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# High point seroprevalence of *Toxoplasma gondii* and *Neospora caninum* in sheep with abortion history in the central part of Türkiye

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**ABSTRACT**

Small ruminant breeding plays a vital role in livestock farming in Türkiye but is adversely affected by many infectious pathogens, including *Toxoplasma (T.) gondii* and *Neospora (N.) caninum*. This study aimed to investigate the seroprevalence of ovine toxoplasmosis and neosporosis in sheep with varying abortion histories in the Central Anatolia Region of Türkiye. Two hundred and forty-three sheep blood samples were taken from different farms, 115 of these samples from sheep with abortion problems, and the others were from sheep herds with no abortion history. Recombinant *Tg*SAG2 and *Nc*SAG1-based indirect ELISA were used to determine specific antibodies against *T. gondii* and *N. caninum.* The study revealed a high *T. gondii* and *N. caninum* prevalence in the herd suffering from abortions. The *T. gondii* and *N. caninum* seroprevalences in sheep with an abortion history were 66.1% and 50.4%, respectively. However, it was 26.6% for *T. gondii* and 10.9% for *N. caninum* in randomly selected sheep without an abortion history. This study reports the highest *N. caninum* seroprevalence both overall (29.63%) and in sheep with an abortion history (50.4%) in Türkiye. Although neosporosis is the primary abortifacient protozoan infection in cattle, the high *N. caninum* seroprevalence detected in the sheep with an abortion history indicates that this dis- ease should also be considered in ovine abortion cases. The present study revealed that ovine toxoplasmosis and neosporosis are prevalent, and may contribute to abortions in sheep from the sampling area in the Central Anatolia Region of Türkiye.

**Key words:** ELISA; neosporosis; ovine abortion; protozoal infection; toxoplasmosis; Türkiye

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## Introduction

*Toxoplasma gondii* and *Neospora caninum* are intracellular apicomplexan parasites with a glob- al distribution that share structural, genetic, and immunological characteristics (DUBEY, 2003; DUBEY, 2009). Although these two protozoan parasites have similar life cycles and infect various animal species, toxoplasmosis primarily impacts small ruminants, while neosporosis mainly affects cattle (DUBEY, 2009; HEMPHILL and GOTTSTEIN, 2000). *T. gondii*'s definitive hosts are cats and other members of the Felidae fami- ly, whereas *N. caninum*'s definitive hosts are ca- nines such as dogs, coyotes, wolves, and dingoes (DUBEY and SCHARES, 2011). *T. gondii* has a broad intermediate host spectrum, including humans, and can infect nearly all warm-blooded animals (DUBEY et al., 2020). However, it is unclear whether *N. caninum* causes human infections or not (DUBEY et al., 2007). In a study, the DNA of *N. caninum* was not identified in human tissues, but anti-*N. caninum* specific antibodies were observed in human serum samples. This situation may suggest that *N. caninum* can cause human infections (TRANAS et al., 1999).

Toxoplasmosis is a reproductive disorder in sheep, and the infection is generally characterized by abortion, neonatal death, embryonic death and resorption, stillbirth, fetal death, and mummification, or congenitally infected apparently healthy lambs (DUBEY, 2009). Ovine toxoplasmosis, which causes economic losses, is also a significant public health problem because the infection may be transmitted to humans through the consumption of raw or undercooked infected mutton (TENTER et al., 2000; DUBEY et al., 2020). On the other hand, neosporosis primarily affects cattle and is one of the leading causes of bovine abortions. The infec- tion may cause neuromuscular disorders in the definitive hosts (DUBEY et al., 2007). Compared to toxoplasmosis, the number of epidemiological and clinical studies on ovine neosporosis is lower. However, some studies have reported that neosporosis in sheep is characterized by symptoms similar to ovine toxoplasmosis and increases economic losses by causing abortions in sheep (GONZALES-WARLETA et al., 2014).

Small ruminant breeding plays a vital role in livestock farming, and sheep constitute approximately 60% of farm animals in Türkiye. Sheep breeding, which significantly contributes to the Turkish economy, is adversely affected by many causes, especially parasitic diseases (CEYLAN et al., 2021). Ovine toxoplasmosis and neosporosis, which cause loss of offspring, are two of the most critical diseases. This study aimed to investigate the seroprevalence of ovine toxoplasmosis and neosporosis in sheep farms with/without an abortion history in the Central Anatolia Region of Türkiye.

## Materials and methods

*Sampling site and serum collection.* The material of this study consisted of 243 serum samples collected from sheep (Anatolian merinos) with abortion problems from a farm in Ankara, and one herd from each of the Konya, Karaman, and Aksaray provinces in the Central Anatolia Region of Türkiye, without an abortion history. One hundred and fifteen blood samples were collected from a farm with abortion problems in the Ankara province, while 128 sheep belonging to three herds without an abortion history in Konya (n=50), Karaman (n=50), and Aksaray (n=28) provinces were sampled. The sheep were individually bled through the jugular vein, and a 5 mL blood sample was collected into gel vials using sterile needles for each animal. All collected blood samples were held in a cooler box and then centrifuged (2000 rpm for 20 minutes) to yield serum at the laboratory of Selcuk University, Department of Veterinary Parasitology. After separation, serum samples were frozen and kept at -20°C until used in an indirect ELISA test. A detailed representation of the places where serum samples were collected in the study is given in Fig. 1.

*Anamnesis.* A long-term anamnesis of abortion in pregnant sheep on the farm in Ankara province was obtained, along with information indicating the presence of numerous carnivorous animals, especially cats, on the farm and the fact that these animals had not been treated with antiparasitic drugs. Samples from the affected herd with an abortion history were tested for a range of known abortifacient pathogens, including *Brucella melitensis*,

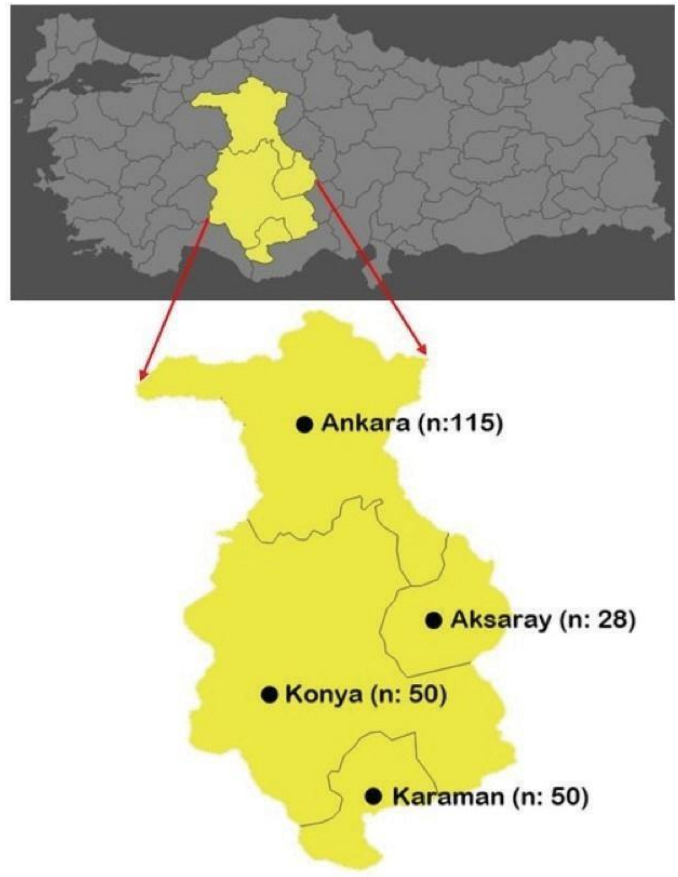


Fig. 1. Türkiye map, sampling area, and the number of samples collected from these areas

*Chlamydia abortus*, *Salmonella abortus ovis*, *Coxiella burnetii*, *Campylobacter fetus subspecies fetus*, and Border disease virus. These analyses were performed at the Department of Microbiology in the Faculty of Veterinary Medicine, as well as at a specialized private laboratory in Konya. Despite extensive testing, no definitive causative pathogen was identified, leading to suspicion of ovine toxoplasmosis and neosporosis as possible underlying factors. Additional information from the anamnesis revealed that the flock consisted of approximately 1000 ewes with an abortion rate of nearly 9%. For the study, representatives of the herd with this abortion history were enrolled for further investigation.

*Indirect enzyme-linked immunosorbent assay.* To detect the presence of specific antibodies in the serum samples, an indirect ELISA test using recombinant *T. gondii* SAG2 (*Tg*SAG2) and *N. caninum* SAG1 (*Nc*SAG1) proteins as antigens was used (ZHOU et al., 2017; LI et al., 2021; CEYLAN et al., 2024). The study also used Glutathione S-transferase (GST) as the control antigen. In the indirect ELISA test, *Tg*SAG2, *Nc*SAG1, and GST proteins were reconstituted with carbonate-bicarbonate buffer (pH 9.6, 0.05 M) at 2 µg/ml concentration. The ELISA plate wells were coated with 100 µl of antigen and incubated at 4°C overnight. After pouring the coating solution and washing with PBST, the plates were blocked for 1 hour at 37°C with 3% skimmed milk solution containing 1X PBS. The microplate wells were rewashed using PBST, and the 1:100 diluted serum samples (with 3% skim milk solution) were added and incubated for 1 hour at 37°C. The washing processes were performed with PBST six times after this step. Binding antibodies were visualized with horseradish peroxidase-conjugated anti-sheep IgG secondary antibody (Bethyl, Montgomery, AL, USA) (1:4000) and ABTS [2,2'-azinobis (3-etilbenztiazolinsülfonik asit)] substrate (Sigma, ABD, Louis, MO, ABD).

The absorbance was observed at room temperature, and 100 µl of stop solution (2 M Sulfuric acid) was added to inactivate the horseradish peroxidase enzyme. Optical density (OD) was measured with an ELISA microplate reader (Rayto Microplate Reader, Model: RT-2100C) at 415 nm.

*Evaluation of the ELISA findings.* The $OD_{415}$ value of the GST protein was subtracted from the $OD_{415}$ value of r*Tg*SAG2 and r*Nc*SAG2 for each sample to evaluate the ELISA results. The threshold for positive samples (cut-off value) was calculated by adding twice the standard deviation to the mean $OD_{415}$ value of the negative sheep sera. If the $OD_{415}$ value of the sample was higher than the cut-off value, the sample was considered positive. In this study, *Toxoplasma gondii* and *N. caninum* positive and negative sheep serum samples were obtained from our previous study (ZHOU et al., 2017). Recombinant *Tg*SA2 and r*Nc*SAG1 proteins were obtained from the Obihiro University of Agriculture and Veterinary Medicine, National Research Center for Protozoan Diseases, Obihiro, Japan.

*Statistical analysis.* The statistical program SPSS version 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) was used to analyze all data. *P* values were calculated to determine the potential statistical significance among different animal statuses. A *P*-value below 0.05 was regarded as statistically significant. The prevalence values were calculated by dividing the number of positive cases by the total number of individuals in a pop- ulation over a specified period, and expressed as a percentage.

## Results

In the study, among the serum samples collected from sheep with an abortion history, anti-*T. gondii* IgG antibodies alone (*T. gondii* mono-infection) and anti-*N. caninum* IgG antibodies alone (*N. caninum* mono-infection) were determined as 24.35% (28/115) and 8.7% (10/115), respectively. Specific IgG antibodies that formed against both protozoa (co-infection) were detected at 41.74% (48/115). The overall *T. gondii* and *N. caninum* seroprevalences in sheep with an abortion history were 66.1% and 50.4%, respectively. Anti-*T. gondii* IgG antibodies alone, anti-*N. caninum* IgG antibodies alone and co-infection with both species were respectively found in 25% (32/128), 9.38% (12/128), and 1.56% (2/128) in randomly selected sheep without an abortion history. The overall *T.*

Table 1. The seroprevalence of *T. gondii*, *N. caninum*, co-infection rates, and the number of sheep by provinces

| Animal status | Locality (districts) | n | *T. gondii* infection | *N. caninum* infection | Co-infection | *T. gondii* overall infection | *N. caninum* overall infection |
|---|---|---|---|---|---|---|---|
| Sheep from the herd with abortion history | Ankara | 115 | 28 (24.35%) | 10 (8.7%) | 48 (41.74%) | 76 (66.09%) | 58 (50.43%) |
| Sheep from the herd without abortion history | Konya (Sızma, Güvenç, Emirgazi) | 50 | 24 (48%) | 5 (10%) | - (0.0%) | 24 (48%) | 5 (10%) |
| | Karaman | 50 | 5 (10%) | 5 (10%) | 1 (2%) | 6 (12%) | 6 (12%) |
| | Aksaray (Sultanhanı) | 28 | 3 (10.71%) | 2 (7.14%) | 1 (3.57%) | 4 (14.29%) | 3 (10.71%) |
| Total | | 243 | 60 | 22 | 50 | 110 | 72 |

| | | | | | |
|---|---|---|---|---|---|
| | (24.69%) | (9.05%) | (20.58%) | (45.27%) | (29.63%) |

Table 2. The results of statistical analysis

| | | Condition | | Total | P |
|---|---|---|---|---|---|
| | | Sheep with abortions | Sheep without abortions | | |
| *Tg* | Negative | 39 | 94 | 133 | 0,001 |
| | Positive | 76 | 34 | 110 | |
| Total | | 115 | 128 | 243 | |
| *Nc* | Negative | 57 | 114 | 171 | 0,001 |
| | Positive | 58 | 14 | 72 | |
| Total | | 115 | 128 | 243 | |

***Tg*: *Toxoplasma gondii*, *Nc*: *Neospora caninum***

*gondii* and *N. caninum* seroprevalences in randomly selected sheep without an abortion history were 26.56% (34/128) and 10.94% (14/128), respectively. Table 1 provides further details. The *T. gondii* and *N. caninum*-specific antibody prevalences in animals with a history of abortion were statistically higher than those in sheep without an abortion history (P<0.001). More detailed results are shown in Table 2.

## Discussion

Türkiye is a suitable country for small ruminant breeding due to its geographical structure, vegetation, and socio-economic and cultural characteristics (CEYLAN et al., 2021). The Central Anato- lia Region is home to a significant proportion of Türkiye's small ruminant population, and makes a significant contribution to the country's meat and milk production (GUNLU and MAT, 2021). One of the indispensable elements of animal husbandry is to obtain healthy offspring regularly every year and to ensure the continuation of the herd (UTUK and ESKI, 2022). Abortion is a common clinical problem that significantly affects productivity in sheep herds. Causes of abortion include a variety of factors, such as stress, nutritional disorders, poisoning, hormonal imbalances, genetic factors, and infectious agents, among others (NOAKES et al., 2021). In healthy sheep herds, the rate of ewe abortion is generally less than 2%. When the abortion rate is between 2% and 5%, it may indicate the endemic presence of a disease. An abortion rate above 5% or a cluster of abortion cases within a short period of time or at a specific location suggests the presence of a pathogenic invasion and warrants an aggressive diagnostic investigation (MENZIES, 2011). In this study, after eliminating several primary bacterial and viral abortifacient agents (*Brucella melitensis*, *Chlamydia abortus*, *Salmonella abortus ovis*, *Coxiella burnetii*, *Campylobacter fetus subspecies fetus*, and Border disease virus), *T. gondii* and *N. caninum*, which are the most notable abortifacient protozoan agents of livestock animals, were investigated in a sheep herd with almost 9% abortion cases and herds comprising apparently healthy sheep. The present study on r*Tg*SAG2 and r*Nc*SAG1-based indirect ELISA revealed a high *T. gondii* and *N. caninum* seropositivity.

*Toxoplasma gondii* and *N. caninum* are well-recognized infectious pathogens leading to abortions and neonatal mortalities in small ruminants worldwide (BUXTON et al., 2007; DUBEY, 2009). Seroepidemiological studies have revealed the prevalence of ovine toxoplasmosis ranging between 2.8 and 98.9% in Türkiye (KARATEPE et al., 2001; MOR and ARSLAN, 2007; CICEK et al., 2011; ZHOU et al., 2017; CAKMAK and KARATEPE, 2017; ESKI et al., 2018; ASLAN CELIK et al., 2020; CEYLAN et al., 2024). In a survey conducted by CICEK et al. (2011), *T. gondii* seroprevalence was found to be the highest in Türkiye (98.9%) by the Sabin Feldman dye test. *T. gondii* overall seroprevalences were found as 66.1% in sheep with abortions and 26.6% in sheep without

an abortion history in this study. It was observed that *T. gondii* seroprevalence values in sheep from Konya, Karaman, Aksaray, and Ankara provinces were within the lower and upper limits obtained in studies conducted in Türkiye (MOR and ARSLAN, 2007; CICEK et al., 2011; CAKMAK and KARATEPE, 2017; ESKI et al., 2018) but higher than some studies which use the same diagnostic techniques (CAKMAK and KARATEPE, 2017; ESKI et al., 2018; ASLAN CELIK et al., 2020). The seroprevalence of toxoplasmosis in aborted sheep in Türkiye was determined as 35.18% in Kayseri (INCI et al., 1999), 46.84% in Elazig (AKTAS et al., 2000), and 53.34% in Hatay (KAMBURGIL et al., 2001). In a study conducted in Kars, serum samples were taken from a total of 78 sheep, which were determined to have abort- ed during the research, and 97.4% of them were determined as seropositive by ELISA (MOR and ARSLAN, 2007). *T. gondii* seroprevalence was detected at 66.09% (76/115) in sheep who suffered abortions in the present study. Some researchers reported that the diagnostic techniques, the presence of cats in the environment, climate, age, and gender may have influenced the observed seroprevalence of ovine toxoplasmosis (SAWADOGO et al., 2005; CLEMENTINO et al., 2007). Moreover, VESCO et al. (2007) reported that *Toxoplasma*-specific IgG antibodies transmitted in colostrum and milk could affect the seroprevalence in sheep under one year old. In light of these factors, the high seroprevalence detected in the aborted sheep may be attributed to the infected cat population around the farm, which likely plays a role in the shedding of *T. gondii* oocysts and the lack of anti-*T. gondii* treatment (DUBEY and PROWELL, 2013) in these cats. High ovine toxoplasmosis seroprevalence and abortion cases are expected in the herd, constant- ly in contact with the contaminated environment. Studies regarding neosporosis are also mostly on cattle, and a limited number of studies have revealed that the seroprevalence of ovine neosporosis is between 0 and 12.4% in Türkiye (GOKCE et al., 2015; ZHOU et al., 2017; CAKMAK and KARATEPE, 2017; ESKI et al., 2018; KARATEPE and KARATEPE, 2020). While *N. caninum* infection has been linked to abortion in sheep in recent years (HECKER et al., 2019), a high seroprevalence and incidence have also been reported in herds and individual ewes without a history of abortion or infertility (ROSSI et al., 2011; FILHO et al., 2017; TIROSH-LEVY et al., 2022).

The overall seroprevalence of *N. caninum* was detected in 29.63% of sheep sampled in the study, but it reached 50.4% in sheep suffering abortions. This study reports the highest ovine *N. caninum* seroprevalence in Türkiye; however, this value is consistent with some seroprevalence values reported from other countries (PANADERO et al., 2010; GUIMARÃES et al., 2015; TAFNER FERREIRA et al., 2016; DUBEY et al., 2017). Studies on the seroprevalence of *N. caninum* in aborted sheep are limited worldwide (HELMICK et al., 2002; EZATPOUR et al., 2015; MEIXNER et al., 2020). The sampling region, the type of serological diagnos- tic technique, animal breed, the existence of dogs around the sampling area, and the number of animals studied can lead to differences in neosporo- sis seroprevalence (FIGLIUOLO et al., 2004). The prevalence of *N. caninum* in the herd with an abortion history is believed to result from the constant contamination of the environment by carnivores (especially shepherd dogs) and the exposure of the sheep to sporulated oocysts for a long time due to their age. Furthermore, the horizontal transmission of the infection from individual to individual may have contributed to this high seroprevalence. The view that the risk of infection increases with age, and vertical transmission of the disease with the advancement of age in animals also supports this situation (NAYERI et al., 2022).

The sheep owners in Ankara reported the presence of cats and dogs around the farm. This fac- tor, along with issues such as inadequate hygienic practices in the facility management and improper disposal of carcasses and fetal-placental waste, may contribute to increased transmission of *T. gondii* and *N. caninum*. Some studies have shown that contact with cats and dogs increases the risk of toxoplasmosis and neosporosis in sheep (ANDRADE et al., 2012; MENDONCA et al., 2013; GOKCE et al., 2015). In this case, taking precautions to prevent the access of carnivores to carcasses and fetal/placental waste after lambing/abortion, and to avoid

contamination of the sheep's water and food by cat feces, can reduce the risk of *T. gondii* transmission to animals and decrease reproductive dysfunction in the herd (FILHO et al., 2017; HECKER et al., 2019; TIROSH-LEVY et al., 2022). In warmer climates, environmental factors, including temperature and humidity, can affect the survival and distribution of *T. gondii* and *N. caninum* oocysts in soil and water, potentially increasing exposure risk for animals (YAN et al., 2016). Such conditions may contribute to higher seroprevalence rates of these pathogens in regions with warmer climates, such as the Central Anatolian region of Türkiye. In a previous study conducted by ZHOU et al. (2017) in Konya and Karaman provinces, *T. gondii* seroprevalence was 24% and 9.2%, and *N. caninum* was 2.7% and 0.8%, and the mixed infection rate was 0.7% and 0% respectively. In the present study, the seroprevalence rates of both apicomplexan protozoa and mixed infection were higher than in the previously mentioned Konya and Karaman provinces, and *T. gondii* and *N. caninum* seroprevalences in animals with a history of abortion were statistically different from sheep without an abortion history ($P<0.001$). Our results indicate a notably higher seroprevalence of *T. gondii* and *N. caninum* in sheep from Ankara, particularly in animals with a history of abortion, compared to previous studies in nearby Konya and Karaman provinces (ZHOU et al., 2017). The association between *T. gondii* and *N. caninum* seropositivity and abortion history suggests that these pathogens may be critical contributors to abortion cases in sheep in the sampling area. This association is supported by the presence of carnivores on the farms, as well as the environmental and management factors mentioned, which may facilitate the spread of oocysts and increase the risk of infection.

In studies investigating *T. gondii* and *N. caninum* seroprevalence in sheep worldwide, the seroprevalences of co-infections were found to be 0.5-9.03% (PANADERO et al., 2010; GUIMARÃES et al., 2015; TAFNER FERREIRA et al., 2016). The overall co-infection seroprevalence was 20.58%, whereas it reached 41.7% in sheep with an abortion history in the present study. Coinfection with *T. gondii* and *N. caninum* has been shown to exacerbate adverse clinical outcomes, notably increasing the risk of abortion and embryonic death compared to single-pathogen infections (CIUCA et al., 2020). In this study, it is thought that the high abortion rate may be attributed to the high co-infection prevalence, as also reported by CIUCA et al. (2020). It is also recommended to consider the impact of co-infection on both transmission and recovery, so these factors can be integrated into future treatment strategies and disease control programs.

In conclusion, two crucial parasitic abortifacient agents, *T. gondii* and *N. caninum*, were investigated in sheep from Ankara, Konya, Karaman, and Aksaray provinces in the Central Anatolian Region. As a result of the study, it was observed that *T. gondii* infection is common in sheep in Konya, Karaman, Aksaray, and Ankara provinces. However, the widespread presence of *N. caninum* in sheep herds indicated that its economic impact should not be underestimated in the sheep industry of the region. It should not be overlooked that sheep infected with *T. gondii* and *N. caninum* may serve as reservoirs for sheep and cattle infections in the investigated provinces, and abortions may occur in herds with *T. gondii* and *N. caninum* seropositive sheep. As control measures, immediate action is necessary to reduce the impact of *T. gondii* and *N. caninum* infections in sheep with an abortion history. Implementing sanitary strategies in animal husbandry, including rigorous cleaning, improved waste management, and restricted access of cats and dogs to livestock areas, can mitigate the spread of these pathogens. Control programs should also secondarily consider antiprotozoal treatments for cats and dogs to reduce oocyst shedding and the overall risk of environmental contamination. In addition, educating farm personnel on the transmission risks and best practices for hygiene around animals can enhance these measures, helping to protect livestock health and productivity.

### Ethical approval

All experimental procedures followed the ethical guidelines of the Veterinary Faculty of Selcuk University, Experimental Animals Production and Research Center Ethics Committee (SU-VDAMEK-2023/019).

**Declaration of competing interest**

The authors declare that they have no known competing professional, financial or non-financial, or personal conflict that could have appeared to influence the work reported in this paper.

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**CEYLAN, C., O. CEYLAN, S. CAO, H. H. HADİMLİ, X. XUAN, F. SEVİNC: Visoka prevalencija parazita *Toxoplasma gondii* i *Neospora caninum* u ovaca s anamnezom pobačaja uzgajanih u središnjem dijelu Turske. Vet. arhiv 95, 411-421, 2025.**

**SAŽETAK**

Uzgoj malih preživača ima ključnu ulogu u stočarstvu u Turskoj, no pod utjecajem je različitih infektivnih patogena, uključujući parazite *Toxoplasma* (*T.*) *gondii* i *Neospora* (*N.*) *caninum*. Cilj rada bio je istražiti seroprevalenciju toksoplazmoze i neosporoze u ovaca s različitom pojavnošću pobačaja. Ovce su uzgajane u Središnjoj Anatoliji u Turskoj. Uzeta su ukupno 243 uzorka krvi ovaca s različitih farmi, među kojima je 115 uzoraka potjecalo od ovaca s problemom pobačaja, dok su ostali uzorci uzeti od ovaca bez povijesti pobačaja. Za određivanje specifičnih protutijela na *T. gondii* i *N. caninum* upotrijebljen je indirektni ELISA test temeljen na *Tg*SAG2 i *Nc*SAG1. Istraživanje je pokazalo visoku prevalenciju parazita *T. gondii* i *N. caninum* u skupini ovaca s problemom pobačaja. Seroprevalencija navedenih parazita u tih ovaca bila je 66,1% za *T. gondii* i 50,4% za *N. caninum*. Seroprevalencija u nasumično odabranih ovaca, bez pobačaja u anamnezi, iznosila je 26,6% za *T. gondii* i 10,9% za *N. caninum*. Rezultati su pokazali najvišu seroprevalenciju parazita *N. caninum* u Turskoj i to kad se u obzir uzme ukupni broj pretraženih ovaca (29,63%) i kad se u obzir uzmu samo ovce s poviješću pobačaja (50,4%). Uzimajući u obzir da je neosporoza primarni protozoalni uzročnik pobačaja u goveda, visoka seroprevalncija parazita *N. caninum* u ovaca ukazuje da bi kod dijagnostike njihova pobačaja u obzir trebalo uzeti i tog uzročnika. Istraživanje je pokazalo da su toksoplazmoza i neosporoza rasprostranjene i mogu pridonijeti pojavi pobačaja ovaca uzgajanih u Središnjoj Anatoliji u Turskoj.

**Ključne riječi:** ELISA; neosporoza; pobačaj u ovaca; protozoalna infekcija; toksoplasmoza; Turska