the cases (Raboisson et al., 2014). The discrepancy between 10% and the 58% reported in the present study may be explained by the animals in suckling herds being less intensively observed, likely resulting in fewer cows with acute clinical signs being reported. The total monthly veterinary costs were significantly higher in Period 3 in case farms than in control farms, which is expected to be due at least in part to SBV infection, although the distribution of veterinary costs among diseases was not analyzed in detail. The significantly higher costs in farms with tie-stalls were likely due to the fact that a sick cow may rather be identified in a tie-stall than in a free-stall.

A significantly higher abortion rate was reported for case herds in the Periods 1 and 2 (before SBV) as compared to control farms. This may indicate the presence of underlying problems (other diseases, stress) in those farms, which might have favored the occurrence of acute clinical signs after SBV infection. The estimated abortion rate in case farms during the period with SBV (6.5%) as well as in the reference period before the SBV outbreak (3.7%) was lower than the one reported in a Dutch-German study (10% in the SBV period and 9.4% in the reference period in infected herds) (Veldhuis et al., 2014b), and is comparable with the defined key figure for abortion in dairy cattle herds of <8% (Kruif et al., 2013). Accurate data on abortions were not available in the frame of the present retrospective study because abortions were often not observed or reported as most farmers did not participate in a regular herd monitoring program. It can therefore be assumed that the prevalence of abortions was in general underestimated in Switzerland. Experts also estimated the abortion rate in suckler cows to be higher in farms with high impact than in farms with low impact of SBV infection in several European countries (2% and 1%, respectively) (Raboisson et al., 2014). Results of a study from Belgium in sheep flocks also showed a significantly higher abortion rate in positive than in negative farms (Saegerman et al., 2014).

In contrast to Veldhuis et al. (2014a), no clear drop in milk production could be calculated based on the data available from the breeding associations. The managers of case farms reported a median milk drop duration of 7 days during acute SBV infection which has likely been missed frequently based on the available monthly test day data. The average self-estimated milk loss of 100 kg per affected cow was higher than the 51 kg per affected cow reported in farms with clinical signs of the disease in the Netherlands based on weekly records and assuming a duration of SBV effect of a month (Veldhuis et al., 2014a). The estimated loss of 100 kg per cow was, however, similar to the effective milk loss registered in a participating farm with an automated milking system which allowed for recording the exact losses. Several farmers in Switzerland indicated that severely affected cows did not give any milk for several milkings or were dried-off earlier than intended. Some farmers of this study also reported that individual affected cows produced only half of the expected amount of milk during the respective lactation. Whereas a drop in milk production was also observed in Period 3 in control farms, milk yield was not significantly different when compared to the same half year in 2011 and 2013. In contrast, case farms had a significantly lower milk production in Period 3 than Periods 1 and 5. Although the effects of SBV infection were short-lived, this result indicates that the effects of SBV in case farms were pronounced enough to be visible at the herd-level based on monthly test day data only. The milk curves in both groups in 2012 were comparable with previous years, which indicates that the drop in milk production in control farms was rather due to changes in feed quality or climatic conditions, especially as the farmers stated that the feed quality in 2012 was lower than in 2011. Results from Germany support that infected cows do not necessarily show a decrease in milk production, as all animals in an infected herd had seroconverted but only 30% of the cows showed fever and none had diarrhea or a reduction in milk production (Wernike et al., 2014).

Except for the lower SCC in control farms in Period 3 compared to Period 1, no significant differences were found within groups which may indicate that SBV had no direct effect on SCC or that such an effect was not detectable with the available data. Nonetheless, 36% of the managers of participating case farms mentioned to have observed a higher SCC and 16% had registered clinical mastitis in the herd at the time of acute SBV infection.

Because the effects of SBV infection on stillbirth rate, percentage of cows with dystocia requesting veterinary assistance, percentage of cows with retained fetal membranes and intrauterine treatment were expected to last longer than the acute phase of infection, the period of interest for these parameters was defined as an entire year from July 2012 to June 2013 (Periods 3 and 4). The periods of reference for these parameters were the previous year (July 2011 to June 2012, Periods 1 and 2) and where available the following 6 months (July to December 2013, Period 5). The data from the last period were multiplied by two under the assumption that calvings were distributed evenly throughout the whole year for the purpose of comparability. These fertility parameters seemed not to be affected by SBV. The survey of experts from the French study estimated that 30% of cows with malformed or dead calves would show dystocia (Raboisson et al., 2014). In Switzerland, there was a slight increase in the number of cows requiring veterinary assistance for calving in the year with SBV, but the differences with the other observation periods were not significant. The causes for dystocia were not analyzed in detail, but the abnormal positioning of the calf in the birth canal rather than calves being malformed appeared to be the main reason. Some farmers also described unprepared calvings after which the cows did not start lactating. In spite of this information which might have suggested shortened gestations, no differences were found in the calving intervals between groups or between time periods. In contrast, more cows with a shorter gestation length were observed in the Netherlands in the SBV period in comparison to the reference period, not only in notifying herds but also in the national population of dairy herds (Veldhuis et al., 2014b).

Because the overall median of the number of inseminations per cow for a successful pregnancy was one, this analysis was repeated only with the cows with more than one insemination. This repeated analysis did not reveal significant differences. It cannot be excluded that the number of inseminations per cow was slightly biased in a few case farms, as some farmers did no longer inseminate their cows during the acute phase of the disease due to the high return rate observed. In the Netherlands, an increased number of inseminations per cow was noticed during the period of acute SBV infection (Veldhuis et al., 2014b). Furthermore, no evidence for an effect of SBV infection on the incidence of retained fetal membranes or metritis/endometritis was found in the present study. While the prevalence of cows with retained fetal membranes laid within the target of <15%, the percentage of cows receiving intrauterine treatment was higher than the recommended target of <10% endometritis (Kruif et al., 2013). This might be due to the fact that the number of cows receiving intrauterine treatment were registered, as opposed to the number of cows clinically diagnosed with endometritis, thus the incidence of endometritis might have been overestimated.

The average Swiss farm size in 2012 was 24 hectares (Anon., 2013), which is lower than the average farm size of the study population. Likewise, the average number of cows in the study farms (40 in case farms and 30 in control farms) was higher than the average of 22.6 cows in Swiss farms in 2012 (Federal Office for Agriculture (FOAG), 2014). Furthermore, herd size was significantly higher in case than in control farms. In the Netherlands, notifying herds had also more cows (97) compared to the mean herd size in all dairy herds (85) of the study (Veldhuis et al., 2014b). Whether this was due to management factors related to herd size or to a higher risk of having several sick animals at the same time, which would make the farmer aware of acute SBV infection, could not be determined. However, as most of the cows in Swiss farms were at least subclinically infected with SBV in the summer and fall 2012 (Balmer et al., 2014), it is unlikely that the failure to notice clinical signs of acute infection was due to insufficient observation in the majority of farms. Some farmers in the case group also noticed that cows with a high milk production and cows in high lactation were more often observed with clinical signs. This might indicate that animals under a strong metabolic stress were more likely to develop clinical signs following an infection with SBV.

Most reported cases of acute clinical signs of SBV infection in adult cattle in Switzerland were dairy cows, therefore the present study was focused on this population. The median within-herd prevalence in the Swiss study population (14.8%) was higher than the median within-herd prevalence of 7.5% reported for adult cattle in Belgium (Martinelle et al., 2012). Prevalence data in the Belgian study were obtained by interviewing veterinarians vs. farmers as in the present study, thus the morbidity rate might have been underestimated in Belgium. Diagnostic investigations were mandatory in all suspected cases of SBV infection in Switzerland, while only the birth of malformed calves was notifiable in other countries (Afonso et al., 2014). In Switzerland, cows with clinical signs suggesting SBV infection were tested throughout the year 2012, which was later useful for the recruitment of case farms and allowed to apply the definition given by the European Food Safety Authority (European Food Safety Authority, 2012b). The relevance of the reported higher density of wild animals around case than control farms should be interpreted with caution in the absence of data on the wild ruminant population at the time of SVB spread and because the distance between matched farms was limited to 10 km or less.

Blood samples were taken to survey the SBV status of participating farms. The results of a countrywide serosurveillance study of bulk tank milk published after the farm visits confirmed that only one out of 244 farms was negative in December 2012 (Balmer et al., 2014). Therefore, seronegativity could not be used for the definition of control farms.

The number of malformed calves and aborted fetuses submitted for necropsy was lower than expected based on the information available on SBV infection at the time of the study start. The distance to the necropsy hall might have discouraged some farmers from bringing calves for post-mortem examination and not all farmers participating in the study notified all abortions and dead calves. It was expected that most malformed calves would be observed between October 2012 and April 2013, given that the infection took place between July and October 2012 and under the assumption that calves were most susceptible between gestation days 76 and 174 as reported for Akabane virus infections (Kirkland et al., 1988). Thus, because the first contact with most farmers was in spring 2013, a significant percentage of aborted or malformed calves might have been missed.

The present study concludes to relatively low estimated losses due to acute SBV infection, however they might have been underestimated due to limitations in data quality (retrospective assessment, monthly values e.g. for milk yield and SCC). Furthermore, additional costs such as extra work for farmers or purchase of replacement animals were not included in the estimation, so that the true losses likely lie somewhere between the calculated loss of CHF 1606 (EUR 1338) for a standardized herd of 33 cows (EUR 40/cow) and the median total loss of CHF 3948 estimated by the farmers. The calculated loss is comparable to the figures calculated for the total economic losses in beef cattle (EUR 42.5/cow) in herds with a high impact of SBV infection in France and the United Kingdom (Raboisson et al., 2014).

5. Conclusion

In general, acute SBV infection in dairy cows had a short clinical effect on affected animals, but several farmers reported a long-lasting reduction in milk production. The overall within-herd prevalence of animals showing acute clinical disease was rather low, but several farmers observed high rates of clinically affected cows and important economic losses in their farms. Nonetheless, the economic impact of SBV infection appeared to be rather moderate at the national level.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

This study was financed by the Federal Food Safety and Veterinary Office. The authors thank the Institutes of Veterinary Bacteriology and Parasitology of Berne for the analyses, Jenny Bressan, Institute of Virology and Immunology in Mittelhäusern for technical assistance, and the farmers, veterinarians and breeding associations for providing data.

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