Estimating the total cost of fasciolosis in sheep and goats in Türkiye with a stochastic simulation model

Mehmet Küçükoflaz[1]*, Savaş Sarıözkan[2], Umut Kamil Danacı[3]

[1]Department of Animal Health Economics and Management, Faculty of Veterinary Medicine, Kafkas University, Kars/Türkiye

[2]Department of Animal Health Economics and Management, Faculty of Veterinary Medicine, Erciyes University, Kayseri/ Türkiye

[3]Department of Animal Science,Health Sciences Institute, Erciyes University, Kayseri/Türkiye

*Corresponding: mehmetoflaz38@gmail.com

Recevied: 05.03.2025 Accepted: 04.06.2025 Published: 31.08.2025

Abstract

This study aimed to estimate the total cost of small ruminant fasciolosis in Türkiye. For this purpose, official and previously published prevalence values were considered, and financial losses were calculated with current prices in 2024 year. A stochastic simulation model (Monte Carlo) was used to estimate the total cost due to fasciolosis. The weighted mean prevalence values were calculated for sheep as 3.47% (95% CI, 3.43-3.51%) and goats as 1.25% (95% CI, 1.20-1.30%). In total cost calculations, mortality losses, production losses and control expenditures were considered. As a result, annual total cost of fasciolosis for sheep was estimated to be $95.2 million (95% CI, $86.7-$104.2) and for goats $5.7 million (95% CI, $3.6-$7.9). The annual total cost of the disease in small ruminants was estimated to be $100.9 million (95% CI, $91.8-$110.2) and this amount is equally to 0.8% of total livestock production value in Türkiye. In conclusion, to reduce the impact of the disease for livestock sector and Turkish economy, producers should be informed about the quantity of losses and prevention/treatment procedures and, fasciolosis should be prioritized in national disease control/eradication strategies.

Keywords: *Fasciolosis, goat, losses, monte carlo simulation, sheep, Türkiye*

INTRODUCTION

Fasciolosis (liver fluke) is located in the bile ducts and liver of domestic ruminants and wild and is caused by *F. gigantica* and/or *F. hepatica* helminths (Tınar & Korkmaz, 2003). The disease is a tropical neglected zoonotic infection reported in more than 50 countries worldwide, including Türkiye (Kaplan & Başpınar, 2009; Mehmood et al., 2017). Fasciolosis has acute and chronic forms, causing considerable economic losses due to mortality, productivity (loss of meat, milk, fleece/mohair, liver), and control expenditures (Odeniran et al., 2017; Köroğlu & Şimşek, 2003; Mehmood et al., 2017).

Based on Otte and Chilonda (2000), the total cost (C) of the disease may be defined as the sum of mortality (M), control expenditures (E), and production losses (L) in mathematical notation: C = M+ E + L. While M is the mortality of infected animals, E consists of the flukicide cost of the farmer, and L may be summarized as losses of meat (L_{meat}), milk (L_{milk}), fleece/mohair ($L_{fleece/mohair}$), and liver (L_{liver}).

Globally, economic losses in livestock productivity related to fasciolosis have been estimated at approximately $3 billion per annum (Spithill et al., 1999). In Türkiye, there are studies about the total cost of bovine fasciolosis (Sarıözkan & Yalçın, 2011) and only production losses (L) due to fasciolosis in small ruminants (Sarıözkan, 2019). However, to the best of the authors' knowledge, there is no study on estimating small ruminant fasciolosis's total cost (C) in Türkiye. Knowing the total cost of the disease is important for both producers and decision-makers in terms of control/eradication of the disease. This study aimed to estimate the total cost of fasciolosis in sheep and goats in Türkiye at current prices of 2024 year.

MATERIALS and METHODS

In this study, it was aimed to determine the total cost due to fasciolosis in sheep and goats in Türkiye by using a stochastic Monte Carlo simulation model. On the other hand, the number of slaughtered/milked/sheared animals, meat/milk production, and yields were obtained from official data (DKKYB, 2024; MAF, 2024; UKON, 2024) and calculated with the current prices of 2024. In the study, some technical and economic parameters used in the analysis were given in Table 1-2.

In the study, due to variation of prevalence values of the disease in the literature, weighted mean prevalence of seven regions are calculated 3.47% in sheep (95% CI, 3.43%-3.51%) and 1.25% in goats (95% CI, 1.20%-1.30%) in Türkiye (Çelik & Çelik, 2018; Tınar & Korkmaz, 2003; Sarıözkan, 2019). Confidence interval (CI) was calculated as below;

Standard error for ratio = $\sqrt{(p(1-p)\ /n}$

CI for ratio =

$$p - t_{(n,\alpha/2)}\sqrt{(p(1-p)\ /n} \le P \le p + t_{(n,\alpha/2)}\sqrt{(p(1-p)\ /n}$$

CI for sheep

(p=0,0347; 1-p=0,9653; n=651.964,30; $t_{(n\alpha/2)}$=1,96) = 3.47% (95% CI, 3.43-3.51%)

CI for goats

(p= 0,0125; 1-p= 0,9875; n=181.989,95;) $t_{(n\alpha/2)}$=1,96) = 1.25% (95% CI, 1.20-1.30%)

Based on previous studies (Fiss et al., 2013; Sarıözkan, 2019; Schweizer et al., 2005), mortality, potential meat, milk, fleece/mohair, and liver losses and control expen-

How to cite this article: Küçükoflaz M., Sarıözkan S., Danacı U.K., (2025). Estimating the total cost of fasciolosis in sheep and goats in Türkiye with a stochastic simulation model. *Journal of Advances in VetBio Science and Techniques*, 10(2), 100-107. https://doi.org/10.31797/vetbio.1651857

Table 1. *Cost of fasciolosis in sheep in Türkiye*

Parameters	Value (Mean)	References
Technical parameters		
No. of sheep (head)	42,060,470	MAF, 2024
No. of infected sheep (head)	1,459,498	&
Mortality rate in infected sheep (%)	10.8	Fiss et al., 2013
No. of slaughtered sheep (head)	25,437,813	MAF, 2024
Mean carcass weight (kg/head)	21.6	&
Reduction in carcass weight of infected anim. (%)	2.5	Njeruh et al., 2004
Reduction in carcass weight (gr/infected anim.)	540	&
Weighted prevalence (%)	3.47	&
Total carcass weight loss (kg)	476,654	&
No. of milked sheep (head)	19,836,985	MAF, 2024
Milk production (kg/head)	77	MAF, 2024
Reduction in milk yield of infected anim. (%)	2.5	Njeruh et al., 2004
Reduction in milk production of infected anim. (kg)	1.9	&
No. of sheared sheep (head)	19,836,985	MAF, 2024
No. of sheared infected sheep (head)	688,343	&
Fleece yield (kg/head)	1.8	Sarıözkan, 2019
Losses of fleece (%)	20	Roseby, 1970
Weight of liver (gr)	400	DKKYB, 2024
Losses of liver (kg)*	353,076	Altınel et al., 1998
Financial parameters**		
Price of adult sheep ($/head)	464	DKKYB, 2024
Price of meat ($/kg)	12	UKON, 2024
Price of milk ($/kg)	1	DKKYB, 2024
Prices of fleece ($/kg)	0.3	DKKYB, 2024
Prices of condemned liver ($/kg)	15	DKKYB, 2024
Cost of treatment ($/head)	1	DKKYB, 2024

*: Liver was assumed to be 2% of the carcass weight. **:36.66 TL=1 US$ in March 2025. &: Calculated from official data by authors (See material and methods)

Total cost of fasciolosis

Table 2. *Cost of fasciolosis in goats in Türkiye*

Parameters	Value (Mean)	References
Technical parameters		
No. of goat (head)	10,302,940	MAF, 2024
No. of infected goat (head)	128,786	&
Mortality rate in infected goat (%)	10.8	Fiss et al., 2013
No. of slaughtered goats (head)	6,753,478	MAF, 2024
Mean carcass weight (kg/head)	19.8	&
Reduction in carcass weight of infected anim. (%)	2.5	Njeruh et al., 2004
Reduction in carcass weight (gr/ infected anim.)	495	&
Weighted prevalence (%)	1.25	&
Total carcass weight loss (kg)	41,787	&
No. of milked goats (head)	5,471,086	MAF, 2024
Milk production (kg/head/lactation)	105	&
Reduction in milk yield of infected animals (%)	2.5	Njeruh et al., 2004
Reduction in milk production infected animals, kg	2.6	&
No. of sheared goats	5,471,086	MAF, 2024
No. of sheared infected goats	68,388	MAF, 2024
Mohair yield, kg/head	0.5	Sarıözkan, 2019
Losses of mohair, %	20	Roseby, 1970
Weight of liver (gr)	400	DKKYB., 2024
Losses of liver (kg)*	33,767	Altınel et al., 1998
Financial parameters**		
Price of adult goat ($/head)	218	DKKYB, 2024
Price of meat ($/kg)	8	UKON, 2024
Price of milk ($/kg)	0.7	DKKYB, 2024
Prices of mohair, $/kg	0.2	DKKYB, 2024
Prices of condemned liver ($/kg)	15	DKKYB, 2024
Cost of treatment ($/head)	1	DKKYB, 2024

*: Liver was assumed to be 2% of the carcass weight. **36.66 TL=1 US$ in March 2025. &: Calculated from official data by authors (See material and methods)

ditures that may occur in small ruminants due to disease were considered in the calculation. In some studies (Ngategize et al., 1993; Odeniran et al., 2021), mortality losses were given higher however, we preferred the optimistic one (Fiss et al., 2013).

The Monte Carlo simulation was run in Python version 3.13 with 10,000 iterations.

RESULTS

The total cost of the disease in sheep and goats is given in Figure 1, 2, and 3.

The cost of fasciolosis in sheep in Türkiye was calculated to be $95,260,663 (95% CI, $86.7-$104.2) in 2024 (Figure 1).

In Türkiye, the cost of fasciolosis in goats was calculated as $5,712,143 (95% CI, $3.6-$7.9) in 2024 (Figure 2).

In this situation, the total cost of small ruminant fasciolosis for the Turkish economy in 2024 was calculated to be $100,972,806 (95% CI, $91.8-$110.2) (Figure 3).

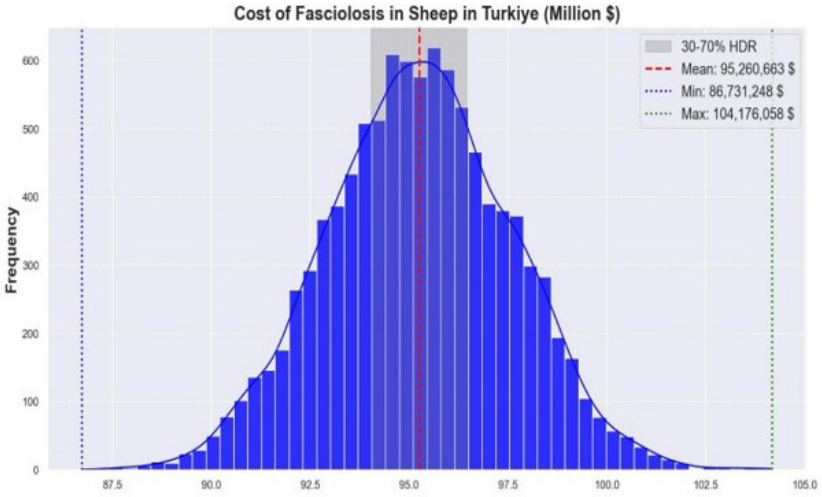

Figure 1. *Cost of fasciolosis in sheep in Türkiye*

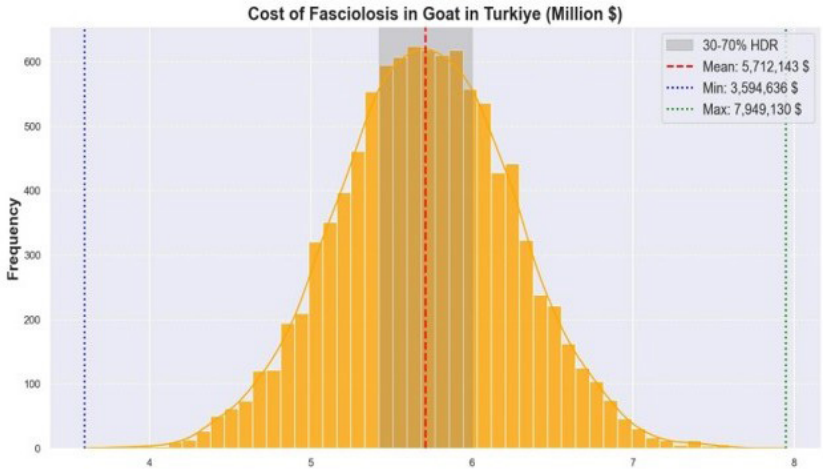

Figure 2. *Cost of fasciolosis in goat in Türkiye*

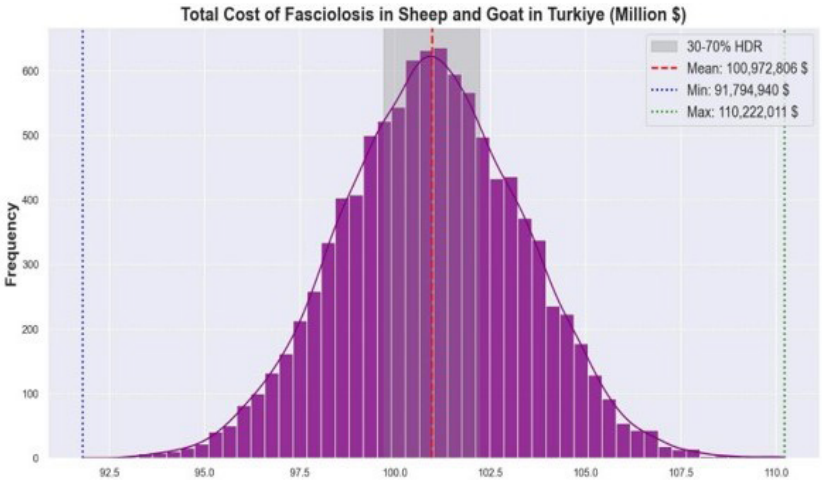

Figure 3. *Total cost of fasciolosis in sheep and goat in Türkiye*

DISCUSSION

Fasciolosis is a neglected tropical zoonotic disease with an estimated 17 million people infected and 180 million at risk of infection. The huge impact on livestock and human health together with the increasing demand for animal-derived food products to support global population growth demonstrate that fasciolosis is a major One Health problem (MAF, 2024). Neglected tropical diseases effect over 1 billion people and causes 600 million disability adjusted life years (DALYs).

Including Türkiye (Adanır & Çetin, 2016; Çelik & Çelik, 2018; Gül & Aydın, 2008; Pekağırbaş et al., 2020), many studies on small ruminant fasciolosis have been carried out in different countries around the world. Prevalence values varies from 2.5% to 39.1% in Africa (Isah, 2019; Khalafala, 2020; Ouchene-Khelifi et al., 2018; Regea & Getachew, 2021); 0.2-41.9% in Asia (Ga et al., 2020; Oryan et al., 2011; Zafar et al., 2018); 8.87-43.0% in America (Munguía-Xóchihua et al., 2007; Opitz Vieira Da Cunha et al., 2007) and 3.0-67.0% in Europe (Bosco et al., 2015; Rinaldi et al., 2015).

The high prevalence is most likely related to poor management practices and lack of knowledge among the farmers about its control (Mehmood et al., 2017) The prevalence of the disease in Türkiye ranges between 0.6-68.6% in sheep and 0.8-62.6% in goats, according to different regions. The significant variation in prevalence values among countries and regions may be related to the geographical location of the study, climatic (rainfall and humidity) and environmental conditions, snail population (*Lymnaea truncatula*), management and control strategies, age / number /sex and breed of animals, and contamination levels of pastures.

On the other hand, the economic effects of the disease were either not calculated or were limited to the condemnation of infected livers in most of the previous studies (Table 3). These missing calculations lead farmers and decision/policymakers to delay the measures to be taken for the disease. To realize the total cost of the disease mortality and control expenditures should also be included in the calculations (Njeruh et al., 2004; Odeniran et al., 2021; Pekağırbaş et al., 2020; Usip et al., 2014).

There is no regular database of animal diseases at the national level in Türkiye. That is why the financial impact calculated in this study will provide certain information and decision support to all livestock sector stakeholders. In addition, the stochastic probabilistic model used in this study to determine economic losses due to fasciolosis takes into account risks and uncertainties that were ignored by previous deterministic models (Sarıözkan, 2019).

Table 3. *Financial losses ($) due to fasciolosis in small ruminants in different countries*

Continent/ Country	Species	M	L	E	C	Comments	References
Africa/Egypt	S	-	3,286	-	-	$L_{liver} + L_{meat}$	Elmonir et al., 2015
Africa/Ethiopia	S+G	-	1,238	-	-	L_{liver} in small rum.	Kedir et al., 2012
Africa/Ethiopia	S+G	-	284,753	-	-	$L_{liver} + L_{meat}$	Lakew & Alebie, 2015
Africa/Kenya	S+G	-	3,652	-	-	L_{liver} due to *F.gigantica*	Mungube et al., 2006
Africa/Nigeria	S+G	-	3,402	-	-	$L_{liver+lung+spleen}$	Ola-Fadunsin et al., 2020
Africa/Nigeria	S+G	55,671,620	18,360,154	196,820	74,228,594	Total cost (C)	Odeniran et al., 2021
Africa/Nigeria	S+G	-	752	-	-	L_{liver} in small rum.	Liba et al., 2017
Asia/Bangladesh	G	-	115	-	-	L_{liver}	Hossain et al., 2011
Asia/Bangladesh	G	-	2,374	-	-	L_{liver}	Islam & Ripa, 2015
Asia/Iran	S+G	-	53,600	-	-	L_{liver} in small rum.	Khoramian et al., 2014
Asia/Iran	S+G	-	13,842,759	-	-	L_{liver}	Kiani et al., 2021
Asia/Iran	S+G	-	13,258	-	-	L_{liver} in small rum.	Arbabi et al., 2018
Asia/Pakistan	S+G	-	213,000	-	-	$L_{liver} + L_{meat}$	Ahmad et al., 2017
Türkiye	S	-	3,281	-	-	L_{liver}	Yibar et al., 2015
Türkiye	S+G	-	1,845	-	-	L_{liver}	Kaplan & Başpınar, 2009

S=Sheep; G= Goat; M=Mortality losses; L= Production losses; E= Control expenditures; C=Total cost

In Türkiye, 94.3% of the total losses ($100,972,806) originated from sheep, and the remaining 5.7% were from goats. Despite the use of anthelmintics to control fasciolosis, these vast losses could be explained by drug resistance, wrong timing, the dose of treatment, and the use of non-specific anthelminthic agents to treat the disease, since farmers often perform deworming only when adult parasites are observed.

When the cost of fasciolosis in small ruminants ($100.9 million) is considered together with the cost of bovine fasciolosis ($ 42.8 million), the total cost of the fasciolosis in ruminants reaches $143.7 million per annum in Türkiye (Sarıözkan & Yalçın, 2011). Fasciolosis is estimated to put more than 700 million animals at risk worldwide, causing a loss of $302 billion to the global economy (Ayvazoğlu et al., 2023; Mehmodd et al., 2017). This equates to 4.8% of the estimated global cost (Spithill et al., 1999). Financial losses from bovine fasciolosis in Sudan and Switzerland were reported at $1.94 million and €52 million respectively (Rahmeto et al., 2010; Schweizer et al., 2005). In Nigeria, and Switzerland, the total cost of fasciolosis in sheep and goats ($77.9 million) is lower than in Türkiye (Odeniran et al., 2021). The economic loss caused by fasciolosis in domestic ruminants in Australia ($60-90 million) is lower than Türkiye (Mehmood et al., 2017).

Differences between the quantities of losses amongst the countries could be related to different livestock populations, prevalence, loss items included in analyses, estimating methodologies, differences in productivity of animals, and prices (meat, drug, milk, liver, and fleece/mohair). In the literature, there are some difficulties in comparing different regions and/or countries in terms of the quantity of losses and loss items included in calculations. Hence, the loss items for calculations and methodologies need to be standardized.

The losses due to livestock diseases in Türkiye and developing countries are obstacles to increasing animal protein consumption, which is already low. Also, the cost of livestock products, which are already produced at high costs due to low productivity, are increasing due to diseases, and producers are gradually moving away from profitability.

CONCLUSION

In conclusion, to reduce the impact of total costs for Turkish economy, producers should be informed about the quantity of losses and prevention/treatment procedures (regular use of flukicide and examination of faeces periodically, etc.), amelioration of pastures should be provided and, fasciolosis should be prioritized in national disease control/eradication strategies.

Financial support

None

Conflict of interest

The authors declared that there is no conflict of interest.

Ethical statement

Ethical committee approval is not required.

Author contributions

MK, SS; Idea, concept and design. MK, SS, UKD; Data collection and analysis. MK, SS; Drafting of the manuscript. MK, SS; Critical review.

Availability of data and materials

The data used to prepare this manuscript are available from the corresponding author when requested.

REFERENCES

Adanır, R., & Çetin, H. (2016). Antalya belediye mezbahasında (an-et) kesilen koyunlarda karaciğer trematodlarının yaygınlığı. *Veterinary Journal of Mehmet Akif Ersoy University*, *1*(1), 15-20. https://doi.org/10.24880/maeuvfd.260786

Ahmad, M., Khan, M. N., Sajid, M. S., Muhammad, G., Qudoos, A., & Rizwan, H. M. (2017). Prevalence, economic analysis and chemotherapeutic control of small ruminant fasciolosis in the Sargodha district of Punjab, Pakistan. *Veterinaria Italiana*, *53*, 47-53. https://doi.org/10.12834/VetIt.114.316.6

Altınel, A., Evrim, M., Özcan, M., Başpınar, H., & Deligözoğlu, F. (1998). Sakız, Kıvırcık ve Alman Siyah Başlı koyun ırkları arasındaki melezlemeler ile kaliteli kesim kuzuları elde etme olanaklarının araştırılması. *Turkish Journal of Veterinary & Animal Sciences*, *22*(3), 257-265.

Arbabi, M., Nezami, E., Hooshyar, H., & Delavari, M. (2018). Epidemiology and economic loss of fasciolosis and dicrocoeliosis in Arak, Iran. *Veterinary World, 11*(12), 1648.

Ayvazoğlu, C., Kızıltepe, Ş., Demir, P. A., & Eser, G. (2023). Prevalence and economic importance of fasciolosis in slaughtered sheep in Iğdır province of Turkey. *Euroasia Journal of Mathematics, Engineering, Natural & Medical Sciences, 10*(26), 87-95. https://orcid.org/0000-0002-7010-0475

Bosco, A., Rinaldi, L., Musella, V., Amadesi, A., & Cringoli, G. (2015). Outbreak of acute fasciolosis in sheep farms in a Mediterranean area arising as a possible consequence of climate change. *Geospatial Health,* 9(2), 319-324. https://doi.org/10.4081/gh.2015.354

Çelik, Ö. Y., & Çelik, B. A. (2018). Investigation of the prevalence of fasciola hepatica in small ruminants in the Siirt region, Turkey. *Iranian Journal of Parasitology, 13*(4), 627.

Elmonir, W., Mousa, W., & Sultan, K. (2015). The prevalence of some parasitic zoonoses in different slaughtered animal species at Abattoir in the Mid-Delta of Egypt; with special reference to its economic implications. *Alexandria Journal of Veterinary Sciences*, *47*(1). https://doi.org/10.5455/ajvs.204290

Fiss, L., de Lourdes Adrien, M., Marcolongo-Pereira, C., Assis-Brasil, N. D., Sallis, E. S., Riet-Correa, F., Jerônimo L. R., & Schild, A. L. (2013). Subacute and acute fasciolosis in sheep in southern Brazil. *Parasitology Research*, *112*, 883-887. https://doi.org/10.1007/s00436-012-3096-2

Gao, X., Zhang, L., Tong, X., Zhang, H., Mehmood, K., Jiang, X., & Li, J. (2020). Epidemiological survey of fasciolosis in yaks and sheep living on the Qinghai-Tibet plateau, China. *Acta Tropica, 201*, 105212. https://doi.or-

g/10.1016/j.actatropica.2019.105212

Gül A., & Aydın, A. (2008). Hakkari (Yüksekova) yöresinde kesilen kıl keçilerinde karaciğer kelebeklerinin yayılışı. *T*ürkiye Parazitoloji Dergisi, 32(4)*,* 334-336.

Hossain, M. M., Paul, S., Rahman, M. M., Hossain, F. M. A., Hossain, M. T., & Islam, M. R. (2011). Prevalence and economic significance of caprine fascioliasis at Sylhet District of Bangladesh. *Pakistan Veterinary Journal*, *3*, 113-116.

Isah, U. M. (2019). Studies on the prevalence of fascioliasis among ruminant animals in northern Bauchi state, North-Eastern Nigeria. *Parasite epidemiology and Control*, *5,* e00090. https://doi.org/10.1016/j.parepi.2019.e00090

Islam, M., & Ripa, R. N. (2015). Prevalence of fascioliasis in slaughtered goat in Bengal meat abattoir house and its economic impact on business. *Journal of Chemical, Biological and Physical Sciences, 5*(3), 2684.

Kaplan, M., & Başpınar, S. (2009). Elazığ'da son 5 yılda kesilen kasaplık hayvanlarda fasciolosis sıklığı ve ekonomik önemi. *Fırat Tıp Dergisi, 14*(1), 25-27.

Kedir, S., Deressa, B., & Tigre, W. (2012). Small ruminant fasciolosis in Jimma area of South Western Ethiopia: its epidemiology and minimum monetary loss. *Global Veterinaria, 9*(5), 635-641. https://doi.org/ 10.5829/idosi.gv.2012.9.5.66213

Khalafala, R. E. (2020). Prevalence and phylogenetic analysis of Fasciola species in upper Egypt based on ribosomal ITS-2 gene sequencing. *Egyptian Veterinary Medical Society of Parasitology Journal, 16*(1), 142-158. https://doi.org/10.21608/EVMSPJ.2020.132162

Khoramian, H., Arbabi, M., Osqoi, M. M., Delavari, M., Hooshyar, H., & Asgari, M. (2014). Prevalence of ruminants fascioliasis and their economic effects in Kashan, center of Iran. *Asian Pacific Journal of Tropical Biomedicine*, *4*(11), 918-922. https://doi.org/10.12980/APJTB.4.2014APJTB-2014-0157

Kiani, B., Budke, C. M., Shams Abadi, E., Hashtarkhani, S., Raouf Rahmati, A., AkbarPour, M., Zarean, M., Bibi R. H. F., Fatemeh, K., & Moghaddas, E. (2021). Evaluation of zoonotic platyhelminthe infections identified in slaughtered livestock in Iran, 2015–2019. *BMC Veterinary Research, 17*(1), 185. https://doi.org/10.1186/s12917-021-02888-9

Köroğlu E., & Şimşek, S. (2003). Ekonomik kayıplar. In fasciolosis. *Türkiye Parazitoloji Dergisi*, *18*, 249-262.

Lakew, Z., & Alebie, A. (2015 A Study on the prevalence, risk factors and financial loses of cattle, sheep and goats fasciolosis in Debrezeit Town, Ethiopia. *American-Eurasian Journal of Scientific Research, 10*(3), 126-133. https://doi.org/10.5829/idosi.aejsr.2015.10.3.9573

Liba, J. W., Atsanda, N. N., & Francis, M. I. (2017). Economic loss from liver condemnation due to fasciolosis in slaughtered ruminants in Maiduguri abattoir, Borno State, Nigeria. *Journal of Advanced Veterinary and Animal Research, 4*(1), 65-70. http://doi.org/10.5455/javar.2017.d192

Mehmood, K., Zhang, H., Sabir, A. J., Abbas, R. Z., Ijaz, M., Durrani, A. Z., Muhammad H. S., Mujeeb U. R., Muhammad K. I., Yajing W., Hafiz I. A., Tariq A., Riaz H., Muhammad T. G., Sadaqat A., Aman U. K., & Li, J. (2017). A review on epidemiology, global prevalence and economical losses of fasciolosis in ruminants. *Microbial Pathogenesis,* 109, 253-262. https://doi.org/10.1016/j.micpath.2017.06.006

Mungube, E. O., Bauni, S. M., Tenhagen, B. A., Wamae, L. W., Nginyi, J. M., & Mugambi, J. M. (2006). The prevalence and economic significance of Fasciola gigantica and Stilesia hepatica in slaughtered animals in the semi-arid coastal Kenya. *Tropical Animal Health and Production, 38*, 475-483. https://doi.org/10.1007/s11250-006-4394-4

Munguía-Xóchihua, J. A., Ibarra-Velarde, F., Ducoing-Watty, A., Montenegro-Cristino, N., & Quiroz-Romero, H. (2007). Prevalence of fasciola hepatica (ELISA and fecal analysis) in ruminants from a semi-desert area in the northwest of Mexico. *Parasitology Research, 101*(1), 127-130. https://doi.org/10.1007/s00436-006-0438-y

Ngategize, P. K., Bekele, T., & Tilahun, G. (1993). Financial losses caused by ovine fasciolosis in the Ethiopian highlands. *Tropical Animal Health and Production, 25,* 155-155.

Njeruh, F. M., Kithuka, J. M., Maingi, N., & Ombui, J. N. (2004). Prevalence and economic importance of fascioliasis in cattle, sheep and goats in Kenya. *Kenya Veterinarian*, *27*, 118-123. https://doi.org/10.4314/kenvet.v27i1.39574

Odeniran, P. O., Omolabi, K. F., & Ademola, I. O. (2021). Economic impact assessment of small ruminant fasciolosis in Nigeria using pooled prevalence obtained from literature and field epidemiological data. Veterinary Parasitology: *Regional Studies and Reports*, *24*, 100548. https://doi.org/10.1016/j.vprsr.2021.100548

Ola-Fadunsin, S. D., Uwabujo, I. P., & Adebanjo, A. O. (2020). A retrospective study on viscera condemnation in small ruminants due to parasitic infections and its economic implications in Ilorin, Nigeria. *Veterinaria*, *69*(2), 129-134.

Opitz Vieira Da Cunha, F., Tietz Marques, S., Tweedie De Mattos, M. J. (2007). Prevalence of slaughter and liver condemnation due to fasciola hepatica among sheep in the state of Rio Grande do Sul, Brazil 2000 and 2005. *Parasitología Latinoamericana*, *62*(3-4), 188-191, 2007. http://dx.doi.org/10.4067/S0717-77122007000200015

Oryan, A., Mansourian, M., Moazeni, M., Nikahval, B., & Barband, S. (2011). Liver distomatosis in cattle, sheep and goats of Northeastern Iran. *Global Veterinaria, 6*(3), 241-246.

Otte, M. J., & Chilonda, P. (2000). Animal health economics: an introduction. *Animal Production and Healthy Division*, 1-12.

Ouchene-Khelifi, N. A., Ouchene, N., Dahmani, H., Dahmani, A., Sadi, M., & Douifi, M. (2018). Fasciolosis due to Fasciola hepatica in ruminants in abattoirs and its economic impact in two regions in Algeria. *Tropical Biomedicine, 35*(1), 181-187.

Pekağırbaş, M., Duran, M., & Eren, H. (2020). The Prevalence of liver trematodes in slaughtered ruminants in Aydın Province. *Animal Health Production and Hygiene, 9*(2), 707-710.

Rahmeto, A., Abunna, F., Berhane, M., Mekuria, S., Megersa, B., & Regassa, A. (2010). Fasciolosis:

Prevalence, financial losses due to liver condemnation and evaluation of a simple sedimentation diagnostic technique in cattle slaughtered at Hawassa Municipal abattoir, southern Ethiopia. *Ethiopian Veterinary Journal, 14*(1), 39-52.

Regea, G., & Getachew, G. (2021). Study on prevalence and associated risk factors of ovine fasciolosis in and Around Nekemte Town, Oromia, Ethiopia. *Journal of Veterinary Medicine and Animal Sciences*, *4*(1), 1069.

Republic of Turkey Ministry of Agriculture and Forestry, MAF. (2024, December 31): Livestock data. https://www.tarimorman.gov.tr/sgb/Belgeler/ SagMenuVeriler/HAYGEM.pdf.

Rinaldi, L., Biggeri, A., Musella, V., De Waal, T., Hertzberg, H., Mavrot, F., & Catelan, D. (2015). Sheep and fasciola hepatica in Europe: the GLOWORM experience. *Geospatial Health,* 9(2), 309-317. https://doi.org/10.4081/gh.2015.353

Roseby, F. B. (1970). The effect of fasciolosis on the wool production of merino sheep. *Australian Veterinary Journal,* 46(8), 361-365.

Sarıözkan, S., & Yalçın, C. (2011). Estimating the total cost of bovine fasciolosis in Turkey. *Annals of Tropical Medicine & Parasitology,* 105(6), 439-445, 2011. https://doi.org/10.1179/1364859411Y.0000000031

Sarıözkan, S. (2019). Production losses due to small ruminant fasciolosis in Turkey. *Eurasian Journal of Veterinary Sciences*, 35(2), 93-98, 2019. https://doi.org/10.15312/EurasianJVetSci.2019.229

Schweizer, G., Braun, U., Deplazes, P., & Torgerson, P. R. (2005). Estimating the financial losses due to bovine fasciolosis in Switzerland. *Veterinary Record, 157*(7), 188-193. https://doi.org/10.1136/vr.157.7.188

Spithill, T. W., Smooker, P. M., & Bruce, D. (1999). Fasciola gigantica: epidemiology, control, immunology and molecular biology. *Fasciolosis*, *50*(2), 465-525.

Tınar, R., Korkmaz, M. (2003). Fasciolosis. *Türkiye Parazitoloji Dergisi*, *18*(1), 2003.

Türkiye Damızlık Koyun Keçi Yetiştiricileri Birliği, DKK-YB (2024, December, 31). *Fiyatlar.* http://turkiyekoyunkeci.org/tr/AnaSayfa.

Ulusal Kırmızı Et Konseyi, UKON (2024, December 31). Fiyatlar. http://www.ukon.org.tr/fiyatlar.aspx.

Usip, L. P. E., Ibanga, E. S., Edoho, H. J., Amadi, E. C., & Utah, E. (2014). Prevalence of Fascioliasis and the economic loss of condemned liver due to Fasciola infection in Cattle slaughtered at three abattoirs in Eket Urban, Akwa Ibom State of Nigeria. *Global Advanced Research Journal of Food Science and Technology, 3*(2), 54-75.

Yibar, A., Selcuk, O., & Senlik, B. (2015). Major causes of organ/carcass condemnation and financial loss estimation in animals slaughtered at two abattoirs in Bursa Province, Turkey. *Preventive Veterinary Medicine, 118*(1), 28-35. https://doi.org/10.1016/j.prevetmed.2014.11.012

Zafar, A., Khan, M. K., Sindhu, D., Abbas, R. Z., Masood, S., Abbas, Z., Muhammad S. M., Muhammad K. S., Junaid A. K., Riaz H., Muhammad U. N., Zafar I., & Javed, H. (2019). Seroprevalence of *fasciola hepatica* in small ruminants of District Chakwal, Punjab, Pakistan. Pakistan *Veterinary Journal, 39*(1), 96-100. https://doi.org/10.29261/pakvetj/2018.024