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Seroprevalence and risk factors related to small ruminant lentivirus infections in Belgian sheep and goats

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ABSTRACT

Maedi-Visna virus (MVV) and caprine arthritis encephalitis virus (CAEV) are two prototype members of the group of small ruminant lentiviruses (SRLVs). Both result in progressive and persistent infections of sheep and goats that impact animal health and cause economic losses. In Belgium, the sheep and goat sector is small and consists mostly of hobbyist farmers keeping few animals. A voluntary control program however exists, but less than 2% of the farmers participate to the program. The current lack of SRLV seroprevalence data and knowledge on risk factors related to SRLV seropositivity in this hobbyist sector makes it difficult to evaluate the risk of SRLV transmission from non-certified to SRLV free certified farms.

We performed a nationwide SRLV seroprevalence study based on a stratified sampling proportional to the number of sheep and goat holders per province. Randomly selected sheep and goat owners were invited to participate and subject to a short questionnaire to collect information about flock size, animal health condition, age, flock constitution and housing conditions. Samples were collected from maximum 7 animals per farm and tested in a commercial ELISA.

In total, we received samples from 87 sheep and 76 goat farms. Sheep flocks showed an overall seroprevalence of 9% (CI $_{95\%}$: 5–15) and a between-herd seroprevalence of 17% (CI $_{95\%}$:11–27). Seroprevalence at animal level in goat flocks was 6% (CI $_{95\%}$: 3–12) and the between-herd seroprevalence was 13% (CI $_{95\%}$: 7–23). Multiple sheep and goat breeds were found SRLV seropositive. Answers provided during the questionnaire confirmed the mostly hobbyist nature of the sector and showed that more than 65% of sheep and goat farmers had never heard of the disease. The only risk factor found to be related to SRLV seroprevalence was flock size. Herds of more than 10 goats had significantly higher chance to harbor seropositive animals (OR: 4.36; CI: 1.07; 17.73).

In conclusion, it was shown that participants to the SRLV free certification program are at risk for reintroduction of the disease in their herds since SRLVs are present on about 15%–20% of non-certified farms. Except from flock size, no clear risk factors were found that are helpfull to identify flocks at risk. Greater effort should be made to inform sheep and goat farmers about the existence and consequences of this disease in order to promote the voluntary control program and further reduce the disease prevalence.

1. Introduction

Maedi-Visna virus (MVV) and caprine arthritis encephalitis virus (CAEV) are two prototype members of the group of small ruminant lentiviruses (SRLVs) belonging to the family of Retroviridae (Blacklaws, 2012). MVV was the first lentivirus to be discovered and was isolated from sheep in Iceland in the 1960s (Sigurdsson et al., 1957). Twenty years later, CAE virus was isolated from goats (Craword et al., 1980). Recent epidemiological studies have shown that natural inter-species transmission can occur in mixed flocks (Leroux et al., 2010). Both viruses are therefore grouped together as SRLVs and are currently divided into five phylogenetic groups; from A to E. Genotype A in sheep consists of MVV-like strains and genotype B corresponds to CAEV-like isolates while the others three genetic groups include genotypes from more restricted geographical areas (Ramirez et al., 2013). Recent reports on SRLV seroprevalence in European countries are limited. Only

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Poland, Spain and Switzerland reported seroprevalence rates of 72%, 53% and 9%, respectively (Schaller et al., 2000; Lago et al., 2012; Kaba et al., 2013).

The primary route of SRLV transmission is via the ingestion of infected colostrum and milk by lambs. Also horizontal transmission via the inhalation of infected secretions has been described and is regarded mainly as a transmission route in intensive and indoor production systems (Leginagoikoa et al., 2006; Villoria et al., 2013; Junkuszew et al., 2016).

SRLV infection results in progressive and persistent disease in sheep and goats leading to neurological disorders and chronic lesions in lungs, joints and mammary glands (Minguijon et al., 2015). Aside from their impact on animal welfare and their fatal outcome in the long term, SRLVs have become a worldwide problem with substantial economic losses in the small ruminant industry due to reduced lamb weight, decrease of milk production, early culling and restrictions to animal trade (Reina et al., 2009; Perez et al., 2010). To our knowledge, no exact quantification of the economic impact due to SRLV infections is however available.

To date, no vaccines or therapies are available. Therefore the control of SRLVs mostly relies on the early detection and removal of infected animals from the flock. Preventive measures such as snatching progeny from infected ewes at birth, artificial rearing of lambs and separating seropositive and seronegative animals have been proposed to minimise spread of the disease in flocks (Reina et al., 2009; Perez et al., 2010; Minguijon et al., 2015). In Belgium, a voluntary program with the possibility to obtain a SRLV-free certification (Royal Decree 24-03-1993 for MVV and 27-11-1997 for CAE) has been implemented and combines measures to prevent contact with potentially SRLV infected animals and to detect SRLV infections in an early stage. To enter this voluntary program, farmers have to show the negative SRLV serological status of all their animals over 1 year and 2 consecutive negative ELISA tests on serum collected within a six to twelve month interval. This allows farmers to get a first certified MVV/CAEV-free flock status for a period of 12 months. After a yearly screening, this one-year certificate can be renewed two times before leading to a 24 months free flock status. In case of positive or doubtful results during the ELISA screening, the certification is suspended and extra confirmatory ELISA, immunodiffusion and PCR tests are performed to define the infection status of the suspected animal. Obtaining the “SRLV free” certification allows farmers to sell, show and export their animals and generates extra value to the animals as breeding and replacement stock (Perez et al., 2010).

As in other countries with a voluntary eradication program of SRLV infections, Belgian participants are always at risk for a potential reintroduction of the virus via contacts with animals from non-certified farms. The current absence of SRLV seroprevalence data in Belgium makes it difficult to assess the extent of this risk and we therefore performed a nationwide SRLV seroprevalence study in the Belgian sheep and goat population. In addition, we also aimed to identify risk factors associated with SRLV seropositivity in order to more easily identify flocks at risk.

2. Material and methods

2.1. Sampling strategy

Participating farms were selected from the Sanitel database, the national Belgian information system that identifies, registers and collects information about animals including ovines and caprines. Farms participating in the national voluntary MVV/CAEV control program were excluded, as well as farms with less than 3 goats or 5 sheep to avoid an excess of small holdings. A stratified random sampling approach proportional to the number of goat and sheep holders per province was applied (Table 1). One database comprising all Belgian sheep holders and another comprising all Belgian goat holders was used to select ‘sheep farmers’ and ‘goat farmers’, respectively. When it became clear during the questionnaire (see further) that some farmers had mixed flocks, and were thus present in both databases, they were nevertheless enrolled in the group they were initially selected from and could only submit samples from that animal species.

According to the methodology described by Thrustfield (Thrusfield, 2005) as implemented on the website ‘http://epitools.ausvet.com.au/’, about 320 herds should be sampled to estimate the between herd SRLV seroprevalence with 95% confidence and a precision of 5% when its prevalence is estimated to be 30%. To remain within the budgetary limits, however, we could only collect samples from 100 sheep and 100 goat farms. This decreases the precision of the 95% confidence interval to about 10%.Only limited data is available in literature on efficiency of SRLV transmission and the prevalence of SRLV to be expected at farm level during an outbreak. Based on i) preliminary data estimating the within herd SRLV seroprevalence in Belgium at 30% and ii) publications indicating that efficient vertical and horizontal SRLV transmission can occur upon introduction of seropositive animals in a herd, sometimes leading to an increase in seroprevalence of 30–50% within a short period (Woodard et al., 1982; Adams et al., 1983; Robinson and Ellis, 1986; Blacklaws et al., 2004; Alvarez et al., 2006, Leginagoikoa et al., 2006), we considered a design prevalence of 30%. In combination with an estimated average farm size of 50 animals, 7 samples per farm were collected, allowing to predict with 95% confidence that the SRLV prevalence is lower than the design prevalence of 30% if all test negative (http://epitools.ausvet.com.au/content.php?page=FreedomSS3). For the calculation of the between herd seroprevalence, such farms where considered as negative. Since SRLV can however exist at a farm at a prevalence below 30%, this assumption might result in an underestimation of the true between herd seroprevalence. As will be discussed later, the actual average farm size in Belgium is however below the initial estimate of 50, making that sampling of 7 animals often meant sampling of all animals present (Supplementary Table 1), and ensuring that those herds were certainly SRLV free.

2.2. Sample collection

After a first series of telephone calls, 100 sheep and 100 goat farmers were enrolled for the study. Three months after having sent them all the documents, it became clear that only a part of them had sent in serum samples from their animals via their veterinarian. A second round of phone calls was launched, recontacting those from the first round that had not yet participated and contacting new potential candidates for those who were no longer willing to participate. Again sufficient people were enrolled to reach 100 sheep and 100 goat farmers. Unfortunately, also after this second round, not all participants sent in serum samples. In total, we received sera from 87 sheep farms (555 samples) out of 149 farmers that confirmed their participation and from 76 goat farms (401 samples) out of 129 that had engaged themselves to participate. Samples were collected between November 2015 and May 2016 by veterinarians designated by the participants. These veterinarians received an instruction letter to streamline the sample collection. They were asked to collect serum from 7 randomly selected animals older than 1 year. Only when less than 7 animals were present in this age category, younger animals could be included. Age information on the sampled animals was provided by the veterinarians.

2.3. Questionnaire

At the moment of enrollment of the participants over the phone, a short questionnaire was submitted to participating farmers. We collected data on their awareness of the disease, their motif to keep sheep

Table 1
Distribution of sheep and goat flocks over the Belgian provinces and overview of the stratified sampling approach.

Provinces	Sheep				Goats			
	Total flocks	Attempted number of participants	Participating number of farmers	Sampled animals	Total flocks	Attempted number of participants	Participating number of farmers	Sampled animals
Antwerp	2105 (7,7%)	8	7	49	1279 (11,9%)	12	10	56
Limburg	1783 (6,5%)	6	6	39	741 (6,9%)	7	5	28
East Flanders	7127 (26,2%)	26	21	133	2321 (21,7%)	22	17	87
West Flanders	5120 (18,8%)	19	18	103	1944 (18,2%)	18	16	85
Flemish Brabant	2973 (10,9%)	11	10	70	1101 (10,3%)	11	7	38
Flanders	19108 (70,1%)	**70**	**62**	**394**	7386 (69%)	**70**	**55**	**294**
Walloon Brabant	578 (2,1%)	2	1	7	215 (2%)	2	1	3
Hainaut	2469 (9,1%)	9	8	51	917 (8,6%)	8	5	28
Liege	2007 (7,4%)	7	7	49	1037 (9,7%)	10	6	28
Luxembourg	1273 (4,7%)	5	4	27	490 (4,6%)	4	3	15
Namur	1818 (6,7%)	7	5	27	664 (6,2%)	6	6	33
Wallonia	8145 (30,0%)	**30**	**25**	**161**	3323 (31,1%)	**30**	**21**	**107**
Belgium	27253 (100,0%)	**100**	**87**	**555**	10709 (100,0%)	**100**	**76**	**401**

The bold values highlight the data of the 2 regions in Belgium, each composed of several provinces.

or goats (hobby, professional), flock size, perceived animal health condition, flock constitution (sheep, goats or mixed), and housing conditions (indoor/outdoor) (Table 2).

2.4. Serological analysis

The serological testing was carried out at the Belgian regional animal health laboratories: 'Dierengezondheidszorg Vlaanderen' and 'Assiociation Régionale de Santé et d'Identification Animales'. The SRLV infection status of each animal was determined by a commercial indirect ELISA test (Elitest, Hyphen Biomed) following manufacturer's instructions. The ELISA is based on a combination of the recombinant capsid protein Gag p25 and the transmembrane peptide gp46 (Saman et al., 1999) and has a reported sensitivity and specificity of 97.8% and 98.2%, respectively (Varea et al., 2001). Based on a comparative study of available serological diagnostic tests for SRLV, this ELISA was found to be the best performing test (Brinkhof and van Maanen, 2007).

2.5. Statistical methods and maps

The generalized estimating equations (GEE) model, which takes into account the correlation between animals that belong to the same herd (Meroc et al., 2014), was used to estimate the overall animal level seroprevalence and the 95% confidence intervals. The between-herd seroprevalence and associated 95% confidence intervals were determined using a generalized linear model (GLM) to model the binary logistic response values of the herds (positive = 1, negative = 0) (Meroc et al., 2014). No other explanatory variables were taken into account. A herd was defined as positive when at least one of the samples from that herd was positive in ELISA, otherwise it was considered negative (see above for implications). Both analyses were done using SPSS statistical software.

To analyse whether any of the risk factors raised in the questionnaire was associated with SRLV seroprevalence, data were summarized in 2 × 2 contingency tables, odd ratios were determined and Fischer exact tests performed. For the purpose of this analysis, a farm was considered SRLV positive as soon as one of its animals was detected positive. These statistics were performed using the QuickCalcs module from GraphPad software and SPSS statistic software. P values < .05 were considered to be significant.

Maps showing positive and negative sheep and goat farms per province were produced using QGIS, version 2.12.3. Owners postal codes were used as geographic coordinates .

3. Results

3.1. Overview of sheep and goat farming in Belgium and descriptive analysis of participating farms

According to the data in the Sanitel database of 2011, the Belgian sheep population accounted 216.018 animals distributed over 27.253 herds. For the goat population, 62.221 animals were listed, belonging to 10.709 flocks. This indicates that a sheep farm has on average 8 animals. In 87% and 45% of the sheep farms, less than 50 and 10 sheep are present respectively (Fig. 1). Goat flocks are even smaller with an average of 6 animals per farms and 95% and 63% of farms having less than 50 and 10 goats, respectively (Fig. 1). In 2014, 508 sheep farmers and 27 goat farmers participated in the voluntary MVV/CAEV control program, indicating that less than 2% of all herds is participating in the program.

Analysis of the data gathered during the questionnaire showed that the average number of animals per flock from the participants in the current study are similar to those reported above at Belgian level. After exclusion of 8 and 6 large commercial sheep and goat farms from the data, the mean number of sheep and goats present per farm are 12 and 7, respectively. Most participants were hobby farmers with less than 10 animals (Table 2). Only 17 farmers with economic incentives were present and these held the largest flocks. Interestingly, more than 65% of the small hobby farmers had never heard of the disease and most participants had not observed any negative animal health conditions in their animals that could be related to SRLV infection (respiratory problems, arthritis, mastitis).

3.2. SRLV seroprevalence

In sheep, 52 animals of the 555 tested seropositive and 15 out of 87 farms had at least one positive animal for SRLV infection. This corresponds with an overall seroprevalence of 9% (CI $_{95\%}$: 5–15) and a between-herd seroprevalence of 17% (CI $_{95\%}$: 11–27). No SRLV seropositive sheep were detected in the provinces of Namur and Walloon Brabant (Fig. 2).

For goats, 6% (CI $_{95\%}$: 3–12) of the tested animals (24 out of 401) were found seropositive. The between-herd seroprevalence was 13% (CI $_{95\%}$: 7–23) since 10 out of 76 farms had at least one animal that tested positive for the presence of SRLV (Fig. 2).

Basted on the maximum of 7 samples collected per farm, the within-herd seroprevalence varied between 14% and 100% in seropositives flocks with a mean value of 49% and 43% in seropositive sheep and

Table 2
Descriptive overview of the responses to the questionnaire. 71 sheep farmers and 69 goat farmers that submitted samples to this study (partially) answered to the questionnaire collected at the moment that participants were enrolled over the telephone.

Question	Category	Sheep herds[a]	Goat herds[a]
Are you aware of the existence of MAE/CAE?	Yes	24	12
	No	36	39
What is the reason for keeping sheep/goats	Professional/financial profit	9	8
	Hobby	56	61
Have you observed negative animal health conditions in your animals? (respiratory problems, mastitis, arthritis)	Yes	13	5
	No	53	62
Do you only have sheep or goats or do you have mixed flocks (presence of sheep and goats in close contact)?	One species	60	37
	Mixed	9	30
Housing conditions	Indoor[b]	9	10
	Outdoor	60	57
Flock size	< 10	31	53
	10–50	31	8
	> 50	9	7
Sheep breeds[c]	Texel	31	
	Roux ardennais	5	
	Crossbred	22	
	Swifter	6	
	Flemish sheep	1	
	Laitier belge	4	
	Others belgian breeds (Entre sambre et meuse, Houtlander)	3	
	English breeds (Devon& Cornwall, Romney, Hampshire Down, Suffolk)	7	
	French breeds (bleu du Maine, Charollais, Ouessant, Vendéen, Ile de France, Rouge de l'Ouest)	11	
	Dutch breeds (Flevolander, Zwartbles)	3	
	Unknown	11	
Goat breeds[c]	Alpine goats		1
	Dwarf goats		46
	Saanen		6
	Crossbred		7
	Anglo-nubian goats		4
	Toggenbourg		2
	Boer goats		2
	Various dairy goat breeds		8
	Flemish goats		1
	Belgian deer goats		1
	Unknown		9

[a] The sum over the categories does not always equals 71 and 69 since not all participants answered all questions.
[b] Herds that kept animals inside for at least 3 months during the winter season were considered to be housed inside.
[c] several farmers had animals belonging to multiple breeds.

goat flocks, respectively.

Interestingly, seropositive animals were found among different sheep and goat breeds. Seropositive animals were found among Texel, Charollais, Flemish and Belgian dairy sheep and Saanen, Anglo-nubian, Toggenbourg, Boer goats, Belgian deer and dwarf goats.

3.3. Risk factors analysis

Information about the participating flocks was collected during the enrollment of the participants over the phone. Since this was done during working hours, some had no or only limited time to participate to the questionnaire. In total we received (partial) answers from 71 sheep farmers and 69 goat farmers. This makes that the number of herds included in the risk factor analysis is not exactly the same for each risk factor under consideration.

In the sheep study, no association was found between one of the risk factors including the observed clinical signs, the presence of goats in the flock, the housing conditions and SRLV seropositivity (Table 3). Although not significant, the obtained P value just above 0.05 in the Fisher exact test for flock size ($P = 0.076$) suggests however that the likelihood of identifying a seropositive sheep increases with flock size (> 10 sheep) (Table 3). No difference could be found in seroprevalence between sheep aged between 12-48 months and those older than 48 months.

Similar results were found in the goat population, although here it was statistically significant ($P < 0.05$) that larger flocks had a higher chance to contain at least one seropositive goat (Table 4). Flocks with more than 10 goats had 4 times higher chance to harbor at least one seropositive animal while this increased to 12 fold for flocks with over 50 animals. Again, no association between SRLV seroprevalence and observed clinical signs, contact with sheep, and the housing conditions were found (Table 4).

4. Discussion

The sheep and goat sector is very small in Belgium, consisting mostly of hobby farmers that keep only a few sheep or goats since, according to the most frequently raised incentive in our questionaire, these are helpfull in mowing the lawn. Compared to other countries like England and Ireland where more than 50–60% of the flocks consist of more than 50 animals (http://beefandlamb.ahdb.org.uk; https://www.agriculture.gov.ie), only about 13% of sheep and 5% of goat flocks in Belgium harbor more than 50 animals. According to our questionaire, most of these tend to do so for commercial reasons like milk or meat production.

Within this small sector, only one to two percent of all herds participate in the voluntary MVV/CAE control program set-up by the government. Although no exact numbers are available, our participation to meetings organised by the national government for the small ruminant sector learn that most sheep and goat owners participating in the program are pedigree breeders that are obliged to be certified MVV/CAE free to participate to exhibitions. Only a minority of professionals participates to the program for economical reasons like higher export prices for their animals. The limited participation among professionals to the program is probably related to the extra costs associated with the screening tests.

The results of our questionnaire showed that there is much unawareness about the disease and its consequences among small scale sheep and goat owners in Belgium. Over 65% of the participants had never heard of the disease. Several aspects such as the lack of data on the presence and impact of the disease in Belgium, absence of acute clinical signs, progressive clinical signs that can be associated with old age of the animal and unavailability of therapy probably contribute to this unawareness. Although it was not specifically asked during the questionnaire, the unawareness about the disease will definitely play an important role in explaining why so few farms participate in the voluntary eradication program.

A nation-wide seroprevalence study was performed to get a first idea of the significance of the disease in Belgium and to assess the risk that participants to the MVV/CAE free certification program have for a possible disease introduction by unwanted contact with non-certified animals. We calculate that 9% ($CI_{95\%}$: 5–15) of the sheep population and 6% ($CI_{95\%}$: 3–12) of the goat population in Belgium is SRLV seropositive, coinciding with a between herd seroprevalence of 17 ($CI_{95\%}$: 11–27) and 13% ($CI_{95\%}$: 7–23), respectively. A similar seroprevalence

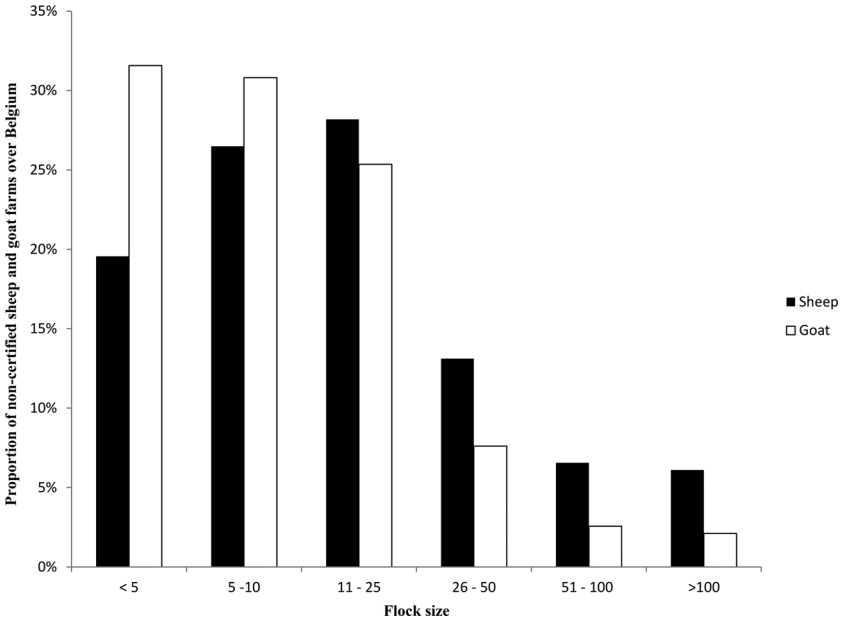

Fig. 1. Flock size distribution in Belgian sheep and goat herds.

rate was found in Switzerland (9% between herd seroprevalence), but it was considerably lower than reported seroprevalence in intensive European sheep and goat rearing countries like Spain (overall seroprevalence of 53% in Aragon) and Poland (72% between herd seroprevalence) (Schaller et al., 2000; Perez et al., 2010; Kaba et al., 2013). The relative limited spread of the disease within the Belgian population is probably related to characteristics of the hobby sector like the limited introductions of new animals in existing flocks and limited contact with other herds.

The limited seroprevalence suggests that the impact of SRLV in small scale hobbyist farms in Belgium is rather limited and that it will probably be difficult to convince people to participate in the voluntary MAE/CAE free program based on economic grounds. Alternatively, if knowledge on the disease and its consequences would be more widespread, the negative impact of the disease on animal welfare would be a more persuavive factor to enroll them in the program. The owners namely showed a clear commitment to animal welfare and to take good care of their animals during the telephone conversations we had with them.

As will be discussed in more detail further, a higher chance to find seropositive animals was found among larger herds which mostly had economic motifs. This could indicate that the impact of the disease could be more significant in such larger herds and that economic profits could be gained by joining the program. Future studies on seroprevalence and impact of SRLV in such professional herds is needed to clarify this aspect.

Our data show that multiple sheep and goat breeds were susceptible to SRLV infection, but our limited dataset however does not allow to evaluate if differences in breed sensitivity exist. The latter has however already been described in literature. For example, it is considered that Texel sheep, Saanen and Alpine goats are more susceptible than others for SRLV infection (Larruskain and Jugo, 2013; Tabet et al., 2015).

The presence of SRLV in about 15% of the small ruminant herds in Belgium makes that participants to the control program are at risk of introduction of the disease in their flocks by unwanted contacts. Therefore, we also tried to identify risk factors associated with SRLV seropositive farms. Flock size was the only investigated risk factor that seemed clearly associated with SRLV seroprevalence in Belgium. Also other studies have identified flock size as an important risk factor and tried to explain this based on flock management strategies. Firstly, more animal replacements occur in larger flocks, thereby increasing the chance on disease introduction. Secondly, considering the presence of the virus in aerogenous secretions, the risk of horizontal transmission is increased in higher stocking density production systems where animals are raised in close contact (Perez et al., 2010; Minguijon et al., 2015; Junkuszew et al., 2016). Finally, also a decrease in appropriate housing management, including nutrition, feeding facilities and hygienic measures, has been suggested to affect the seroprevalence in larger flocks (Perez et al., 2010). To minimise virus spread in larger flocks and reduce the seroprevalence, preventive measures like separation of infected and non-infected animals, quarantine of newly introduced animals until tested, and avoiding animal introduction from non-certified farms should be taken (Lago et al., 2012; Minguijon et al., 2015).

Other herd management factors like indoor housing and maintaining mixed flocks that have been suggested before to potentially increase the risk for disease prevalence and spread (Olech et al., 2009; Lago et al., 2012; Junkuszew et al., 2016), could not be identified as risk factors in our study. Again, this is probably related to the specificity of the Belgian small ruminant sector with mostly small hobby farmers, making that too few mixed flocks and flocks with intensive indoor housing were enrolled in this study to find a significant relation of these parameters with SRLV seroprevalence. Interestingly, no association between SRLV seroprevalence was found with the animal health condition as assessed by the owner. On the one hand, this is probably related with the slow disease progession seen after infection with this virus and the fact that a part of the infected animals never show clinical disease (Shuaib et al., 2010; Junkuszew et al., 2016), but on the other hand, also the unawereness about the disease among hobby farmers probably contributes to this observation. Therefore it would be advisory to spend more attention to inform sheep and goat owners about the existence and consequences of the disease caused by SRLVs and to promote the voluntary MVV/CAE control program in order to reduce the disease in Belgium. The latter would improve animal welfare and increase the economic value of Belgian sheep and goats.

5. Conclusion

In summary, the present survey confirmed the presence of SRLV in the Belgian sheep and goat population. Despite the presence of a voluntary control program for SRLVs, we observed that the infection remains present on 13%–17% of non-certified farms. Moreover, the risk factor analysis confirmed the significant association between the flock size of more than 10 animals and the increased risk of SRLV infection in the goat population. Increased efforts to inform the sheep and goat

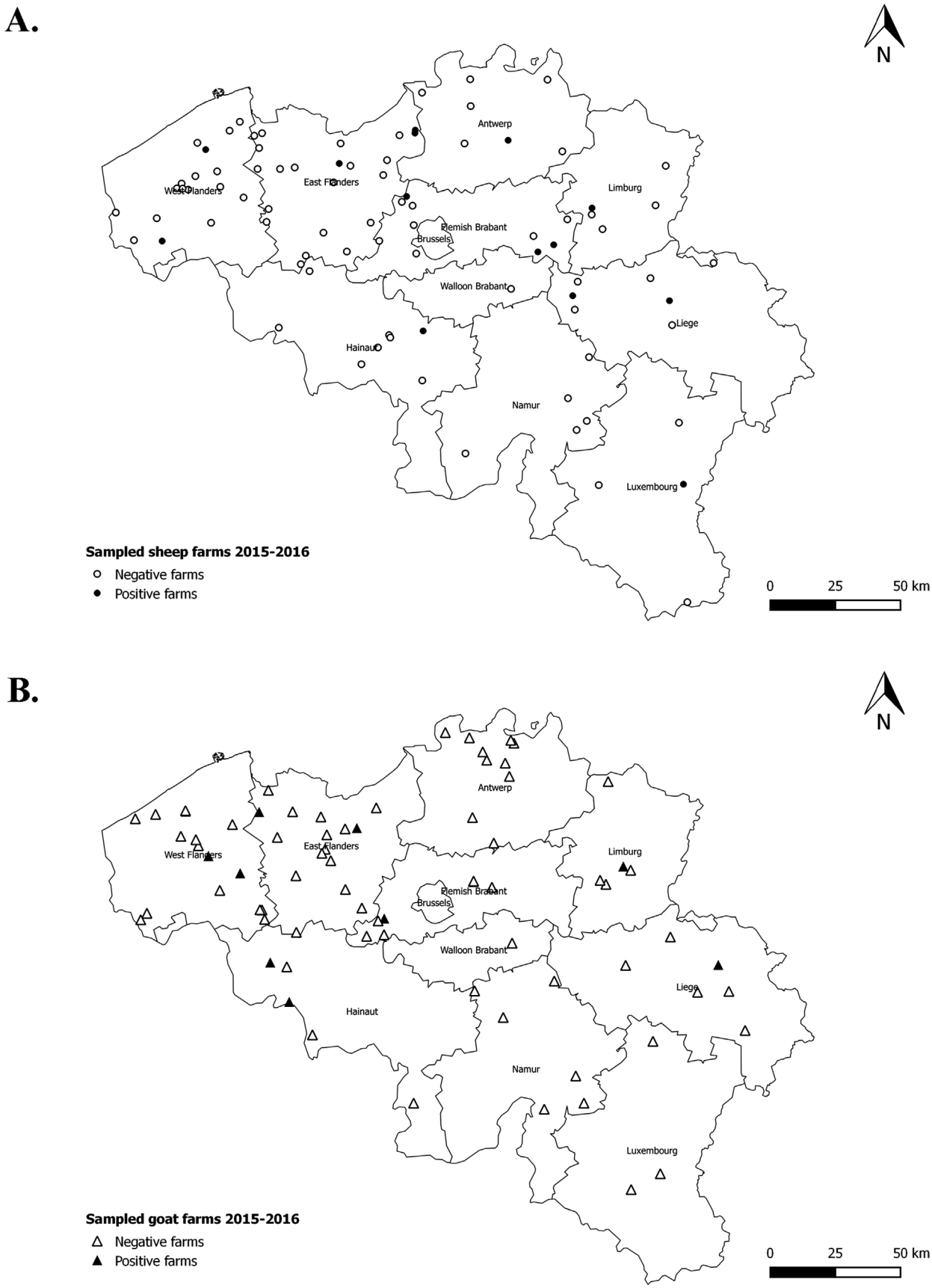

Fig. 2. Geographical distribution of participating sheep (A) and goats (B) farms among the different Belgian provinces.

Table 3
Risk factor analysis in the sheep population.

Risk factor	Category	SRLV seropositivity		OR (CI)	Prevalence (%)	p-value
		+	−			
Flock level						
Clinical signs (including mastitis, joints respiratory and nervous symptoms)	Yes	1	12	0.32 (0.04, 2.72)	7,69	0.434
	No	11	42		20,75	
Presence of goats	Yes	2	7	1.27 (0.23, 6.98)	22,22	0.674
	No	11	49		18,33	
Housing Facilities	Inside	1	8	0.5 (0.60, 4.39)	11,11	1.000
	Outside	12	48		20,00	
Flock size	≥50	4	5	4.16 (0.95, 18.25)	44,44	0.068
	< 50	10	52		16,13	
	≥10	11	29	3.54 (0.89, 14.05)	27,50	0.076
	< 10	3	28		9,68	
Animal level						
Age	12–48 month	22	263	0.59 (0.30, 1.14)	7,72	0.149
	> 48 month	17	119		12,50	

OR: odd ratio; CI: confidence interval.

Table 4
Risk factor analysis in the goat population.

Risk factor	Category	SRLV seropositivity		OR (CI)	Prevalence (%)	p-value
		+	−			
Flock level						
Clinical signs (including mastitis, joints respiratory and nervous symptoms)	Yes	1	4	1.47 (0.15, 14.72)	20,00	0.57
	No	9	53		14,52	
Presence of sheep	Yes	4	26	0.79 (0.20, 3.12)	13,33	1.000
	No	6	31		16,22	
Housing Facilities	Inside	3	7	3.06 (0.64, 14.67)	30,00	0.163
	Outside	7	50		12,28	
Flock size	≥ 50	4	3	12.44 (2.23, 69.32)	57,14	0.006
	< 50	6	56		9,68	
	≥10	5	11	4.36 (1.07, 17.73)	31,25	0.045
	< 10	5	48		9,43	
Animal level						
Age	12–48 month	14	167	1.22 (0.51, 2.91)	7,73	0.828
	> 48 month	9	131		6,43	

OR: odd ratio; CI: confidence interval.

owners about the existence and consequences of this disease and the voluntary control program should be promoted to reduce the disease prevalence in Belgium.

Conflict of interest

None of the authors declares to have a conflict of interest that could influence or bias the content of the paper

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.prevetmed.2017.12.014.

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