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Research Article

Investigation of seroprevalence of small ruminant lentivirus infections in Erzurum province of Türkiye and determination of individual and environmental variables

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ABSTRACT

Small ruminant lentiviruses (SRLVs) are chronic, incurable, and vaccine-free viral diseases that cause respiratory problems and nervous disorders and yield losses in sheep and goats. Caprine arthritis encephalitis virus in goats and maedi-visna virus in sheep have been named as SRLVs. This study aimed to determine the epidemiological status of SRLV infection in Erzurum province and to evaluate the risk factors of the disease based on breed, age, and sex. For this purpose, 204 animals including 184 sheep (Akkaraman, Morkaraman, and Hemşin breeds) and 20 goats (Anatolian Black goats) from 8 districts of Erzurum province (Aşkale, Hınıs, Horasan, Karaçoban, Palandöken, Pasinler, Pazaryolu, and Tekman) were included in the sample. Commercial antibody-ELISA kit was used to determine the seroprevalence of SRLV and 15.12% seropositivity was detected. In terms of SRLV, 14.67% of females and 20% of males were positive. In terms of breed, 20%, 13.76%, 0%, and 15% seropositivity was determined in Akkaraman, Morkaraman and Hemşin breed sheep and Anatolian Black goats, respectively. Although there was no statistically significant difference in terms of breed groups and sex, the detection rates in the districts were significant. In conclusion, the prevalence of SRLV infection was investigated in 8 locations of Erzurum province, which is one of the important centers of animal breeding and where small ruminant breeding is at a high level, and significant findings were obtained at the district level. With this study, updated data on seroprevalence of SRLV in the region were obtained and a broader perspective was tried to be provided by comparing with other SRLV studies in Türkiye and the world. These findings are important in terms of evaluating the prevalence and transmission risks of SRLV infections in the region and will shed light on future control and prevention strategies.

INTRODUCTION

Sheep farming plays a strategic role for the economy and agricultural sector of many countries as one of the main sources of meat and milk production on a global scale. Compared to other species raised for economic purposes, sheep breeding comes to the forefront due to some reasons such as being content with variables such as feed, environment, etc., being resistant to adverse environmental conditions, and being able to utilize meadows and pastures with low yields better than cattle (Gunes and Akin, 2017). Sheep breeding is a continuous activity that provides various products such as meat, milk, fleece, leather, fertilizer, etc. (Karadas, 2018; Yılmaz, 2019). While pork and beef have a significant share in red meat production in the world, red meat production and consumption in Türkiye is mainly based on beef and mutton (FAO 2023). Türkiye ranks first in Europe and seventh in the world with 44 million sheep and 11 million goats (FAO 2023; TUIK 2023). Erzurum is an important center for sheep breeding in Türkiye and is one of the provinces with the highest small ruminant population in the country with approximately 877 thousand sheep and goats (TUIK 2023).

As in every sector, there are some problems in small ruminant breeding. These problems are largely related to breeding and health. Among the health problems, especially infections have an important place. In small ruminants, especially infectious diseases (bacterial, parasitic, viral infections, etc.) increase their importance due to reasons such as the ease of transmission, herd problems, and lack of treatment for most of them. Among the viral diseases of small ruminants; bluetongue, border disease, sheep-goat pox, and small ruminant lentivirus (SRLV) infections are species-specific infections, while foot and mouth, rift valley fever, akabane, Schmallenberg virus infections are important viral infections that cause infections in both small and large ruminants. Among these infections, SRLV infections are distinguished from other viral infections since they do not have a vaccine, cause slow infections and remain persistent in the host for life (de Andrés et al., 2005).

According to the previous taxonomic nomenclature, SRLV infections included Maedi-Visna (MVV) and Caprine Arthritis Encephalitis viruses (CAEV). In 2023, in the new taxonomic classification, the viruses in the genus *Lentivirus* in the *Retroviridae* family were named as Lentivirus capartenc, the causative agent of the disease formerly known as CAEV, and Lentivirus ovivismae, the causative agent of the disease formerly known as MVV (ICTV, 2023). These viruses are known as SRLVs due to their structural, genetic and pathogenic similarities. Both viruses can infect sheep and goats. However, MVV infection

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is more common in sheep; whereas, CAEV infection is more common in goats (Blacklaws, 2012). The respiratory form of MVV is called as "Maedi" and its nervous form is called as "Visna". Maedi form is more common (Gomez-Lucia et al., 2018). The disease affecting the joints and nervous system in goats is known as CAEV and it causes encephalitis especially in kids and mastitis and arthritis in adult goats (Blacklaws, 2012). Small ruminant lentiviruses contain a positive single-stranded RNA chain with a diameter of 80 - 100 nm. And they contain nucleocapsid, capsid, matrix and envelope proteins from the inside out (Minguijón et al., 2015).

SRLV has a long incubation period in sheep and causes a lifelong infection without clinical signs (Pépin et al., 1998). Clinical signs include pneumonia, mastitis, arthritis and encephalitis (Kalogianni et al., 2023). Infection can lead to weight loss and death in some cases (Straub, 2004). The virus is transmitted to colostrum and milk via macrophages in the mammary gland, and lambs are infected via colostrum (Blacklaws, 2012; Gomez-Lucia et al., 2018). SRLV are slowly progressive infections and although humoral and cellular responses develop against the virus, the disease is difficult to control and eradicate because it is lifelong persistent (Oguma et al., 2014; Peterhans et al., 2004). There is no treatment or commercial vaccine for SRLV. Therefore, accurate diagnosis is fundamental to establish an optimal control program of the infection and reduce its prevalence (Straub, 2004). Currently, the prevalence of SRLVs is investigated based on cross-sectional epidemiological studies. Serological diagnosis of viruses in the family *Retroviridae* also indicates the presence of antigen.

Seroprevalence values vary between countries, animal breeds and age groups and are largely dependent on the laboratory tests used. Various tests such as indirect immunofluorescence (IIF), complement fixation test (CFT), agar gel immunodiffusion (AGID), Western blot, indirect ELISA and radio-immunoassay (RIA) are used for serological diagnosis (de Andrés et al., 2005). AGID and ELISA are recommended as the most suitable methods to detect infected animals; ELISA has higher sensitivity but lower specificity than AGID (Straub, 2004).

Due to the significant socio-economic impact of SRLVs, the World Organization for Animal Health (OIE) has included this disease in the list of notifiable animal diseases (OIE 2023). SRLV puts in danger the sustainability of sheep farms by affecting the health and welfare of animals, causing significant economic losses due to mortality and reduced milk production and lamb growth (Echeverría et al., 2020; Lipecka et al., 2010).

Looking at the national studies, it is seen that among SRLV infections, especially Maedi-Visna virus (MVV) infection has been investigated serologically more (Burgu, 1990; Ün et al., 2018). Although these infections have been studied at the geographical region and province level, a limited number of studies have been conducted in Erzurum region, which has an important share in sheep breeding. The aim of this study was to investigate SRLV infection in small ruminant farms in Erzurum, one of the provinces where sheep breeding is intensively practiced in the Eastern Anatolia Region of Türkiye, and to evaluate the epidemiology of the infection in a broader framework and to make recommendations for combating the infection. For this purpose, blood samples were collected from sheep and goat farms in various districts of Erzurum province, the disease was analyzed by ELISA method and the epidemiology of the infection was evaluated.

MATERIALS and METHODS

Study Area

Erzurum is one of the provinces with the highest altitude in Türkiye and has a harsh continental climate. This climate causes heavy snowfall in the winter months and hot and dry weather in the summer months. Erzurum is covered with snow for about 150 days of the year and this snow feeds the rivers in the region. These climatic characteristics of Erzurum create a very favorable environment for animal husbandry. Winter's heavy snowfall keeps the large plateaus and pastures supplied and ensures an abundance of the plants used as sheep feed. Erzurum's harsh continental climate supports sheep breeding activities and makes a significant contribution to the regional economy.

Materials

A total of 204 blood samples were collected from 15 sheep and goat flocks in Erzurum (Figure 1) by random sampling method. The sampled population consisted of 184 sheep (167 ewes and 17 rams) and 20 goats (17 goats and 3 bucks). In this study, individual (age, gender, breed) and environmental (Erzurum province and districts) factors of the sampled animals were also recorded. Blood samples to be used in serological tests were collected in sterile vacuum tubes and centrifuged at 3000 rpm. The sera obtained were collected in stock tubes and stored at -20 °C until testing.

Detection of SRLV antibodies by ELISA

A commercially available Pourquier ELISA Maedi-Visna/CAEV Screening (Cat. No: P00303-10, Institute Porquier, France) test kit was used for the detection of SRLV-specific antibodies. The ELISA test was performed according to the protocol recommended by the manufacturer. To obtain Optical Density (OD) data, the measurement was performed at 450 nm and OD data were calculated.

Statistical Analysis

Chi-square ($\chi 2$) test was used in IBM SPSS 29.0 statistical program for statistical evaluation of the data obtained in the study. Differences between the groups in terms of the analyzed parameters were considered as significant at level of $P<0.05$.

RESULTS

ELISA Analysis

Of the 204 sheep and goat blood sera tested, 15.12% were positive for SRLV antibodies. When analysed for two species, SRLV antibodies were detected in 28 of 184 sheep (15.2%) and 3 of 20 goats(15%). The seroprevalence of infection was 14.67% in females and 20% in males. When analysed by gender for two species, this rate was 14.37% (24/167) in ewes,

23.53% (4/17) in rams and 17.65% (3/17) in goats. No positivity was detected in bucks (0/3). Among the sheep breeds included in the study, 20% positivity was found in Akkaraman and 13.76% positivity was found in Morkaraman. The presence of specific antibodies was not observed in the Hemşin breed. The positivity rate in Anatolian Black goat was determined as 15% (Figure 1).

No positivity was detected in Pazaryolu and Hınıs districts. Table 1 shows detailed results of the distribution of the variables such as sex, breed, and district.

Statistical Analysis

When the chi-square test was performed for breed and sex variables, p values were found to be 0.32 and 0.52, respectively.

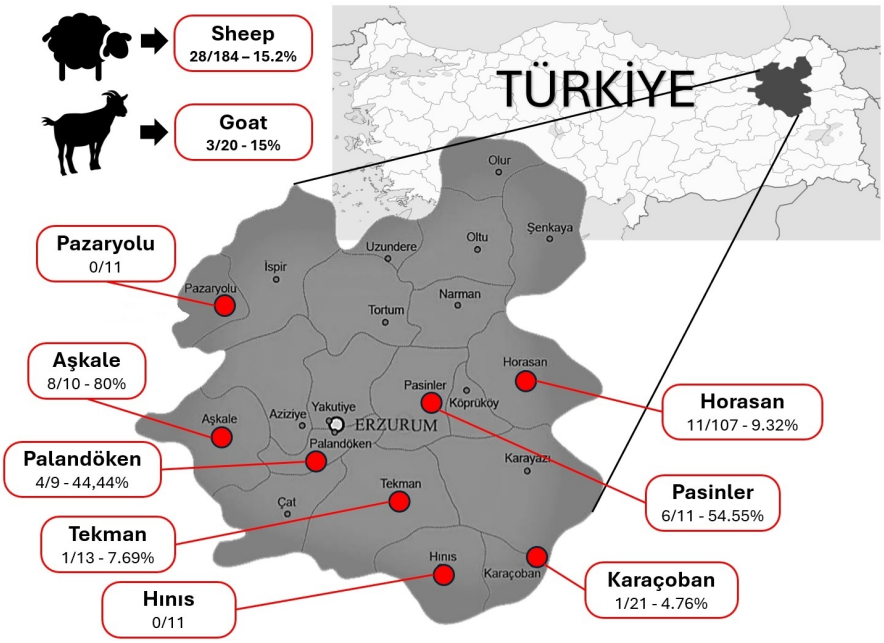

Figure 1. Geographical locations of Erzurum province and its districts in Türkiye. Red circle: The related districts and SRLV positivity rates.

Table 1. Number and positivity rate of sheep and goats by district and gender.

Districts	Sheep Positivity Rate		Goats Positivity Rate	
	Female (n=167)	**Male** (n=17)	**Female** (n=17)	**Male** (n=3)
Aşkale (n=10)	8/10 (%80)	-	-	-
Horasan (n=118)	9/98 (%9,18)	1/10 (%10)	1/9 (%11,11)	0/1
Pazaryolu (n=11)	0/11	-	-	-
Palandöken (n=9)	2/7 (%28,57)	2/2 (%100)	-	-
Hınıs (n=11)	0/10	0/1	-	-
Tekman (n=13)	1/12 (%8,33)	0/1	-	-
Karaçoban (n=21)	0/11	0/2	1/6 (%16,67)	0/2
Pasinler (n=11)	4/8 (%50)	1/1 (%100)	1/2 (%50)	-

When the districts were evaluated in terms of the presence of SRLV specific antibodies, Aşkale ranked first with 80%, followed by Palandöken and Pasinler districts with a positivity rate of 54.55%. The positivity rate was 9.32% in Horasan and 7.69% and 4.76% in Tekman and Karaçoban, respectively.

No significant correlation was found between breed and sex and SRLV antibody positivity rates. The p value was found to be 0.0001 as a result of the chi-square test for the district variable. P<0.05 indicates that there is a significant correlation between the district variable and SRLV antibody positivity.

According to the statistical results in Table 2, no significant correlation was found between seropositivity and breed and sex ($p>0.05$). However, a significant correlation was found between the district variable and seropositivity ($p<0.05$). In ad-dition, Table 2 shows the number and percentage of positive and negative animals according to individual (gender, breed) and environmental (Erzurum province and districts) variables of the sampled animals.

Table 2. Seroprevalence of SRLV according to breed, gender and districts.

Factor	Positive	Negative	Positive %	P value
Location				
Aşkale (n=10)	8	2	80.00	0,0001
Horasan(n=118)	11	107	9.32	
Pazaryolu (n=11)	0	11	0.00	
Palandöken (n=9)	4	5	44.44	
Hınıs (n=11)	0	11	0.00	
Tekman (n=13)	1	12	7.69	
Karaçoban (n=21)	1	20	4.76	
Pasinler (n=11)	6	5	54.55	
Breed				
Akkaraman(n=64)	13	51	20%	0.32
Morkaraman(n=109)	15	94	13.76%	
Hemşin (n=11)	0	11	0.00%	
Anatolian Black goat (n=20)	3	17	15%	
Gender				
Female (n=184)	27	157	14.67%	0.52
Male (n=20)	4	16	20.00%	

DISCUSSION

Small Ruminant Lentivirus (SRLV) infection occurs in most of sheep farming countries of the world except for Australia and New Zealand and causes significant economic losses (Tan and Alkan, 2002). In the case of small ruminants, economic losses are caused by decreased reproductive activity, low milk yield, postpartum litter mortality and low growth rates in seropositive sheep and goats (Arsenault et al., 2003).

In studies conducted to determine the seroprevalence of the disease in the world, different prevalence rates were found. Fevereiro (1995) found 34.3% seropositivity in 1.912 samples in Portugal, Dawson and Clarkson (1995) found 0.39% seropositivity in 14.675 blood serum samples in England, Giangaspero et al. (1993) found 6% seropositivity in 1.445 small ruminants in Syria and Cutlip et al. (1992) found 26% seropositivity in 16.827 blood serum in the USA. In Iraq, seropositivity rates were reported to be 21.82% and 5.88% in 110 blood serum samples and 68 milk serum samples obtained from sheep and goats, respectively (Mosa et al., 2024). Cana et al. (2020), obtained seropositivity rates of 34.8% for sheep and 15.6% for goats in blood serum samples collected from 5.272 sheep and 435 goats in Kosovo. In Italy, where small ruminant farming is very common, Cirone et al. (2019) reported a seropositivity rate of 18.64% in 4800 goats. In studies conducted in Greece (Kalogianni et al., 2023) and Spain (Lago et al., 2012) to determine seroprevalence, 66.5% and 24.8% positivity rates were obtained in sheep, respectively. The differences in the results of these studies may have varied depending on addition of new animals into the facilities, care strategies, hygiene and sanitation practices, and the number of animals included in the sample. Seropositivity rate was 40.9% in Europe and ranged between 16.7% and 21.8% in Africa, Asia and North America (de Miguel et al., 2021). Although SRLV infections have different detection rates around the world, the high seroprevalence values may be a result of the persistence mechanism of the virus. Due to asymptomatic and carrier sheep-goats, the virus persists in the herd and can be transmitted to new generations. The virus may be transmitted between countries through the trade of animals that have not been serologically tested. As shown in this study, the prevalence of SRLV in Türkiye is below the average of the Asian and European continents, but it is high for an infection without a vaccine. Imports are limited in the ovine livestock sector in Türkiye. Breeding is mostly done with domestic breeds and herds are not culled for seropositive animals. In this sense, seronegative animals can be imported by looking at the results of the necessary serological tests, and it can be aimed to reduce the current positivity in Türkiye and to obtain purified herds.

Many serological and virological studies on SRLVs have been conducted in Türkiye (Eroksuz et al., 2022; Karapınar et al., 2016; Muz et al., 2012). The infection was first reported

in sheep in Türkiye by Alibaşoğlu and Arda (1975) and was detected in 1984 by Girgin et al. (1987) in two imported rams through clinical, pathological and serological analysis. In the following years, studies on the presence of infection in both public and state-owned small ruminant enterprises were carried out. Burgu (1990) detected 23.9% seropositivity in 1.099 samples in 12 sheep farms across the country and found positivity in 10 of the 12 flocks they screened. In a serological study conducted by Muz et al. (2012) with blood serum samples collected from 911 sheep from 3 flocks in different regions of Türkiye, they recorded seropositivity in the flocks as 58.65%. Karapınar et al. (2016) conducted a serological examination for the presence of CAEV infection in 435 blood samples and 285 milk samples collected from goats in 4 regions (Central Anatolia, Aegean, Mediterranean, Marmara) between 2007-2010 and found its prevalence rate as 8.5% and 4.9%, respectively. SRLV was reported in all of 7 regions in Türkiye. In Erzurum in Eastern Anatolia Region, Schreuder et al. (1988) found 1.5% seropositivity in sheep. In Van, Ağrı, Hakkâri and Kars provinces, seropositivity rate was 19.76%, 16.66%, 10.5% and 16%, respectively (Ameen and Karapınar, 2018; Gezer et al., 2021). In two studies conducted in the Southeastern Anatolia region, 21.1% seropositivity was detected in Şanlıurfa (Gürçay and Parmaksız, 2013), but seropositivity was not detected in Siirt (Çelik et al., 2018). In a study conducted in the Central Anatolia region, seroprevalence rate was found to be 2.90% in Konya (Yavru et al., 2012). In the study conducted in Afyonkarahisar province in the Aegean region (Arik et al., 2015), a positivity rate of 5.70% was detected. In the Marmara region, Yilmaz et al. (2002) found a seroprevalence of 1.2% in Istanbul. In the Black Sea region, 23% positivity was determined in a study conducted in Samsun, Sinop, Ordu, Trabzon, Rize, Amasya, Tokat, and Giresun provinces (Albayrak et al., 2012). In the Mediterranean region, Doğan et al. (2021) found 9.43% seropositivity in Hatay, Kahramanmaraş and Osmaniye and Kale (2020) found 1.60% seropositivity in Burdur. In the light of all these studies, rates ranging between zero and 58.65% can be mentioned for SRLV seroprevalence in Türkiye. In this study, using the total number of sheep and goats in Erzurum province in 2023 (n=877.000) reported by TUIK, the minimum sample size was determined as 166 at confidence interval of 99% and a margin of error of 10% and a total of 204 samples from 8 districts of Erzurum were studied. The high margin of error can be attributed to the fact that some of the animals were in the barn and some in the pasture, a homogeneous sample could not be achieved from the whole herd and sampling was hardly performed from only 8 of the 20 districts in Erzurum province. SRLV seroprevalence was found to be 15.12% in the present study. In a study conducted in Erzurum province in 1988 (Schreuder et al., 1988), a seroprevalence value of 1.5% was found. Compared to a very old study, the present study both updated the epidemiologic data and determined the current prevalence of the infection. In addition, the correlation of Erzurum with studies in the geographically neighboring provinces (Rize, Trabzon, Van, Ağrı, Kars) is close to the values found in seroprevalence studies. While the highest seroprevalence value was found in Aşkale district (80%), the lowest value (0%) was found in Pazaryolu and Hınıs districts. The reason for the regional high seroprevalence of SRLV in the eastern provinces may be the seasonal migration of small ruminants and the contact of herds with more than one herd in several cities and the grazing of many herds on the same pasture. In addition, the fact that small ruminant breeders in the region do not renew the herd and positive animals live in herds for many years, lambs and kids are added to the herd and fed from the mother may also be an important factor. In order to reduce the current seroprevalence in the region and Erzurum province and to obtain pure herds, precautions such as reforming seropositive animals, adding new animals to the herd after serological controls, bottle feeding lambs and kids in separate sections, selecting breeding animals used in ram and billygoat from seronegative ones can be taken.

Studies on SRLV infection have also mentioned about breed susceptibility. A study conducted in Northern Ireland reported that Texel sheep breed was more susceptible than local breeds (Adair, 1986). In Iceland, Karakul sheep imported from Germany in 1933 for the breeding of local breeds did not show clear clinical signs of the disease, while local breeds were observed to be more susceptible (Tan and Alkan, 2002). Studies conducted in Türkiye have revealed that cultivated sheep are more susceptible to infection compared to local breeds (Yavru et al., 2002). Burgu (1990) compared the susceptibility of domestic sheep breeds to the disease and found seropositivity rates of 2.6%, 3.1% and 3.1% in Akkaraman, Morkaraman and Karakaya sheep breeds, respectively, while high rates of seropositivity of 40.5%, 64.7% and 32.5% were found in Sakız, Dağlıç and Kıvırcık breeds, respectively. In their study, Yavru et al. (2002) found seropositivity rates of 2.36%, 1.42% and 6.45% in Akkaraman, Morkaraman and Merino sheep, respectively. Kalaycı et al. (2023) also found that SRLV prevalence was higher in Pirlak sheep and Saanen goats compared to the other breeds in the study. Albayrak et al. (2012) found in their study that Amasya Herik breed sheep were more susceptible than Karakaya breed sheep, while Muz et al. (2012) reported that seropositivity was higher in Ivesi, Sakız, Dağlıç, Kıvırcık and Merino breeds. In this study, Akkaraman, Morkaraman and Hemşin breed sheep and Anatolian Black goats were studied and seroprevalence was found to be zero in Hemşin sheep. The fact that Hemşin sheep are the only sheep flock in the district where they are raised and they are not combined with other flocks in the pasture may explain the seronegativity. In the present study, seroprevalence values were found to be 20% and 13.76% in Akkaraman and Morkaraman breeds, respectively. When compared with previous studies conducted with these breeds in Türkiye, higher positivity was found. In previous studies, it was evaluated that these breeds may be resistant, but the high positivity rates determined in this study indicate that the presence of a breed resistance is unlikely to be the case, and this situation can be clarified in future studies with a larger sample size and a broader perspective that will include other provinces in the region. In addition, the difference in the regions where the study was conducted and the high rate of breeding and circulation of these two breeds in the Eastern Anatolia region are also important for the value determined. As far as known, there are no studies on the presence of the disease in Anatolian Black goats. Therefore, the present study is the first study in Anatolian Black goats at the breed level. The seroprevalence value in Anatolian Black goats was found

to be 15%. In this study, the seroprevalence value in Anatolian Black goats in Erzurum province was higher than that in sheep. Although no significant inference can be made in terms of breed disposition due to the small number of samples, the first detection of the disease in Anatolian Black goats is an important epidemiological data.

Studies conducted in terms of SRLV have investigated age-related changes in seroprevalence. Gezer et al. (2021) sampled 2- and 3-year-old sheep and found that the seropositivity rate increased with increasing age and interpreted the reason for this increase as increased exposure to the agent with increasing age. In their study, Cana et al. (2020) reported that age did not make a significant statistical difference in sheep, while the seroprevalence value in goats younger than 2 years of age was lower than that in goats younger than 4 years of age. Kalaycı et al. (2023) also obtained data supporting that infection increased with increasing age. Kalogianni et al. (2023) also reported that seroprevalence increased with increasing age. In this study, the animals included in the study were generally over 2 years old. Retroviruses, which are the causative agents of infection, cause slow persistent infection by nature. The high positivity value we found in the present study also supports the correlation with the age factor. This result supports that the seroprevalence of the disease increases proportionally with age in parallel with previous studies.

SRLV can affect both sexes in sheep and goats (Hasegawa et al., 2016). In the studies conducted by Mosa et al. (2024) in Iraq and Gezer et al. (2021) in Türkiye, they showed that sex had no effect on seroprevalence values. In this study, antibody screening of 20 male and 184 female animals yielded positivity rates of 20% and 14.67%, respectively. The presence of SRLVs in male animals is important and should be monitored regularly as it may affect the entire herd if used as breeding stock.

CONCLUSION

It also plays a significant role because Türkiye's meadows and pastures are more appropriate for sheep and goats, small ruminant meat, milk and milk products are produced there, their wool is used, they provide raw materials for industries, and the breeding of sheep and goats increases employment (Benli and Kandemir, 2019; Yazgan et al., 2018). SRLV infections, which are common in small ruminant herds all over the world and in Türkiye, are important due to the econom-ic losses they cause (Carrozza et al., 2023). Europe has been determined as the continent with the highest seroprevalence rate for SRLV and Türkiye acts as a bridge between Asia and Europe due to its location (de Miguel et al., 2021). In Türkiye's neighboring countries (Greece, Iraq, Syria and Iran), approximately 22% positivity for these diseases was reported (Dousti et al., 2020; Giangaspero et al., 1993; Kalogianni et al., 2023; Mosa et al., 2024). However, the disease has been reported in most regions of Türkiye (Albayrak et al., 2012; Kalaycı et al., 2023; Sait and İnce, 2022). SRLV infections are infections that need to be taken into consideration due to the lack of vaccine and treatment options and the fact that they are persistent infections and can be transmitted in many ways (Minguijón et al., 2015). Due to the nature of their persistence mechanism (Trojan horse mechanism), retroviruses can persist in the infected organism for many years and therefore serologic detection can also prove their virologic presence (Bouzalas et al., 2024). For this reason, ELISA antibody test was selected as the appropriate detection method for this study and was deemed sufficient. This study, together with the seropositive sheep and goat data of SRLV infection in Erzurum province, is thought to shed light on new studies to be planned and conducted and eradication measures to be taken. Based on this study conducted in Erzurum, up-to-date data on the presence of infection in flocks were obtained. It is thought that the infection can be eliminated to a significant extent by informing animal owners and veterinarians, identifying persistently infected animals with eradication programs to be planned, and removing persistently infected sheep and goats from the herd.

DECLARATIONS

Ethics Approval

All procedures were approved by the Unit Ethics Committee, Veterinary Faculty, Atatürk University, Türkiye (Date: 27.03.2019 / No:2019/04).

Conflict of Interest

Authors do not have any conflict of interests.

Consent for Publication

Not applicable.

Competing Interest

The authors declare that they have no competing interests

Author contribution

Idea, concept and design: MOT, AE.

Data collection and analysis: AE, HBY, YK, SA.

Drafting of the manuscript: AE, HBY, YK.

Critical review: MOT.

Data Availability

Not applicable.

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