ORIGINAL ARTICLE

Veterinary Research Forum. 2024; 15 (11): 599 - 604
doi: 10.30466/vrf.2024.2026460.4233
Journal Homepage: vrf.iranjournals.ir

Veterinary Research Forum

Seroprevalence of bovine leukemia virus in cattle and buffaloes in the border provinces of the Eastern Anatolia region, Türkiye: insights into the eradication of infection

Ali Riza Babaoglu[1]*, Fatma Ertas Oguz[2], Volkan Yilmaz[3], Nuvit Coskun[3], Fatima Abounaaja[1]

[1] Department of Virology, Faculty of Veterinary Medicine, Van Yuzuncu Yil University, Van, Türkiye; [2] Department of Medical Services and Techniques, Tuzluca Vocational School, Igdir University, Igdir, Türkiye; [3] Department of Virology, Faculty of Veterinary Medicine, Kafkas University, Kars, Türkiye.

Article Info

Article history:

Received: 22 April 2024
Accepted: 14 August 2024
Available online: 15 November 2024

Keywords:

Agar gel immunodiffusion
Bovine leukemia virus
Buffalo
Cattle
ELISA

Abstract

Bovine leukemia virus (BLV) is the causative agent of enzootic bovine leukosis, an oncogenic deltaretrovirus that has emerged as a potential zoonotic infection. The BLV naturally infects cattle and causes economic losses through a slow persistent infection with various clinical symtoms following preleukosis. The main objective of this study was to determine the seroprevalence of BLV antibodies in cattle and buffaloes in the border provinces of the Eastern Anatolia region, Türkiye, using the agar gel immunodiffusion (AGID) assay and enzyme-linked immunosorbent assay (ELISA). For this purpose, a total of 1,033 serum samples were collected from 982 cattle and 51 buffaloes from the provinces of Ağrı (n = 178), Iğdır (n = 252), Kars (n = 317), Van (n = 221), and Hakkari (n = 65) during 2021 - 2022. In AGID and ELISA tests, seropositivity for BLV-specific antibodies was not detected in cattle and buffaloes from the mentioned provinces. This study revealed that BLV was not circulating in cattle and buffaloes in the easternmost border provinces of Türkiye during the sampling period and contributed to determine the status of BLV in the mentioned region. Due to the presence of virus in other regions of Türkiye and neighboring countries, Iran and Iraq, it is recommended to control animal movements, continue efforts to combat the transmission of the virus, and maintain control measures.

Introduction

Bovine leukemia virus (BLV) is the causative agent of enzootic bovine leukosis (EBL), a widely distributed contagious retroviral disease of cattle populations. Economic losses due to BLV infection include losses from decreased yields, slaughter, and other indirect losses, such as restrictions on imports of animals and animal products from the infected regions.[1,2] Although several animal species can be infected by the virus, only cattle, water buffaloes, camels, and capybaras are naturally infected. Sheep are more susceptible to experimental infection and develop tumors at a younger age compared to the cattle.[3-5] However, previous evidence has demonstrated the presence of virus in humans as well as other species of livestock, and possible relationships between BLV and human carcinoma may indicate its potentially zoonotic character.[6,7]

The etiological agent, BLV, is a retrovirus with oncogenic potential belonging to the *Retroviridae* family and *Deltaretrovirus* genus. It shares close genetic similarities with human T-lymphotropic viruses 1, 2, and 3, as well as simian T-lymphotropic viruses 1, 2, and 3.[8] The viral genome consists of a positive-sense single-stranded RNA virus, after enters the target cell, it integrates a DNA copy of the RNA genome as a provirus, both randomly and permanently into the host cell's genetic material.[9] It has been reported that, when an infection-carrying cell with an integrated BLV genome is transformed into a new host cell, the BLV provirus is expressed into the viral particles infecting the target and other B lymphocytes.[10] During the initial stages of the BLV infection, the infected cell may not exhibit any viremia; instead, a remarkably high and persistent humoral immune response is shown against the major core (p24) and envelope (gp51) functional proteins.[11]

***Correspondence:**

Ali Riza Babaoglu. DVM, PhD
Department of Virology, Faculty of Veterinary Medicine, Van Yuzuncu Yil University, Van, Türkiye
E-mail: arbabaoglu@yyu.edu.tr

The BLV can be transmitted through biological materials, like blood, colostrum, saliva, semen, and milk, as well as by certain insects transfering infected cells.[12] The BLV infects lymphocytes, integrating its genetic material into the genome as a provirus. Exposure to contaminated biological fluids can transmit the virus. Around 70.00% of infected cattle are asymptomatic, 30.00% develop persistent lymphocytosis, and up to 5.00% develop malignant B-cell lymphosarcoma in the lymph nodes, the disease's most advanced stage.[13,14]

The BLV is a notifiable disease in most European countries, and most European countries and Oceania have successfully carried out eradication campaigns, but BLV is still a worldwide-distributed viral disease with a prevalence of 90.00% of herds in endemic regions, such as East Europe, South America, and several Asian nations.[15] The first report of BLV in Türkiye, based on clinical and pathological findings, was in Karacabey Agricultural Enterprise in dairy cattle imported from European country in 1962. Although, according to some records, clinical and pathological cases of EBL were observed in 1942, especially in dairy cattle kept in herds.[16,17] In later years, the presence of disease was reported to be at different seroprevalences in different regions of Türkiye, with high prevalence rates especially in imported cattle and industrial herds.[18-21] However, serological investigations carried out in select provinces of the Eastern Anatolia region of Türkiye (Kars, Iğdır, Ağrı, Muş, and Ardahan) since 2000 have shown the absence of BLV antibodies or their occurrence at remarkably low levels.[22-27]

In serological studies for the BLV infection, the methods usually used to detect specific antibodies against BLV infection are the agar gel immunodiffusion (AGID) assay using serum and enzyme-linked immunosorbent assay (ELISA) using serum or milk. These tests are recommended for individual diagnosis before movement, control eradication policies, confirmation of clinical cases, and prevalence of infection surveillance. In addition, they are used for diagnostic purposes in many countries and form the basis of successful eradication policies.[4] The antibodies most commonly detected by these methods are those against the p24 and gp51, but ELISAs are more sensitive than AGID tests.[28,29]

The Eastern Anatolia region is where livestock farming is intense and is one of the most important sources of income for the people of the region. According to the TÜRKVET data affiliated with the Ministry of Agriculture and Forestry at 2024, there are around 1,429,816 bovines, 6,384,220 small ruminants (sheep and goat), and 3,473 buffaloes in the provinces included in the study area, including Ardahan province. This region shares borders with five countries, including Georgia, Armenia, Azerbaijan, Iran, and Iraq, suggesting that animal movements may occur due to its geographical location. Considering the presence of virus in neighboring countries, Iran and Iraq,[30-33] as well as the high prevalence of BLV in the western region of Türkiye and low presence or absence of BLV antibodies in the Eastern Anatolia region, the aim of this study was to determine whether the virus is circulating in cattle and buffaloes within the study area. Additionally, it seeked to provide insights into the control and eradication programs for BLV in the region.

Materials and Methods

Study area. The Eastern Anatolia region is located in the easternmost part of Türkiye. It is bordered by Iraq in the southeast, and Georgia, Armenia, Azerbaijan, and Iran in the east. The border provinces of this region with neighboring countries are Ardahan, Kars, Iğdır, Ağrı, Van, and Hakkari. The main geographical features of the region, with an average altitude of 2,200 m, include plains, plateaus and massifs. Since most of the region is far from the sea and at high altitude, it has a harsh continental climate with long winters and short summers.[34] Figure 1 shows the geographical location of the relevant region and location of the provinces sampled for this study.

Fig. 1. Geographical regions of Türkiye with province borders and location of study area.

Sampling. A total of 1,033 blood samples were collected from 982 cattle and 51 buffaloes located in the Ağrı (n = 178), Iğdır (n = 252), Kars (n = 317), Van (n = 221), and Hakkari (n = 65) provinces between 2020 - 2022 (Table 1). Buffalo samples were collected only from farms in Iğdır province (Fig. 1). Ardahan province, one of the border provinces of the Eastern Anatolia region, was not included in our study due to the availability of new data on BLV seroprevalence.[26] The animals included in the study were randomly selected from traditional farm animals in private farms form different locations and sexes, with ages ranging from 6 months to 10 years. It should be noted that no clinical symptoms or lymphosarcoma were observed during the study period or in previous records of all farms. All samples were immediately transported to laboratory of the Department of Virology, Faculty of Veterinary Medicine, Van Yuzuncu Yil University, Van, Türkiye. Serum samples were removed after centrifugation at 2,000 rpm for 10 min, and sera were transferred to the stock tubes, being inactivated at 56.00 ˚C for 30 min in order to

inactivate indigenous complement activity and stored at – 20.00 ˚C until testing. Blood collections were performed with the permission of farm owners, and the study was approved by the Animal Research Local Ethic Committee of Van Yuzuncu Yil University, Van, Türkiye (approval date: 29.09.2022, No. 22-09-05), and the Ministry of Agriculture and Forestry of Türkiye (approval date: 21.09.2022, No. 7049260).

Serological examination using AGID and ELISA. All serum samples (n = 1,033) were examined serologically for the detection of antibodies against the gp51 of BLV using the BLV-AGID (IDVet, Paris, France) and bovine leukosis serum competitive-ELISA (IDVet) kits according to the manufacturer's instructions. Breifly, positive and negative controls were included in both tests. The AGID test is validated by ensuring that the positive control provided in the kit reacts with the BLV antigen to form a precipitin line. The AGID results were interpreted as follows: A serum was considered negative if it did not produce a specific precipitation line with the BLV antigen, and positive if it formed a specific precipitation line with the BLV antigen, which should align with the line of the positive control. The ELISA is validated when the optical density (OD) of the negative control (OD_{NC}) is greater than 0.70 and the OD of the positive control is less than 30.00% of the OD_{NC}. The ELISA results for each sample were interpreted by calculating the competition percentage (S/N %).

$$S/N\ (\%) = OD_{sample} / OD_{NC} \times 100$$

Samples with a S/N% less than 50.00% were considered positive, while those with a S/N% greater than 60.00% were considered negative.

Results

The seroprevalence of BLV was determined to be negative in 1,033 serum samples obtained from domestic cattle and buffaloes in the Eastern Anatolian border provinces, with ages ranging between 6 months and 10 years. Despite sampling from five different districts and species, no antibodies against BLV infection were detected in AGID and ELISA tests. Therefore, no statistically significant difference was observed between animals during the study. The results of antibody tests against BLV in the five provinces are summarized in Table 1.

Discussion

The global spread of BLV infection began during the 1960s due to the international trade of milk, beef cattle, and related products. Subsequently, some conuntries, such as the United Kingdom, Denmark, the Netherlands, New Zealand, and Australia, reported the successful eradication of BLV following the implementation of effective control initiatives.[35] However, several countries, including the United States (83.90% in dairy cattle and 39.00% in beef cattle), Canada (89.30% at the herd level), Argentina (90.16%), and Japan (73.30% at the individual level), have neglected control measures for BLV infection, leading to high prevalence rates.[36]

Since the first emergence of BLV infection in Türkiye in 1962, numerous researchers have conducted studies on the seroepidemiology of the infection, using AGID and ELISA techniques in milk and serum samples collected from cattle in various districts. These studies have reported varying seroprevalence rates for the presence of BLV antibodies, between 0.00 and 48.30%.[17-27] The prevalence of BLV infection was reported to vary from 0.50 to 81.90% in Iran[28-30] and 7.00% in Iraq,[31] being neighboring countries to the border provinces in the Eastern Anatolia region. However, there is no information regarding the prevalence of BLV in the neighbouring eastern countries of Azerbaijan, Armenia, and Georgia. Additionally, given the geographic location of the sampling in this study, there is always the assumption of potential animal movement in border provinces.

Although seroprevalence studies show seropositivity, there are limited studies on molecular presence of the virus in Türkiye.[37-40] The BLV is reported to have at least 12 genotypes based on the *BLV gp51* gene region.[40] These studies indicate that the BLV isolates belong to genotype 1. There is no study to reference cross immunity status of different genotypes. However, this situtation presents a herd immunity problem for our country, since there is only one genotype in circulation in Türkiye according to the studies.[37-40]

In this study, blood serum samples from 982 cattle and 51 buffaloes of various genders and ages (ranging from 6 months to 10 years) in Ağrı, Iğdır, Kars, Van, and Hakkari, the border provinces of the Eastern Anatolia region, one of the seven geographical regions of Türkiye, were analyzed

Table 1. Serological results of bovine leukemia virus infection in agar gel immunodiffusion (AGID) and enzyme-linked immunosorbent assay (ELISA) methods.

Provinces	Species	Serum samples	AGID positive antibody (%)	ELISA positive antibody (%)
Ağrı	Cattle	178	-	-
Iğdır	Cattle	201	-	-
	Buffalo	51	-	-
Kars	Cattle	317	-	-
Van	Cattle	221	-	-
Hakkari	Cattle	65	-	-
Total		1,033	0.00	0.00

for BLV using AGID and ELISA tests. All of the animals were found negative by both tests. The high sensitivity of the ELISA enables the detection of antibodies in herds with a prevalence of under 1.00%, while the AGID test can only detect 50.00% of the herds identified by ELISA. The ELISA is currently considered more sensitive than alternative serological assays, like the AGID test and can detect the initial phases of infection, a capability not being found in AGID tests.[41] Therefore, both assays were applied to all samples in this study, ensuring consistency in the results obtained. Considering the number of cattle and buffalo samples and the sampling from different provinces examined, the results of the present study indicate that BLV is not yet a problem for cattle and buffalo breeding in the border provinces of Eastern Anatolia.

In the studies conducted on the prevalence of BLV infection in several provinces of the South-eastern and Eastern Anatolia regions of Türkiye over the past 20 years, the presence of BLV antibodies was reported as follows: 0.00% in Ağrı, Iğdır, Kars, Adıyaman, Batman, Gaziantep, Mardin, Kilis, Siirt, Şanlıurfa, and Şırnak, 4.87% in Erzurum, 2.13% in Diyarbakır,[23] 0.00% in Kars,[25] 1.83% in Diyarbakır,[21] 0.00% in Ardahan,[26] and 0.00% in Muş.[27] When the findings of studies conducted in the region over the last 20 years are evaluated together with the data from this study, it becomes possible to form an opinion on the eradication of BLV infection in the border provinces of Eastern Anatolia. Additionally, these data are compatible with the findings of studies sampling small family farms and support the conclusions of some researchers on this subject.

Regarding the zoonotic potential and public health hazards of BLV, its relevance to humans requires much investigation. There are various studies on the relationship between breast cancer and BLV to resolve this uncertainty. Many researchers have studied the development of breast cancer in milk-borne infections, even in experimental animals, over the last 40 years. Of course, breast cancer is a complex disease, and there are various factors leading to the development of breast cancer.[42,43] Some studies have shown both the ability of BLV to infect human breast cells *in vitro* and the possible link between the development of breast cancer and other hematopoietic neoplastic diseases in women.[6,44,45] Therefore, these findings are important to investigate BLV for its possible zoonotic potential and public health hazards. Nevertheless, there are some polemic results from different countries due to the lack of a relationship between BLV and breast cancer in malignant and benign cancer samples *in silico*. For example, a study conducted in China reported that the *BLV* gene was not found in breast cancer samples and no positive samples were found serologically.[7,46]

Considering the results of previous studies conducted on BLV in different regions of Türkiye, it becomes clear how important controlling domestic animal movements and periodically screening herds with ELISA testing are to maintain the BLV-free status of the provinces in this study, qualify them as free, and make the claim regarding the eradication of the infection. In this context, the current study provides a situational assessment of the seroepidemiology of BLV infection in cattle and buffaloes of animal farms in the border provinces of the Eastern Anatolia region and emphasizes the importance of maintaining this situation in the region. Additionally, there is a need to highlight the necessity of implementing control and eradication programs for BLV infection in this region, as well as other parts of Türkiye.

Acknowledgments

The authors declare that no funds, grants, or other supports were received during the study.

Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Aida Y, Murakami H, Takagashi M, et al. Mechanisms of pathogenesis induced by bovine leukemia virus as a model for human T-cell leukemia virus. Front Microbiol 2013; 4: 328. doi: 10.3389/fmicb.2013.00328.
2. Nishimori A, Konnai S, Ikebuchi R, et al. Direct polymerase chain reaction from blood and tissue samples for rapid diagnosis of bovine leukemia virus infection. J Vet Med Sci 2016; 78(5): 791-796.
3. Juliarena MA, Barrios CN, Lützelschwab CM, et al. Bovine leukemia virus: current perspectives. Virus Adapt Treat 2017; 9: 13-26.
4. World Organisation for Animal Health (WOAH) website. Enzootic bovine leukosis. Manual of diagnostic tests and vaccines for terrestrial animals. 12th ed. 2023. Available at: https://www. woah.org/fileadmin/ Home/eng/Health_standards/tahm/3.04.09_EBL.pdf. Accesed Feb 10, 2024.
5. Selim A, Megahed AA, Kandeel S, et al. Risk factor analysis of bovine leukemia virus infection in dairy cattle in Egypt. Comp Immunol Microbiol Infect Dis 2020; 72: 101517. doi: 10.1016/j.cimid.101517.
6. Olaya-Galán NN, Salas-Cárdenas SP, Rodriguez-Sarmiento JL, et al. Risk factor for breast cancer development under exposure to bovine leukemia virus in Colombian women: a case-control study. PLoS One 2021; 16(9): e0257492. doi: 10.1371/ journal. pone.0257492.
7. Khan Z, Abubakar M, Arshed MJ, et al. Molecular investigation of possible relationships concerning bovine leukemia virus and breast cancer. Sci Rep 12(1): 4161. doi:10.1038/s41598-022-08181-5.

8. International Committee on Taxonomy of Viruses: ICTV website. Retroviridae, Deltaretrovirus. Available at: https://ictv.global/report/chapter/retroviridae/retroviridae/deltaretrovirus. Accessed Jan 12, 2024.
9. Schwartz I, Bensaid A, Polack B, et al. In vivo leukocyte tropism of bovine leukemia virus in sheep and cattle. J Virol 1994; 68(7): 4589-4596.
10. Tanaka AS, Komuro K. Targeted rearrangement of a chromosomal repeat sequence by transfection of a homologous DNA sequence using purified integrase. Gene Ther 2005; 12(9): 783-794.
11. Jacobs RM, Pollari FL, McNab WB, et al. A serological survey of bovine syncytial virus in Ontario: associations with bovine leukemia and immuno-deficiency-like viruses, production records, and management practices. Can J Vet Res 1995; 59(4): 271-278.
12. Dogan F, Bilge Dagalp S, Dik B, et al. Detection of genotype 1 bovine leukemia virus from a *C. schultzei* pool: Do Culicoides spp. has a role on the transmission of bovine leukemia virus? Infect Genet Evol 2020; 85: 104469. doi:10.1016/j.meegid.2020.104469.
13. Nava Z, Obando C, Molina M, et al. Seroprevalence of enzootic bovine leukosis and its association with clinical signs and risk factors in dairy herds from Barinas State, Venezuela [Spanish]. Rev Fac Cienc Vet 2011; 52(1): 13-23.
14. Selim A, Marawan MA, Ali AF, et al. Seroprevalence of bovine leukemia virus in cattle, buffalo, and camel in Egypt. Trop Anim Health Prod 2020; 52(3): 1207-1210.
15. Marawan MA, Alouffi A, El Tokhy S, et al. Bovine leukaemia virus: current epidemiological circumstance and future prospective. Viruses 2021; 13(11): 2167. doi:10.3390/v13112167.
16. Hakioğlu F. The first report of haematological research on leukosis in Karacabey stud cattle [Turkish]. Turk Vet Dern Derg 1962; 186-187.
17. Burgu I, Alkan F, Karaoglu T, et al. Control and eradication programme of enzootic bovine leucosis (EBL) from selected dairy herds in Turkey. Dtsch Tierarztl Wochenschr 2005; 12(7): 271-274.
18. Kale M, Bulut O, Yapkic O, et al. Effects of subclinical bovine leukemia virus infection on some production parameters in a dairy farm in southern Turkey. J S Afr Vet Assoc 2007; 78(3): 130-132.
19. Avci O, Bulut O, Yapici O, et al. Investigation of bovine leukosis virus ınfection in blood and milk serum in dairy cattle by ELISA [Turkish]. Erciyes Univ Vet Fak Derg 2013; 10(3): 171-176.
20. Acar A, Gür S. A serological investigation of enzootic bovine leukosis virus (EBLV) infection in cattle in Afyonkarahisar Province [Turkish]. Kocatepe Vet J 2013; 6(1): 33-40.
21. Şimşek A, Gürcay M, Parmaksız A, et al. Investigation of the role of enzootic bovine leukosis (EBL), bovine viral diare (BVD), ınfectious bovine rhinotracheitis (IBR) and blue tongue (BT) ınfections in digestive and respiratory system problems of cattle in Diyarbakir region [Turkish]. Dicle Üniv Vet Fak Derg 2017; 10(1): 13-18.
22. Çabalar M, Voyvoda H, Sekin S. Enzootic bovine leukosis (EBL) seroprevalence in dairy cattle in eastern and south-eastern Anatolia region. In Proceedings: 4th international congress on internal medicine. Konya, Turkey 2001; 180-183.
23. Özgünlük İ, Yildirim Y, Alkan F. The seroprevalence of bovine leukemia virus (BLV) infection in cattle housed in private farms in GAP region in Turkey [Turkish]. Ankara Üniv Vet Fak Derg 2005; 52: 109-112.
24. Yildirim Y, Burgu I. The seroprevalence of bluetongue (BT), IBR, PI-3, EBL and BVD infections in cattle in northeastern Anatolia [Turkish]. Ankara Üniv Vet Fak Derg 2005; 52: 113-117.
25. Yildirim Y, Yilmaz V, Otlu S, et al. The seroprevalance of bovine leukemia virus (BLV) infection in imported-breed cattle in Kars district in Turkey [Turkish]. Kafkas Üniv Vet Fak Derg 2008; 14(1): 99-103.
26. Ayvazoğlu C, Akyüz E, Kızıltepe Ş, et al. The prevalence of enzootic bovine leukosis in cattle in Ardahan region. J Adv VetBio Sci Tech 2021; 7(1): 1-7.
27. Sökmen A, Babaoğlu AR. Seroprevalence of bovine leukemia virus ınfection in cattle in Muş Province, Türkiye. TURJAF 2023; 11(10): 1878-1881.
28. Chung YS, Rogers RJ, Dimmock CK. Enzootic bovine leucosis. In: Pathology, virology and serology. Australian standard diagnostic techniques for animal disease. East Melbourne, Australia: Australian Agricultural Council 1984; 49.
29. European Commission website. Commission Decision of 15 December 2009 amending Annex D to Council Directive 64/432/EEC as regards the diagnostic tests for enzootic bovine leucosis (2009/976/EU). OJEU 2009; 336: 36-41. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2009.336.01.0036.01.ENG&toc=OJ%3AL%3A2009%3A336%3ATOC. Accessed Feb 10, 2023.
30. Mousavi S, Haghparast A, Mohammadi G. et al. Prevalence of bovine leukemia virus (BLV) infection in the northeast of Iran. Vet Res Forum 2014; 5(2): 135-139.
31. Kazemimanesh M, Madadgar O, Mahzoonieh MR, et al. Serological study on bovine leukemia virus ınfection in ten provinces of Iran between 2010 and 2012. Iran J Virol 2012; 6(3): 1-7.
32. Morovati H, Shirvani E, Noaman V, et al. Seroprevalence of bovine leukemia virus (BLV) infection in dairy cattle in Isfahan Province, Iran. Trop Anim Health Prod 2012; 44(6): 1127-1129.
33. Khudhair YI, Hasso SA, Yaseen NY, et al. Serological and molecular detection of bovine leukemia virus in cattle

in Iraq. Emerg Microbes Infect 2016; 5(6): e56. doi:10.1038/emi.2016.60.
34. Wikipedia. Eastern Anatolia Region. Available at: https://en.wikipedia.org/wiki/Eastern_Anatolia_Region. Accessed Jan 10, 2022.
35. Bartlett PC, Sordillo LM, Byrem TM, et al. Options for the control of bovine leukemia virus in dairy cattle. J Am Vet Med Assoc 2014; 244(8): 914-922.
36. Lv G, Wang J, Lian S, et al. The global epidemiology of bovine leukemiavirus: current trends and future ımplications. Animals (Basel) 2024; 14(2): 297. doi:10.3390/ani14020297.
37. Alkan F, Oğuzoğlu TÇ, Timurkan MO, et al. Characterisation of env and gag gene fragments of bovine leukemia viruses (BLVs) from cattle in Turkey. Arch Virol 2011; 156(10): 1891-1896.
38. Ataseven VS, Kanat Ö, Ergün Y. Molecular identification of bovine papillomaviruses in dairy and beef cattle: first description of Xi-and Epsilon papillomavirus in Turkey. Turk J Vet Anim Sci 2016; 40: 757-763.
39. Alkan F, Karayel-Hacioglu I, Duran-Yelken S, et al. The genotype determination and molecular characterization of bovine leukemia virus in Turkey. Vet Arhiv 2021; 91(3): 237-247.
40. Duran-Yelken S, Alkan F. Molecular analysis of the env, LTR, and pX regions of bovine leukemia virus in dairy cattle of Türkiye. Virus Genes 2024; 60(2): 173-185.
41. Radostits OM, Gay CC, Hinchcliff KW, et al. Veterinary medicine: A text book of the diseases of cattle, sheep, pigs, goats, and horses. 10th ed. Maryland, USA: Saunders 2007; 2065.
42. Khatami A, Pormohammad A, Farzi R, et al. Bovine leukemia virus (BLV) and risk of breast cancer: a systematic review and meta-analysis of case-control studies. Infect Agent Cancer 2020; 15: 48. doi: 10.1186/s13027-020-00314-7.
43. Gao A, Kouznetsova VL, Tsigelny IF. Bovine leukemia virus relation to human breast cancer: meta-analysis. Microb Pathog 2020; 149: 104417. doi: 10.1016/ j.micpath.2020.104417.
44. Giovanna M, Carlos U, María U, et al. Bovine leukemia virus gene segment detected in human breast tissue. Open J Med Microbiol 2013; 3(1): 84-90.
45. Buehring GC, DeLaney A, Shen H, et al. Bovine leukemia virus discovered in human blood. BMC Infect Dis 2019; 19(1): 297. doi: 10.1186/s12879-019-3891-9.
46. Zhang R, Jiang J, Sun W, et al. Lack of association between bovine leukemia virus and breast cancer in Chinese patients. Breast Cancer Res 2016; 18(1): 101. doi: 10.1186/s13058-016-0763-8.