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Review article

Routes of transmission and consequences of small ruminant lentiviruses (SRLVs) infection and eradication schemes

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Abstract – Small ruminant lentiviruses (SRLV = maedi-visna in sheep and caprine arthritis encephalitis in goats) are distributed throughout most countries of the world, particularly Europe. Laboratories from 16 European countries established collaborations within the framework of a COST (CO-operation in the field of Scientific and Technical Research) action sponsored by the European Union in order to (i) better organize their research programmes on SRLVs and (ii) to coordinate efforts to combat these two diseases. After five years, a consensus conference – the first one in the veterinary medicine field – concluded the work of this network of laboratories by reviewing the present position and discussing three important questions in the field of SRLVs: routes of transmission, consequences of infection and potential role of eradication programmes at either a European or local level, according to the situation in each country or region. This paper brings together existing information regarding these questions and identifies areas for future research.

Maedi-visna / caprine arthritis-encephalitis virus / lentivirus / small ruminants / European consensus conference

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1. INTRODUCTION

Infections caused by small ruminant lentiviruses (SRLVs), comprising maedi-visna virus (MVV) initially isolated in sheep and caprine arthritis encephalitis virus (CAEV) initially isolated in goats, are widespread in many countries [10, 17, 26, 30, 32, 37, 40, 44, 67, 69, 97, 106, 108, 115, 127, 133, 138, 148]; SRLVs are responsible for significant economic losses that have led to the development of control programmes in Europe and elsewhere. A European Co-operation in the field of Scientific and Technical Research (COST) action was initiated in 1998 to coordinate research in 16 European countries. This review is a report of the discussions held during the final meeting of this COST[a] action; it was organized as a consensus conference for the purpose of identifying aspects of SRLV infections that are generally accepted and to discuss those that are open to debate due to a lack of scientific evidence or to regional differences.

Three questions were addressed: (i) What routes of transmission for infection by SRLVs need to mainly be considered? (ii) What are the consequences of SRLV infections? (iii) Should a control policy be implemented on a European or a local scale?

2. THE ROUTES OF TRANSMISSION

Precise knowledge of the routes of transmission is a critical component of control programmes [120].

Colostrum and milk are considered of prime importance in the transmission of

[a] http://ue.eu.int/cost

SRLVs from mother to offspring [35, 46, 55, 83, 87, 95, 115, 131]. This is also supported by the apparent success of eradication programmes in which offspring are removed at birth and reared on bovine colostrum and milk [29, 64, 115]. Particularly in sheep, contact between ewe and lamb also represents an important risk factor in viral transmission to the newborn [9, 66]. This may be explained by aerosol transmission from the respiratory tract, the lungs being a major target organ in this species. Aerosol transmission between animals of all ages in close contact and over distances of up to several meters appears to be a significant route of spread both within and between flocks and herds, particularly under intensive housing or grazing conditions [46].

The significance of intrauterine viral transmission continues to be unclear [28, 33, 34]. Published evidence suggests that intrauterine transmission may occur in up to 10% of fetuses born to infected dams [15]. The role of this route of vertical transmission is difficult to assess because the results can vary depending on the methodology employed and on the immune response to the virus. If PCR is used to demonstrate virus in the caesarean-derived foetus, the nucleotide sequences of the amplicon should be compared to the virus infecting the dam. If serology is used, the long and variable time to seroconversion may make it difficult to establish that transmission has been via the intrauterine route. Moreover, any contact with infected animals must be excluded. However, the success of eradication programmes based on removal at birth and rearing on bovine colostrum and milk suggests that intrauterine viral transmission is generally of minor importance [65].

Placentas contaminated by maternal blood may also represent a source of infection.

Semen has been demonstrated to contain virus but its role in viral transmission has not been studied [41, 100, 111, 141, 147]. However, virus-infected rams and bucks can infect females by other routes.

Transmission by contaminated milking machines or buckets is considered to be a risk factor [2, 84].

Humans may also contribute to the spread of infection by not changing clothing, boots and equipment when dealing with infected and uninfected flocks [55]. Animals such as dogs or cats are unlikely to play a role in viral transmission.

2.1. Methods of detection

A wide array of techniques is used to detect SRLV infections. These are based on the detection of either antibody or virus [75].

Serological tests include agar gel immunodiffusion (AGID), ELISAs, Western blot and radioimmunoprecipitation.

Tests for virus include isolation in cell culture and detection by cytopathic effect or antigen staining, and genome detection by PCR or RT-PCR. In situ hybridization is useful in histopathological studies [68, 122].

Although now there is no universally accepted gold standard to determine the sensitivity and specificity of the tests used for detecting SRLV infection, the success of control programmes indicates that the available tests are useful for reducing the prevalence of infection. Radioimmunoprecipitation and Western blot are considered good verification methods by most laboratories when using optimized antigen and technical protocols. Radioimmunoprecipitation is technically demanding and rarely used. Western blotting is established more widely as a routine standard for confirming ELISAs [12, 61, 137].

2.1.1. Serological tests

Some aspects specific for SRLV infections influence the outcome of serological tests. Estimates of the mean time from infection to seroconversion range from three weeks to several months although some animals may remain seronegative [70, 113, 132]. The mean time to seroconversion is

shorter in heavily infected flocks than in those with a low seroprevalence. In addition, animals with a low antibody titre may transiently become seronegative [59, 61, 78].

Genome analyses have shown that SRLVs are highly heterogeneous [6, 24, 86, 89, 98, 99, 139, 154]. This is also a notable feature of MVV and CAEV strains. Individual proteins of different SRLV strains have immunodominant linear epitopes, some of which are largely or strictly strain-specific [11, 56, 119]. Strain-specific epitopes are found not only in the more variable envelope proteins but also in the more conserved Gag-encoded proteins [56]. Current findings suggest that the immune reaction to these epitopes may have a significant impact on the sensitivity of serological tests. It is therefore advisable to use tests that can detect antibodies to antigens of strains present in the animal population under investigation.

2.1.1.1. Agar gel immunodiffusion

This test has been the classical method for the detection of antibodies to lentiviruses in domestic animals [1, 31, 39, 57, 76, 117]. It is considered to have a good specificity but is generally less sensitive than ELISA [114, 144]. It is technically simple but its interpretation, being somewhat subjective, requires experience [117, 137, 145].

2.1.1.2. ELISA

ELISAs are suitable for screening large numbers of samples and are more sensitive than AGID. An additional advantage is the quantitative readout, which permits computer-based analysis of raw data. A large number of different antigens is used to detect antiviral antibodies by ELISA. These include whole virus, recombinant proteins, and peptides containing immunodominant epitopes [13, 19, 22, 42, 48, 60, 62, 63, 72, 80–82, 90, 103, 110, 112, 114, 117, 126, 145, 151, 155]. Biphasic tests are preferable because they have a lower frequency of non-specific reactions. Such reactions may be caused by antibodies to cellular components in whole virus ELISAs, by glutathione-S-transferase, or by bacterial constituents in the case of recombinant proteins.

Recently, synthetic peptides have been used in ELISAs to detect antiviral antibodies [81]. Preliminary results look promising but knowledge of the SRLV strains present in the population being tested, as well as the selection of appropriate peptides are essential for the development of reliable tests.

2.1.1.3. Western Blot

Western Blotting is more sensitive than ELISA and is used routinely as a confirmatory test for sera that give indeterminate results in ELISA [14]. Currently, there is no standardized protocol for performance or interpretation of Western Blotting in SRLV diagnostics (e.g. reaction to one versus two or several bands, intensity of bands).

2.1.1.4. Other serological methods

Radioimmunoprecipitation and radioimmunoassay are largely limited to experimental work and these methods are not considered as routine diagnostic procedures [51, 77].

2.1.1.5. Recommendations on serology

The most sensitive and specific test should be used for SRLV serology. To facilitate large sample throughput and objective interpretation, it is advisable to use a proven ELISA. Due to the heterogeneity of viral strains, care should be taken when selecting the antigen. Specifically, the antigen should contain epitopes present in the virus strains circulating in the population being investigated. The results of the flock test should be considered when interpreting the results of individual animals [3]. Where validated,

milk may be used instead of serum for antibody detection [72, 94, 155].

2.1.2. Virus detection

Critical aspects of viral detection are (i) the body part and tissue sampled; (ii) the viral load at the time of sampling; (iii) the biological properties and genetic composition of the virus.

The most common material collected for virus detection is blood. The low viral load in blood is a major challenge for virus detection. In addition, as shown in goats experimentally infected with CAEV and in sheep infected with MVV, the viral load may fluctuate over time and may differ between individual animals [70, 156].

2.1.2.1. Virus isolation in cultured cells

This is the classical method of demonstrating the presence of a virus. The best results are obtained by co-culturing the test sample (ex: peripheral blood mononuclear cells or monocytes) with SRLV-free susceptible cells such as goat synovial membrane cells for CAEV and sheep chorioid plexus cells or skin fibroblasts for MVV [124]. Microscopic examination for the appearance of a cytopathic effect (presence of syncytia) in these sensitive cells is commonly used to confirm the presence of virus. Due to the existence of SRLVs with a low cytopathic potential, it is advisable to stain the cells for the presence of viral antigen. This may be combined with the measurement of reverse transcriptase activity and PCR [76].

2.1.2.2. PCR

Theoretically, this technique has the advantage of detecting infection in animals before seroconversion [8, 23, 68, 146, 152, 153]. For years, numerous groups have attempted to establish PCR as a diagnostic method for SRLV infection, with variable results, such as the finding of amplicons in some seronegative animals and vice versa [20]. The former may represent animals before seroconversion [68,113], or long-term seronegative carriers, while the latter suggests that the PCR protocols may have lacked sensitivity. The reasons for this may be due to a combination of low viral load and of the use of primers that failed to detect all strains of SRLVs. To overcome the latter problem, efforts should be made to determine the sequences of as many SRLV strains as possible. This is important for improving the performance of PCR as a diagnostic test and is a prerequisite for the establishment of molecular techniques to study the epidemiology of infection [85, 118, 125, 154].

2.1.2.3. Recommendations on virus detection

At present, virus detection by co-culture and PCR should not be considered as alternatives to serology, but as complementary tests for use in selected cases [47]. However, PCR protocols of use for a wide spectrum of strains and geographical areas are currently being developed. The sensitivity of virus isolation techniques by co-culture should always be confirmed by including a field strain at limiting dilution in parallel to the field sample being examined. The sensitivity of PCR can be enhanced by using nested or semi-nested methods for sequence amplification. Appropriate positive and negative controls should be included and strict control of contamination is essential. If necessary, the best control method is to sequence the amplicons obtained in positive test samples and to demonstrate that the sequence obtained is different from SRLV used in the laboratory.

2.2. The risk of live animal trading

Live animals trading is considered a major risk factor in the spread of SRLV infection between herds [25].

2.3. The role of derived products in viral transmission

As outlined in previous sections of this document, milk and colostrum as well as semen have been shown to contain virus. The placenta has also been considered in the context of the intrauterine transmission of SRLVs [2, 50]. A recent study has demonstrated the presence of CAEV-infected cells in the goat genital tract which suggests the potential role of this tract for vertical transmission of CAEV from doe to embryo or fetus [49]. Data on the virus content of ovocytes are not available.

Cheese is unlikely to be involved in viral transmission.

3. THE CONSEQUENCES OF SRLV INFECTION

“Maedi-visna” (MV) refers to pneumonia (Icelandic “maedi”) and encephalitis (“visna”), which together with mastitis characterize lentiviral infection in sheep [129, 130]. The introduction of lentivirus-infected Karakul rams from Germany to Iceland in 1933 not only led to an epizootic in the indigenous breed of sheep in Iceland but culminated in the first isolation of lentiviruses and a description of the clinical signs of infection [101]. Knowledge of the viral cause of caprine arthritis-encephalitis (CAE) in goats is more recent. The disease was known to goat owners as “big knees” (i.e. enlargement of the carpal joints) long before the first isolation of the virus in the USA in 1980 from arthritic goats that had previously suffered from encephalitis [27]. In contrast to the epizootic nature of the outbreak of MV in Iceland and due to vertical transmission, CAE was originally believed to be a hereditary disease in the heavily infected regions of central Europe.

Knowledge of animal welfare and of economic consequences may determine if, and by what means, control or eradication of lentiviral infection is a priority in sheep and goat farming.

3.1. Economic consequences

The general consensus was that economic losses due to SRLV infection are significant. However, analysis of the literature indicated that information on such losses is incomplete and in some instances contradictory. The reasons for this are complex and involve the interaction of SRLVs with their hosts as well as management factors [136]. Factors influencing economic losses are the following: (i) clinical disease caused by SRLV infection develops slowly; (ii) only about 30% of infected animals develop clinical disease; (iii) disease signs and economic losses are related to seroprevalence, with no signs evident in herds with low prevalence of infection; (iv) genetic factors influence the extent of disease (in sheep, susceptibility to disease may be influenced by breed whereas in goats this is associated with certain major histocompatibility haplotypes present in all breeds investigated); (v) certain management practices such as milk production, or housing and keeping animals in crowded conditions increase the rate of viral transmission and hence seroprevalence [73]; (vi) disease signs may be influenced by concurrent infections which may vary with different geographic areas and management practices. For example, co-infection by maedi visna and Jaagsiekte retrovirus, which causes ovine pulmonary adenocarcinoma, a contagious lung tumor, results in aggravated disease [52, 149].

Analysis of the literature showed that SRLV infection influences the following production-related parameters.

3.1.1. Milk production

Milk production can be decreased by an estimated 10% – due to indurative mastitis, which is often a feature of SRLV infection [79, 135, 136]. Precise data are unavailable because standardized procedures to assess

milk production are less common in small ruminants than in dairy cattle. It should be noted that reduced milk production is influenced by husbandry practices [109]. The lower weight gain in offspring born to infected dams and demonstrated in most studies, indicates that losses have an impact on the productivity of the following generation [54].

3.1.2. Birth weight

There is evidence [54] or no evidence [7, 136] that SRLV infection decreases the birth weight. Low birth weight is known to negatively affect the development of lambs and kids, thus lowering productivity, particularly in heavily infected flocks [74].

3.1.3. Weight gain

Infection with SRLVs decreases the weight gain of lambs (presumably due to depressed milk yield from indurative mastitis [105]) [38, 45, 54]. Losses may range from 0.3 to 3.0 kg per lamb at weaning [7, 74, 104, 105].

3.1.4. Mortality rates

Mortality due to SRLV infection is low in enzootic areas, but is strongly influenced by concurrent disease, husbandry, nutrition and environmental factors. Observations made during the epizootic of MV in Iceland show that mortality may reach 20–30% in newly infected animals [128, 129]. SRLV infection decreases the average life span of animals due to decreased productivity. The effect of premature culling, typically a year earlier than uninfected animals, is generally underestimated [5]. It also affects productivity indirectly by decreasing the average number of offspring born to each generation. Related to the decrease in milk production is an increase in lamb mortality.

Alternatively feeding with bovine colostrum may increase lamb mortality due to haemolytic anaemia if the source cow is not well chosen.

An element that has not received much attention in the past is the impact of SRLV infection on the quality of production. Infection may negatively affect quality by increasing somatic cell counts in the milk. As consumers increasingly demand products from animals with the best health status possible, animals persistently infected with SRLVs may not meet this requirement.

3.2. Animal welfare consequences

The term "animal welfare" is used in relation to aspects of SRLV infection that directly affect the quality of life of the animals. Factors that primarily affect productivity without causing obvious pain or discomfort are not included in this definition. It is obvious that this distinction is difficult and may be subject to cultural differences and individual opinions. However, the consensus was reached that SRLV infection has a significant impact on animal welfare because the quality of life of clinically affected animals is reduced due to pain and disability.

Originally, MVV and CAEV were considered two distinct yet closely related viruses which infect sheep and goats, respectively. As will be seen below, these viruses are not strictly host-specific. It is the consensus that MVV and CAEV share the same target organs. Both viruses affect the mammary gland equally [143]. However, their predilection for some other organs is different. Lung and brain are classical targets for MVV [93], whereas joints appear to be the most commonly affected organs in CAEV infection. In contrast to MV, encephalitis is typically – although rarely – observed in young kids. Although weight loss and ill thrift are features of SRLV infection, actual emaciation is less common. When considering SRLV infection, it is important to emphasize that usually only a minority of infected animals develop clinical signs. There was consensus that immunosuppression is

not a feature of SRLV infection probably because, in contrast to the immunodeficiency-causing lentiviruses, SRLVs do not infect lymphocytes [16, 53]. Genetic factors of both the host (breed- and family-associated disease susceptibility) and the virus (virulence) influence the outcome of SRLV infection [36, 123].

3.3. Virulence of SRLVs

"Virulence" refers to the ability of a pathogen to cause disease. Information on the virulence of SRLVs is scant. It was noted in Iceland that certain strains of MVV are neurotropic and this was recently found to be correlated with a change in the LTR region of the viral genome [4]. Lentiviruses are genetically unstable, with a high rate of genome evolution typical of RNA viruses and subject to genetic recombination with viruses of identical or closely related species. However, there is no evidence from clinical and epidemiological data that SRLVs may evolve rapidly in vivo, nor is there evidence for recombination between MVV and CAEV in vivo. In fact, evolution of SRLVs in infected animals is approximately 10 times slower than that of HIV in humans. This may be because the viral load of SRLVs in infected animals is lower than that of immunodeficiency-causing lentiviruses. Therefore, the latter should not be regarded as models for SRLVs in this regard [91]. There is also no evidence that the higher disease incidence observed in heavily SRLV-infected flocks may be related to a higher virulence, because reducing the seroprevalence decreases the prevalence of disease.

3.4. The risk of the transmission of SRLVs to other species

Early reports suggested that MVV and CAEV could be transmitted experimentally to goats and sheep, respectively, but concluded that such a transfer was unlikely under natural conditions. However, in the light of several recent reports this conclusion cannot be upheld. Using phylogenetic sequence analyses, several reports clearly demonstrate that MVV can infect goats, and CAEV can infect sheep [18, 150]. It is unclear how infection crosses the species barrier [21, 71, 102, 116, 142]. The most likely risk factors are ingestion of virus-contaminated ovine colostrum and milk by goats and vice versa, as well as a close contact between the species in overstocked barns. It is unclear at what rate these viruses spread within the "heterologous" host population, but there was consensus that SRLV infection across the species barrier must be taken into account in control programmes. Specifically, the same regulations should apply to both MV and CAE, and control programmes that only target sheep or goats alone are no longer acceptable.

There is serological evidence of SRLV infection in wild ruminants such as moufflon, ibex and chamois [92]. The prevalence of SRLV infection is difficult to determine in these species. It is also unclear whether the viruses responsible for the SRLV-specific antibodies in these species originated from domesticated small ruminants, or form a cluster of their own. Preliminary evidence suggests that SRLVs in these species may be different from MVV and CAEV (Chebloune Y., personal communication). To date, no such viruses have been isolated from sheep and goats, which suggests that "exotic" SRLVs are not a cause of concern for domestic small ruminants. Moufflon and ibex are the closest relatives of sheep and goats respectively, which may explain the existence of SRLVs in these species [58]. There is no evidence that, under natural conditions, SRLVs can infect species such as cattle that are not closely related to sheep and goats.

Recently, the zoonotic potential of viruses of domestic animals has been intensively scrutinized particularly because of the zoonotic origins of HIV and new variant Creutzfeldt-Jacob disease [96]. There was a clear consensus that transmission of these

agents must not be confused with SRLVs. This consensus was based on the following arguments: (i) there is no evidence that diseases caused by SRLV in sheep and goats are new; (ii) although small ruminants have been domesticated for several thousand years and have lived in close contact with man, there is no epidemiological evidence, either clinical or serological, for SRLV infection in humans. A recent study has shown that in some goats infected with CAEV, antibodies can recognize linear epitopes on HIV gp120 [88].

In summary, it was the view of the conference that, based on the present knowledge, SRLV do not present a risk to man.

4. THE NEED FOR A CONTROL POLICY TO BE IMPLEMENTED ON A EUROPEAN OR LOCAL SCALE

Due to the increased role of free trade of live animals, embryos and semen in the EU, this issue is of key importance in national or regional control programmes. Several parameters must be considered if the best strategy is to be chosen, as indicated below.

4.1. The size and distribution of small ruminant populations in Europe

In December 2000, the sheep population of the EU was 96.5 million and the goat population 11.5 million. The population varied markedly in different countries. For instance, there were nearly 30 million sheep in the UK and 24 million in Spain, whereas the number in Germany was 2.15 million. Nearly half of the 11.5 million goats were in Greece and only 77 000 in England.

4.2. The incidence of SRLVs in different regions

In contrast to the census data, information on the prevalence of SRLVs in the sheep and goat population of Europe is less updated. In some countries, information dates from 2000 whereas in others the latest figures are from 1978. Assuming an average small ruminant generation time of four years, the latter information reflects the prevalence in animals six generations ago. Furthermore, in view of differences in sensitivity and specificity of diagnostic tests and varying sampling methods used, the data on the prevalence of SRLVs in different countries cannot be directly compared at present. However, the data clearly show that no European country can be considered to be free of SRLV infection as defined by the Office International des Epizooties (< 1% of herds infected, probability 99%). A notable exception is Iceland which eradicated MV following the epizootic initiated by the importation of MVV-infected rams.

4.3. Transmission between different regions

Transmission of SRLVs has occurred repeatedly between different regions. The export of European breeds of goats and sheep has resulted in the spread of SRLVs to various parts of the world [25, 140]. In contrast, certain indigenous goat breeds that have had no contact with imported goat breeds, such as Toggenburg and Saanen in Europe or Criollo in Mexico [140], are free of CAE. Phylogenetic evidence for the introduction of SRLVs via live animal trade is provided by the similarity of the South African sheep lentivirus with European strains such as the Scottish EV1. This reflects the historical role played by imported European sheep in the establishment of the South African sheep industry. The best known example of importation of disease via live animal trade is Iceland. SRLVs were also transmitted via live animal trade from Denmark to Norway, Scotland to Canada [44], England to Hungary [138], Holland to France and Sweden to Finland.

4.4. The results of the various eradication schemes

Control programmes have been initiated in many countries [120]. The European pioneer in the control of SRLVs was the Netherlands, where the eradication of MV in breeding flocks was initiated in the early 1980's [65]. This successful programme provided much information on the methods that could be applied to control SRLVs, not only in sheep but also in goats. Similar programmes were introduced in France, Italy, Germany, Spain, Finland and Switzerland [107, 134]. The removal of serologically positive animals, as well as the separation of lambs and kids of seropositive dams immediately at birth for rearing on serologically negative or bovine colostrum have been important features of successful CAE eradication programmes [9, 121]. The separation of seronegative from seropositive flocks and the strict control of live animal trade are other important measures adopted. The prevention of contact is also necessary during transhumance. This husbandry practice, in which livestock are moved to another climatic region such as grazing areas in the mountains in summer, plays an important role in some European countries.

All programmes were initiated voluntarily and highlighted the crucial role played by motivated sheep and goat owners as well as their organizations [43]. Official health authorities were more reluctant to introduce SRLV controls. The main reason was the cost and the lack of appropriate legislation. In Switzerland, CAE eradication started voluntarily in 1984 when it was realized that the seroprevalence was 60 to 80%. Federal, and in some instances, regional authorities supported the efforts by funding research projects for studying the epidemiology and improving diagnostic methods. Since 1998 "CAE-free" status has been legally recognized. Seroprevalence in the goat population has decreased to around 1% and disease is no longer seen.

5. FINAL RECOMMENDATIONS

5.1. Recommendations on the policy of SRLV control

SRLV infections are a concern for all European countries, irrespective of the current prevalence. Those countries with a very low prevalence aim to maintain this status or even become officially free of infection, while others aim to improve the situation by reducing the seroprevalence.

The consensus reached was the following. Europe should embark on a control programme with the aim of eventually eradicating the virus. The control programmes implemented in the different countries should take into account the national and regional differences and aim to maintain the gene pool of sheep and goat breeds in Europe. The stages of SRLV control leading to eradication are the following: (1) determine the prevalence of SRLVs by surveys and other sources of data; (2) reduce high seroprevalence to low seroprevalence thus decreasing the prevalence of disease; (3) reduce low seroprevalence to serologically negative thus eradicating disease; (4) consolidate the serologically negative status and eradicate the virus.

Each participating country should establish a national SRLV reference laboratory. The main tasks of these laboratories should be to: (1) advise on the national strategy for SRLV control adapted to the epidemiological situation and to the regional conditions; (2) decide on the diagnostic tests for the regional laboratories; (3) decide on the status of results that cannot be resolved by the regional laboratories; (4) organize national ring tests to bring the regional laboratories to the same level of quality; (5) advise the national and regional authorities responsible for animal health on all matters relevant to SRLV control, including the information policy for the goat and sheep farming industry; (6) participate in ring tests organized by the conference of the national reference laboratories within Europe; (7) participate in

the European conference of the national reference laboratories (see below).

The individual programmes should include the following points: (1) MV and CAE should not be treated as separate entities but combined; (2) SRLV-infected and -free flocks should not be kept on the same farm; (3) animal traffic should be regulated; (4) testing should be performed by accredited laboratories.

Individual countries should draft legislation supporting the eradication.

The EU should support the eradication programme by: (1) sponsoring research aimed at improving knowledge on pathogenesis, epidemiology, prophylaxis and diagnostics of SRLV infection; (2) sponsoring periodic meetings of the national SRLV reference laboratories (the conference of national SRLV reference laboratories); thus (3) facilitating exchange of knowledge and harmonization of diagnostic procedures which are essential for open trade in Europe.

5.2. The public and control of SRLV infections

Sheep and goat owners are mostly unaware of the role of SRLVs in animal welfare and economics of sheep and goat farming. Countries are encouraged to pursue an active information policy through pre-existing animal health information channels. Researchers should support this by advising the authorities on the pertinent aspects of SRLV infection and by lecturing and publishing in periodicals produced for sheep and goat farmers. Ideally, articles should be co-authored by farming leaders. The style should be easy to read and stimulate interest and any statements that might suggest a zoonotic dimension of SRLV infection should be avoided.

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