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Studying the factors affecting the prevalence of Platyhelminthes in slaughtered ruminants in Lorestan province, Iran (2012-2022)

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Abstract
Production-limiting diseases, such as helminth infections, are a major concern in temperate regions. They can lead to decreased meat and milk production and quality in livestock. This investigation aimed to assess the prevalence of *Fasciola* spp., *Dicrocoelium* spp., and Cystic echinococcosis in different livestock species (cattle, sheep, and goats) at the Khorramabad slaughterhouse between March 21, 2012, and March 20, 2022.ANOVA was employed to assess how disease prevalence varies across different periods and among various livestock species, aiming to comprehend the interplay of these independent variables on disease prevalence. The highest prevalence of *Fasciola* spp. was related to cattle, with a seasonal pattern showing a higher prevalence in autumn and winter. Hydatid cysts have increased over the past decade, with *D. dendriticum* being prevalent from 2017 to 2020. The investigation conducted has provided evidence that diseases caused by parasitic infestations in ruminants continue to persist even after treatment. This highlights the need for more effective and targeted sanitary and preventive measures that consider the type of parasite and its prevalence during different seasons. It is hence important to design and implement measures tailored to the specific needs of each parasite species, and aligned with the seasonal fluctuations in its population. This will help minimize the risk of disease transmission, thus reducing the impact on animal health and productivity, ultimately benefitting the livestock industry as a whole.

Introduction

Recorded data from meat inspection have been an important source for investigating the economic losses and epidemiological aspects of parasitic infections of ruminants in several countries of the world (1-3). Parasitic infections of fascioliasis,

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cystic echinococcosis, dicrocoeliasis, and cysticercosis are often detected in slaughtered animals at slaughterhouses (1, 3). Infections caused by parasites can affect the production and quality of meat, milk, and wool by reducing growth rate, carcass weight, and reproduction (4). One of the major concerns is production-limiting diseases such as helminth infections, especially in temperate regions (5). Helminth infection is seasonal, ubiquitous in livestock farms, and responsible for major impacts on animal production and reproduction (4).

Domestic and wild ruminants are mainly infected by rumen flukes (6), but these flukes may also affect new-world camelids (7). Fascioliasis is an important zoonotic parasitic infection, which is considered to be of major interest in the field of global public health. About 50 million people worldwide and more than 180 million people in developed and underdeveloped countries are at risk of infection (8). In Iran, fasciolosis poses a notable threat to domestic livestock, which includes 75 million sheep and goats, as well as six million domestic cattle. Additionally, infection has also been found in wild animals, such as wild boar and wild sheep (9). Due to its abundance in humid areas, this zoonosis is primarily transmitted to herbivores and rarely to humans through the consumption of green vegetables and contaminated water (10).

Cystic echinococcosis, also known as hydatidosis, is caused by the metacestode of the larval stage of the tapeworm *Echinococcus* spp. (11). It is a zoonosis with a global distribution that affects livestock such as cattle, sheep, goats, camels, and buffaloes, and humans are also infected with the cystic form through contaminated food and water (12, 13). In a hyperendemic region such as Iran, this disease is still an important problem (14). *Echinococcus* spp. has been identified as one of the 20 neglected tropical diseases by the World Health Organization (15). Since this disease causes mortality in animals and humans, communities are facing serious health, social, and economic challenges (13).

Dicrocoelium spp., which inhabit the bile ducts and gallbladders of ruminants, cause dicrocoeliasis in them and sometimes in humans, rabbits, horses, dogs, and pigs (16). Studies based on post-mortem inspection in Iran show the high prevalence of *D. dendriticum* in most parts of Iran (2, 16-18). It has been reported that in Tehran province, 2.9% of 571,991 sheep and goats slaughtered and 0.8% of 80,001 cattle slaughtered from 2015 to 2018 were positive for *D. dendriticum* (19), but dicrocoeliasis rarely affects humans in Iran, thus that only five cases have been reported (20). The life cycle of *Dicrocelium* spp., a parasite with two intermediate hosts, is greatly affected by weather. The survival of miracidia-containing eggs and the growth of snail and ant intermediate hosts in their respective environmental niches are influenced by temperature and humidity (21).

Breeding methods in Lorestan province are often traditional and pasture-based, thus they are exposed to chronic and insidious diseases that limit production (2). However, to date, few slaughterhouse studies have been conducted on the prevalence and effect of helminth infection in ruminants slaughtered. This study was conducted to compare the prevalence of *Fasciola* spp., *Dicrocoelium* spp., and Cystic echinococcosis among different livestock species (cattle, sheep, and goats) in seasonal and annual periods in western Iran for ten years.

Materials and methods

Study area

This retrospective study was conducted from 21 March 2012 to 20 March 2022, based on the records of daily condemnation of cattle, sheep, and goats at the Khorramabad Veterinary Organization (Lorestan province) (Figure 1). Lorestan province is situated in the western region of Iran at 32°37′ 34°22′ N and 46°51′ 50°3′ E, standing at an average altitude of 2200 meters in the rugged Zagros Mountains. It has a semi-arid climate and covers a total area of 28,300 km² (22). The average annual precipitation in Khorramabad is 509 mm, with an average maximum temperature of 25.06 °C and an average minimum temperature of 8.48 °C (23).

Data collection

The study livestock population included cattle, sheep, and goats that were brought to the slaughterhouse of this city from different parts of the country. Cattle, sheep, and goats were studied in different age groups (young and adult) and both sexes (male and female). A total of 150,694 cattle, 742,493 sheep, and 174,531 goats were examined. Observations were gathered and documented as monthly slaughter frequencies at the slaughterhouses.

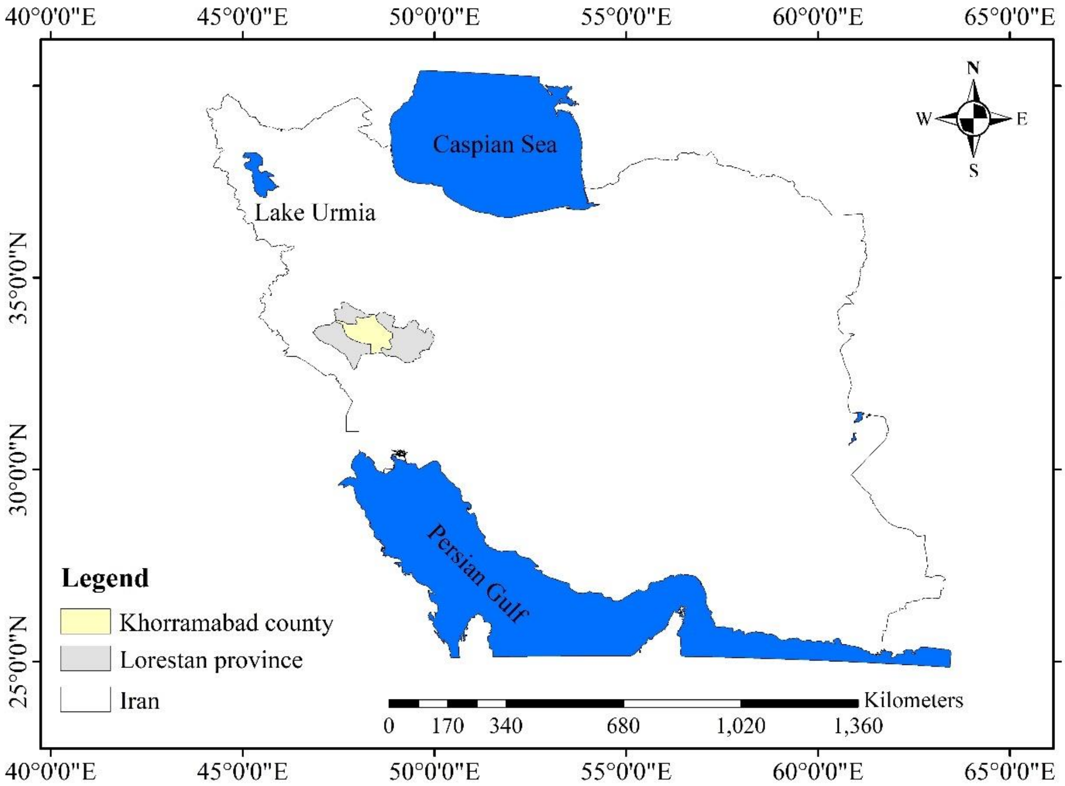


Fig. 1. Map showing the geographical layout of Iran and the specific region under investigation.

Examination of each slaughtered animal during post-mortem examinations is performed by meat inspectors following standard meat inspection procedures such that all animals are macroscopically inspected, palpated, and incised (24). Slaughtered ruminants were inspected for the presence of *F. hepatica* and/or *F. gigantica* (adults), *D. dendriticum* (adults), *E. granulosus* (hydatid cysts), and *Sarcocystis* spp. As a part of the continuous surveillance system, information such as the reason for the condemnation of the organs, the slaughter rate, and daily population data are recorded in the prepared data sheets.

Statistical analysis

This study aims to investigate the factors that contribute to the spread of livestock diseases in Lorestan province over ten years. The study utilizes monthly slaughter frequency data from slaughterhouses in the province and focuses on common diseases such as *Fasciola* spp., hydatid cyst, and *Dicrocelium* spp. and aims to compare disease prevalence among different livestock species (sheep, goat, cattle) during both seasonal and annual periods. To estimate how the mean of a quantitative variable (disease prevalence) changes according to the levels of two categorical variables (livestock species and periods), we have applied the two-way ANOVA (factorial design) considering the interaction analysis to compare the mean of each independent group. The two-way ANOVA compares the mean differences (point estimations) between groups that have been split on two independent variables (called factors) using the F-test. The primary purpose of a two-way ANOVA is to understand if there is an interaction between the two independent variables and the dependent variable.

Results

Fasciola spp.

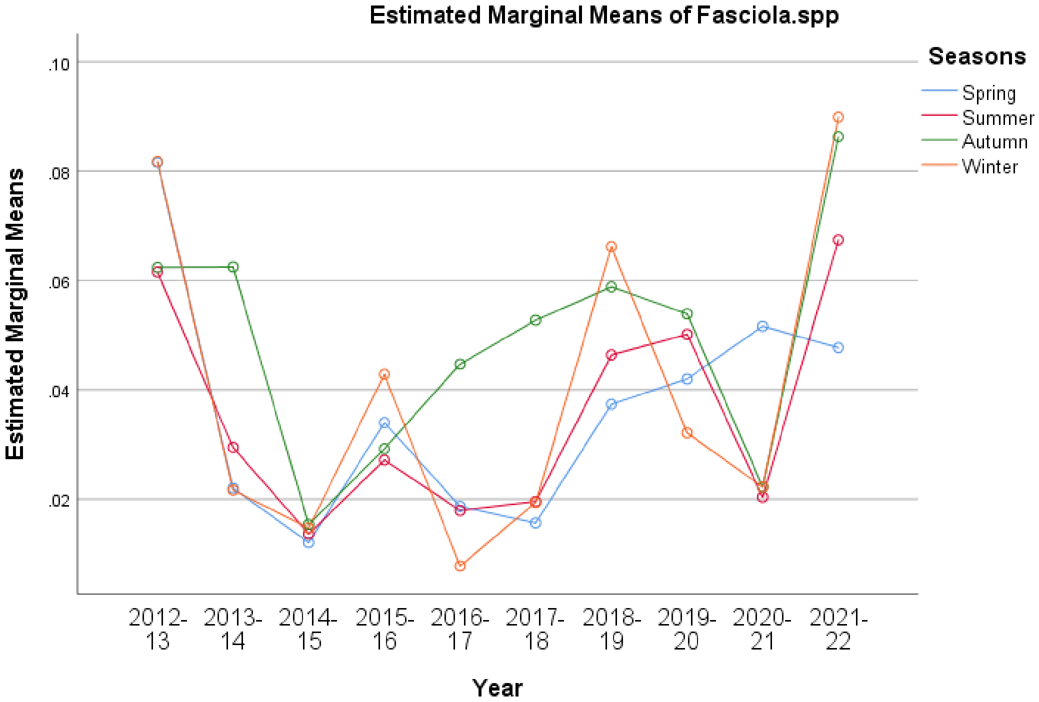
Ten-year prevalence statistics (2012-2022) of slaughtered ruminants (cows, sheep, and goats) in Khorramabad are summarized in Table 1. The prevalence rate in cattle (7.50%) is higher than in sheep (2.41%) and goats (2.55%), and the overall prevalence rate of fasciolosis among ruminants in this city is 4.15%. Furthermore, the prevalence of *Fasciola* spp. in 10 years based on year, type of animal, and season is depicted in Figures 2 a,b, and c. The prevalence rate of *Fasciola* spp. in cattle has been higher than in sheep and goats, and this disease has been more prevalent in autumn and winter. The prevalence was particularly high in 2012, decreased in the following years, but increased again in 2022, especially in cattle.

Table 1. Platyhelminthes rates of ruminants slaughtered (2012-2022) in Khorramabad, Lorestan Province.

	Animal Group	Prevalence (%)	Std. Deviation
***Fasciola* spp.**	Sheep	2.41	0.02
	Goat	2.55	0.03
	Cattle	7.50	0.06
	Total	4.15	0.04
Hydatid cyst	Sheep	7.70	0.08
	Goat	5.36	0.07
	Cattle	10.64	0.08
	Total	7.90	0.08
***Dicrocoelium* spp.**	Sheep	5.52	0.02
	Goat	6.10	0.06
	Cattle	8.09	0.06
	Total	6.57	0.05

As shown in Figure 2, the concurrence of this infection in all years was much higher in cattle than in sheep and goats. Furthermore, the rate of occurrence of this disease in different livestock has been investigated based on the seasons, and in all seasons, the prevalence of the disease in cattle was much higher than in the other two livestock. However, in 2017, the incidence of the disease in goats was higher than in cattle. According to Figure 2 c, the incidence of fasciolosis in autumn in cattle, sheep, and goats was higher than in other seasons of the same year, however, there were variations in the seasons over the years, such as in 2013 and 2017, when the incidence of this disease in winter was higher.

a)


Estimated Marginal Means of Fasciola.spp
Seasons
Spring
Summer
Autumn
Winter
Estimated Marginal Means
.10
.08
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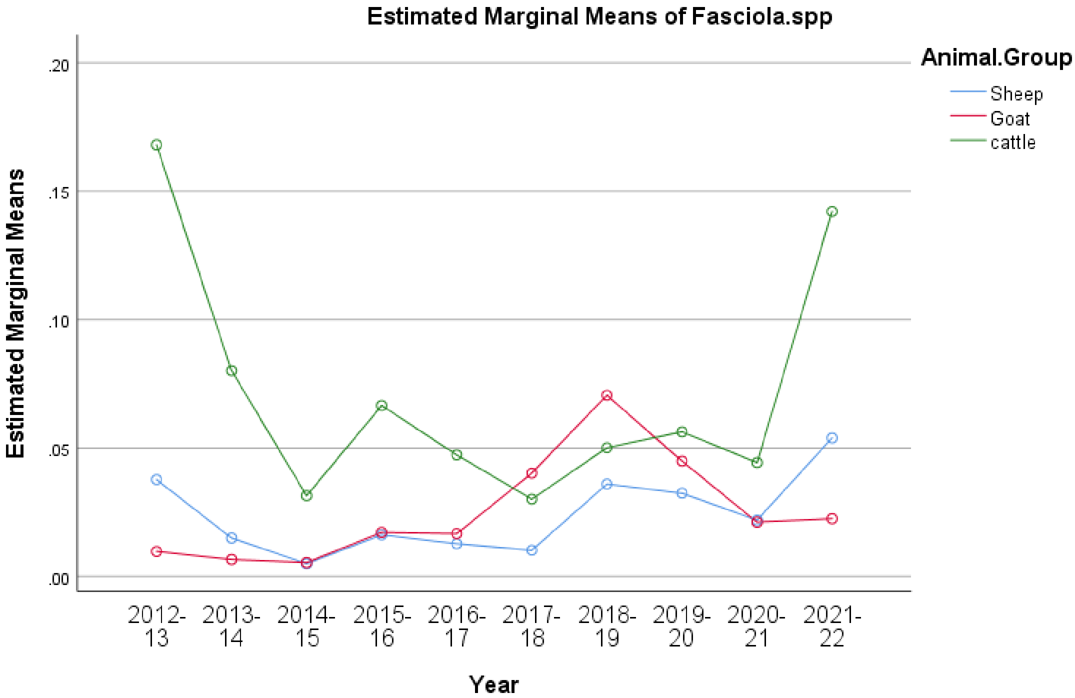
Year

b)


Estimated Marginal Means of Fasciola.spp
Animal.Group
Sheep
Goat
cattle
Estimated Marginal Means
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2021-22
Year

c)

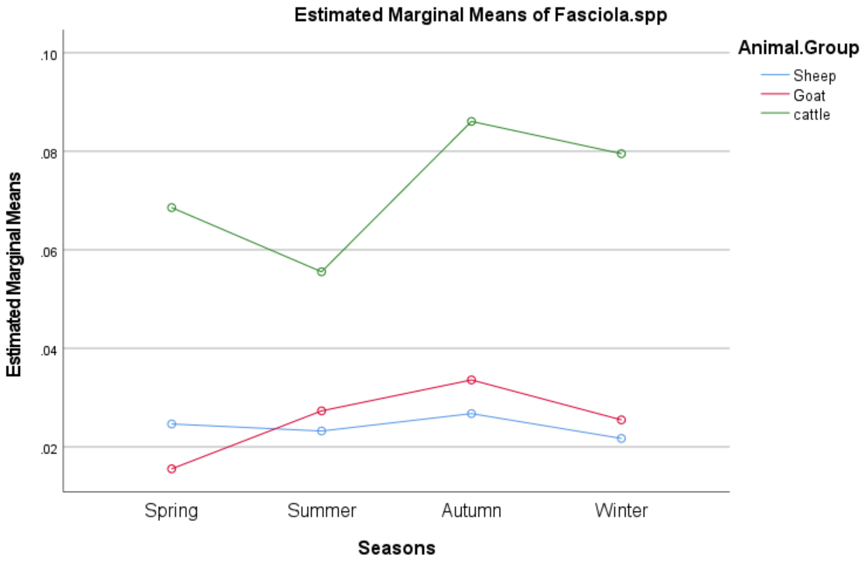


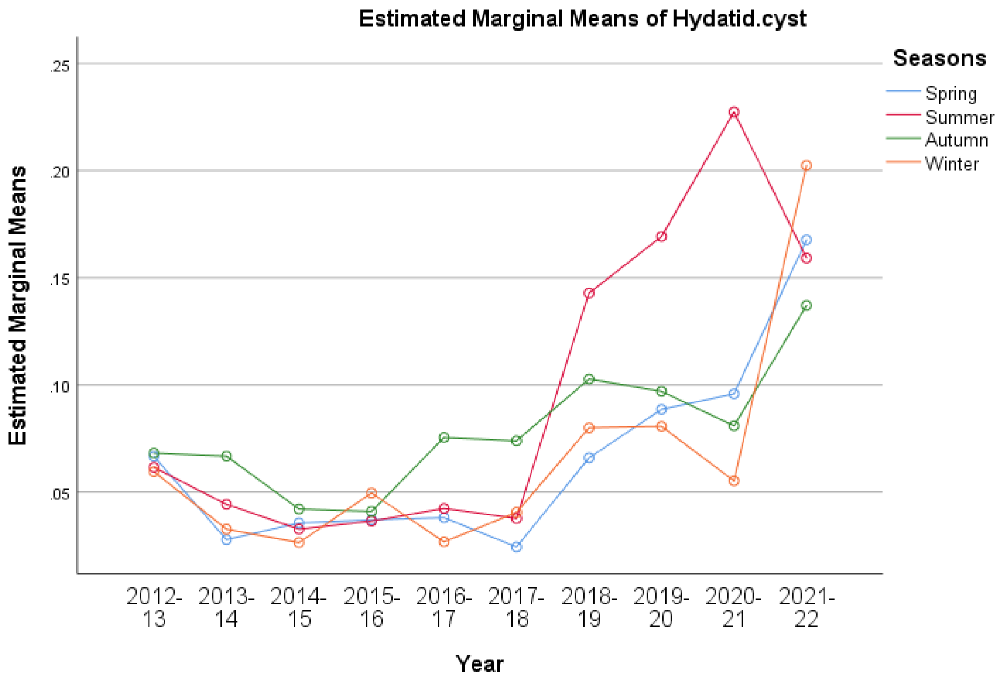
Fig. 2. *Fasciola* spp. in cattle, sheep, and goats slaughtered in Lorestan Province, Iran, 2012- 2022; **a**: The trend of annual prevalence; **b**: The comparison of prevalence in livestock slaughtered per year; **c**: Mean of prevalence of *Fasciola* spp. in livestock slaughtered per season.

E. granulosus metacestode (hydatid cyst)

Figures 3 a, b, and c illustrate the prevalence of hydatid cysts in slaughtered animals between 2012-2022. The prevalence of this parasite has increased significantly over time, particularly in 2022. According to Table 1, the ten-year prevalence (2012-2022) of hydatid cysts in slaughtered ruminants displays that the prevalence rate was higher in cattle (10.64%) compared to sheep (7.70%) and goats (5.36%). In addition, the overall prevalence of fasciolosis among ruminants was 7.90%. Sheep and goats demonstrated a higher prevalence of hydatid cysts in summer, whereas cattle had a higher prevalence in autumn and winter. In general, except for the summer, cattle had a higher prevalence of the disease compared to sheep and goats (Figures 3a, c).

However, climate data revealed that the seasonal pattern affected the prevalence of hydatid cysts in goats and sheep, with the highest level of infection rate occurring in summer and the lowest in winter and spring. In contrast, cattle had the highest prevalence in winter, and the lowest in summer.

a)


Estimated Marginal Means of Hydatid.cyst
Seasons
Spring
Summer
Autumn
Winter
Estimated Marginal Means
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2020-21
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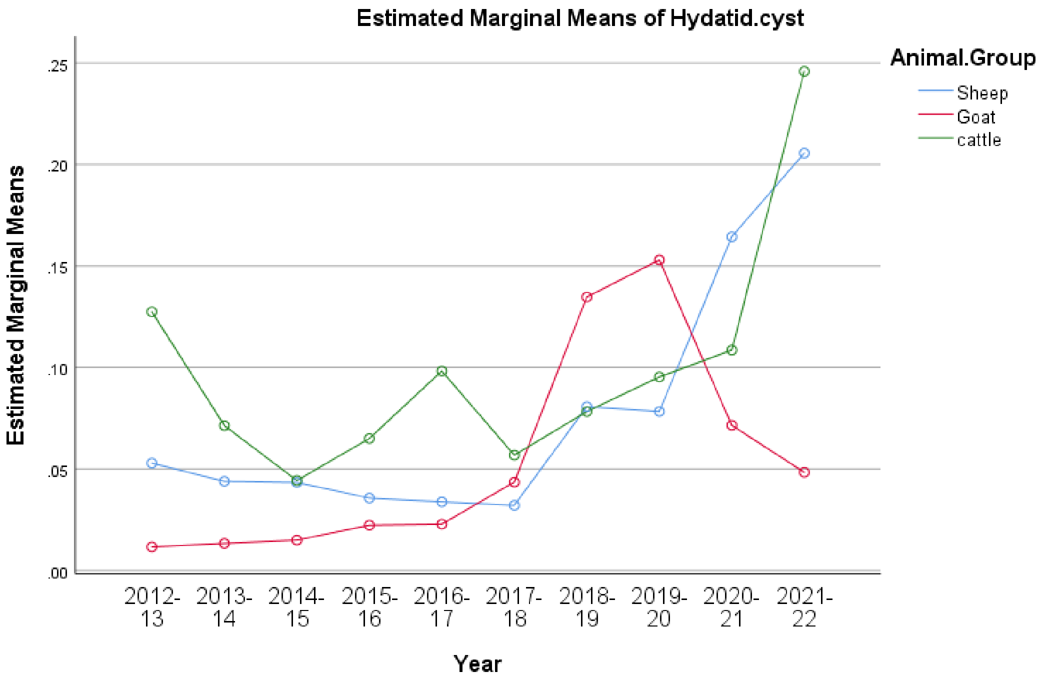
Year

b)


Estimated Marginal Means of Hydatid.cyst
Animal.Group
Sheep
Goat
cattle
Estimated Marginal Means
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Year

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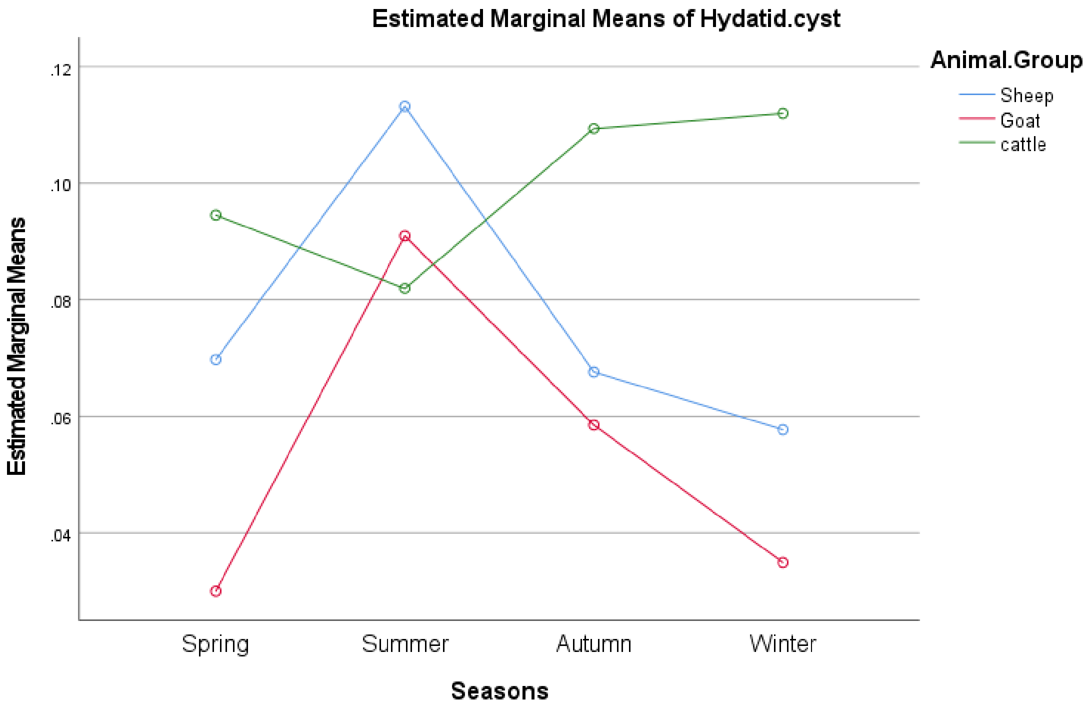


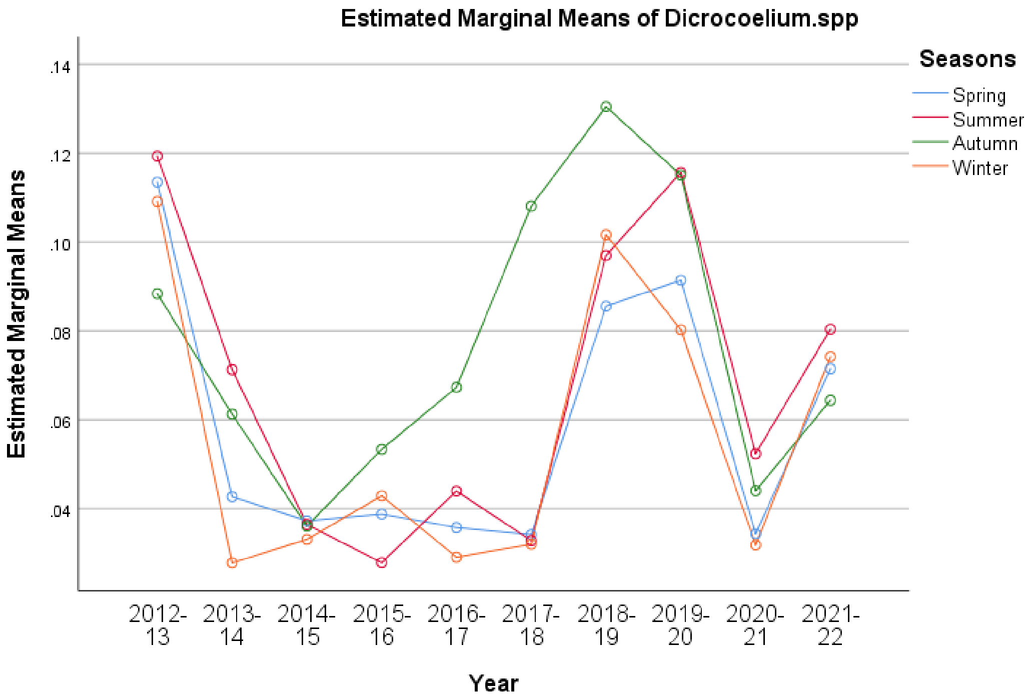
Fig. 3. Hydatid cyst in cattle, sheep, and goats slaughtered in Lorestan Province, Iran, 2012- 2022; **a**: The trend of annual prevalence of hydatid cyst; **b**: The comparison of prevalence of hydatid cyst in livestock slaughtered per year; **c**: Mean of prevalence of hydatid cyst in livestock slaughtered per season.

Dicrocoelium spp.

According to Table 1, the ten-year prevalence (2012-2022) of *Dicrocoelium* spp. in cattle was 8.09%, which was higher than in sheep (5.52%) and goats (6.10%) The overall prevalence among ruminants was 6.57%. In addition, results indicated a significant seasonal pattern for *Dicrocoelium* spp. infections in cattle, goats, and sheep (Figures 4 a, b, and c). The highest number of infections occurred during the autumn of 2018, showing the highest prevalence rate of *Dicrocoelium* spp. in autumn.

The prevalence of *Dicrocoelium* spp. decreased from 2012 to 2016, but in 2017, particularly in autumn, the prevalence of this disease was very high. This increase in prevalence between 2019 and 2020 was more pronounced in sheep (Figure 4 a). For goats, the highest incidence rate of this parasitic infection was in autumn, surpassing that of other seasons. In this study, there were seasonal patterns in the prevalence rate of *Dicrocoelium* spp. However, there was no significant relationship between the overall seasonal prevalence in cattle, goats, and sheep (Figures 4b and c).

a)


Estimated Marginal Means of Dicrocoelium.spp
Seasons
Spring
Summer
Autumn
Winter
Estimated Marginal Means
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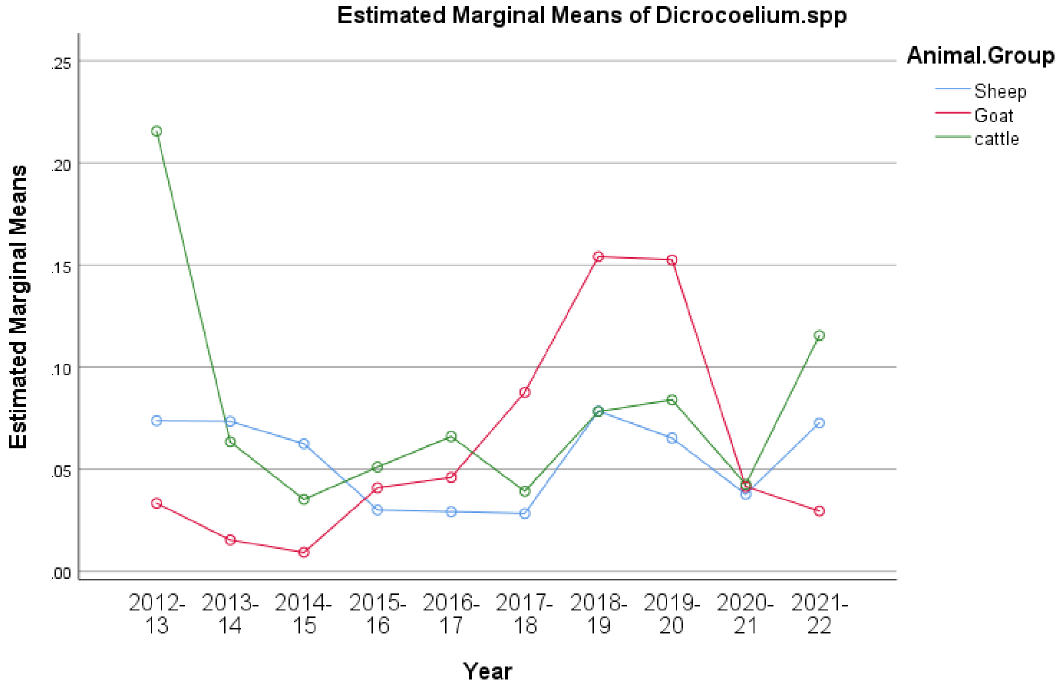
Year

b)


Estimated Marginal Means of Dicrocoelium.spp
Animal.Group
Sheep
Goat
cattle
Estimated Marginal Means
.25
.20
.15
.10
.05
.00
2012-13
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2020-21
2021-22
Year

c)

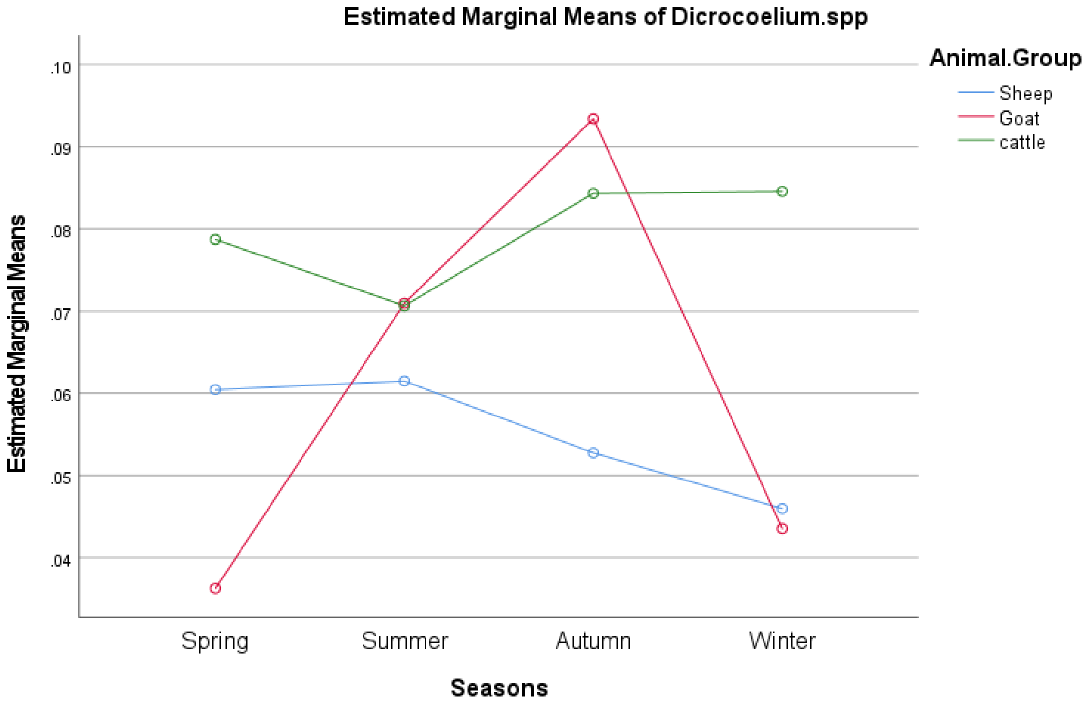

Fig. 4. *Dicrocoelium* spp. in cattle, sheep, and goats slaughtered in Lorestan Province, Iran, 2012- 2022. **a**: The trend of annual prevalence of *Dicrocoelium* spp.; **b**: The comparison of prevalence in livestock slaughtered per year; **c**: Mean of the prevalence in livestock slaughtered per season.

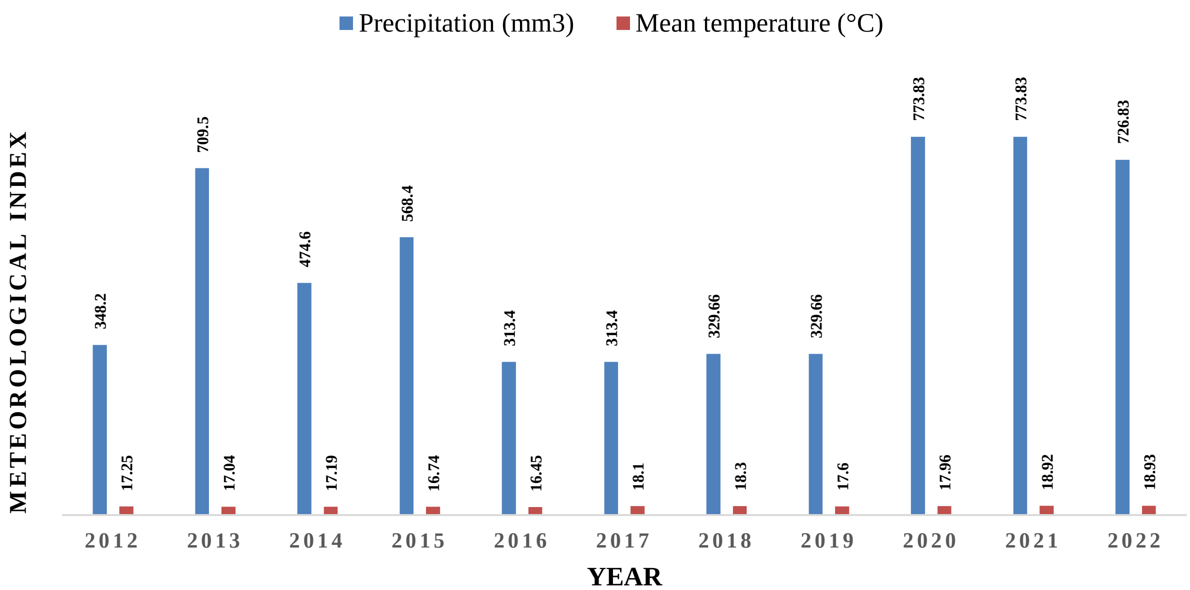

Fig. 5. Comparative metrological patterns from 2012 to 2022 in Khorramabad, Lorestan Province.

Discussion

Parasitic diseases are prevalent and economically significant in ruminants globally. Diagnosis of these diseases is crucial as they also affect humans worldwide, and it is probable that where animal cases are recorded, there are also human cases (25). In this region, cattle and small ruminants like sheep and goats are the primary animals raised, vital for the social, cultural, and economic welfare of rural and nomadic communities. Livestock production systems for these animals include extensive, intensive, and semi-intensive systems (26). Ruminants are usually housed in basic pens close to herders' homes and tended to by younger family members. Ruminant farming predominantly occurs on small plots, with animals primarily fed agro-pastoral products and grazing in pastures.

Fasciola spp. is a widespread parasite causing health issues globally (27). It is common in ruminants in Iran and is considered endemic by the WHO (28) due to high human prevalence, especially in the north (17, 29). *F. hepatica* and *F. gigantica* have been prevalent in domestic ruminants, in many parts of Iran, especially in subtropical and humid areas (30). For ten years, the prevalence of this parasite in cattle, sheep, and goats has been investigated, and the most changes were related to cattle, which is consistent with the findings of other researchers who showed that buffalo and cattle had a higher concurrence of the disease compared to sheep and goats (30). Another study (31) also reported the prevalence rate of *Fasciola* spp. from 2015 to 2019 in Iran to be 3.86% in cattle and 1.56% in goats and sheep, which is nearly similar to the findings of this study.

Since 2020, the rate of prevalence decreased drastically, and the trend was maintained at an almost low level until 2020, but this disease spread again in 2020. A relatively small incidence of fasciolosis was shown among sheep and goats, except for cattle. Based on the data from Figure 5, the increased prevalence observed from 2020 onwards can be attributed to the rise in precipitation. Therefore, the differences observed can be explained by the presence of various factors e.g., climatic variation and husbandry practices (9). In addition to other reasons for increasing the rate of fasciolosis infection, it may be the socio-economic status of livestock farmers and the development of drug resistance in anti-parasitic drugs due to improper use of appropriate doses (32). In a systematic review, *Fasciola* spp. was reported as the causative agent of 2.6% of all inspected livers of ruminants in Iran. Also, in the study, they stated that the mean prevalence of *Fasciola* spp. in Iran was 2%, 2.4%, and 2%, in cattle, goats, and sheep, respectively (9). It has been shown that the distribution rate of *Fasciola* spp. in temperate regions, especially with high humidity, may have been higher in endemic foci (27, 30). In a study that was conducted on Fasciolosis in livestock based on data from slaughterhouses in Shiraz (southern Iran) for 5 years, it was shown that the data had a general downward trend for the annual percentage, (29), which is consistent with our study.

Most contamination is related to the western and northern regions of Iran, and the prevalence of this disease in these regions remains at a hypoendemic level (9). These areas have proper environmental and climatic conditions for the life cycle of this parasite, as well as a higher density of domestic ruminants, thus they have a higher prevalence. Since precipitation and temperature (climatic variables) significantly affect the survival rate of snails, miracidia, and cercariae, they are considered the most likely factors affecting the prevalence of *Fasciola* spp. (30, 33).

In addition to environmental conditions and precipitation, increased contamination may be attributed to livestock predominantly raised in an extensive farming system, heightening exposure risk to fasciolosis through ingestion of contaminated forage containing metacercaria *Fasciola* spp. Furthermore, heightened contamination could result from animals grazing on forage cut from leftover plants or weeds thriving in rice fields or rivers, posing a significant risk of *Fasciola* spp. metacercariae infection (34). Research indicates that the majority of cattle are raised in an intensive farming system, reducing their grazing activity and susceptibility to fasciolosis (34). The transmission of *Fasciola* spp. metacercariae infection may be linked to feeding cattle paddy straw that could be attached to plants in aquatic environments like paddy fields and riverside plants (35). To minimize the infection risk, it is advisable to process the straw before feeding by drying it for 2–3 days, cutting it slightly above the water surface, and mixing it with dry rice leaves (36). It is possible that this case occurred due to unscheduled deworming activities (34) and feeding management. This includes unhygienic feed or giving waste plants as feed, which could potentially be the reason for high parasite infection (37). According to studies, different cattle breeds have varying rates of fasciolosis, with local breeds being at a higher risk (34, 38). Cattle aged 3.5 years or older are more susceptible to fasciolosis compared to younger cattle (34). Additionally, since older cattle are more commonly slaughtered in this province, the incidence of fasciolosis is also higher.

Fasciolosis has been reported in various provinces of Iran, including Kurdistan, Zanjan, Kermanshah, Mazandaran, Tehran, Azerbaijan, Gilan, Fars, and Khuzestan (30).The high precipitation in the northern provinces of Iran, along with suitable temperature and humidity, food habits, and ecological aspects of *Fasciola* spp. transmission, free grazing of ruminants, and the presence of intermediate hosts are the main factors contributing to the spread of this common disease between humans and animals in Iran (39). However, the prevalence rate of this parasite in slaughterhouses does not indicate its occurrence rate in the region, as cattle are transported from all over Iran to this slaughterhouse.

Interpretation of this trend is rather difficult since the age of slaughtered animals is not available and *Fasciola* spp. is a chronic liver parasite. However, the climatic conditions of the region can be the probable reason for this decreasing trend. Severe drought has prevailed throughout the country for years, due to which the lack of food has led to an increase in animal slaughter, as the data shows that the total number of animals slaughtered has increased. Therefore, studies based on useful slaughterhouse information can be used to better manage infection in a herd or a specific region.

Hydatidosis is a common disease shared between humans and ruminants globally, particularly in the Middle East. Its incidence and economic impact have been studied worldwide (40, 41). The study of hydatidosis in ruminants slaughtered is a convenient and cost-effective way to estimate the prevalence in the human population in a region.

In general, the prevalence of hydatid cysts has significantly increased in sheep and cattle throughout all seasons in the past year. However, there has been a decline in the case of goats over the past two years. Despite the implementation of the protection and control program of the Iran Veterinary Organization, which was based on the training of livestock farmers and the use of wormseed, the level of contamination has not decreased in the last ten years. The epidemiology of hydatidosis involves two cycles: pastoral and sylvatic. In the pastoral cycle, dogs are typically involved and become infected by consuming ruminant offal containing hydatid cysts. The specific domestic intermediate host may vary based on local farming practices, but the primary host is sheep, which appears to be the natural intermediate host. Scolices from these animals are highly infectious for dogs. The pastoral cycle is the primary source of hydatidosis in humans, with infection usually occurring through accidental ingestion of oncospheres from dog hair, vegetables, or other food contaminated by dog feces. The sylvatic cycle occurs in wild canids and ruminants, where predation or scavenging on carrion is the basis. It is less significant as a source of human infection, except in hunting communities where the infection can be transmitted to domestic dogs by feeding them wild ruminant viscera (42).

One of the main reasons may be the easy access of stray dogs to ruminant carcasses and the traditional slaughtering of animals. Stray dogs and herds are the primary contributors to the transmission of this infection in this province. Additionally, wild carnivores like yellow jackals and red foxes also play a role in sustaining the parasite's life cycle in certain regions of the country (43). In goats and sheep, the presence of hydatid cysts is influenced by the climate. The infection rate is highest during the summer and lowest during the winter and spring seasons. Conversely, in cattle, the infection rate is highest during the winter and lowest during the summer. These findings differ from a previous study conducted in Alborz province, which reported the highest prevalence in summer and the lowest prevalence in spring (10). These differences can be caused by different climatic patterns in these regions and other possible risk factors involved.

Various reasons have caused Iran to be endemic for this disease, including stray dogs infected with this parasite, vast plains suitable for preserving discarded eggs, traditional and semi-industrial slaughter, and access of stray dogs to slaughtered animal carcasses, as well as in many cases, unsanitary disposal is one of the causes of the spread of this disease in this region (10). The prevalence of hydatidosis in different provinces of Iran, including Lorestan Province (2), has been previously reported, thus the highest and lowest prevalence rates in previous studies were related to the study of Ezatpour, Chegeni (44) (25.7%), and Azami, Anvarinejad (45) (6.5%), respectively. The mean prevalence rates of hydatid cysts over a decade presented in this study align with Khalkhali, Foroutan (43) research which indicated a prevalence of 8.8% in cattle, 5.9% in sheep, and 6.4% in goats in Iran. Kiani, Budke (31) also reported the prevalence rate of hydatid cysts in western regions to be 6.95%, which is similar to the findings of this study. The findings of this study do not align with Kheiri, Kaboudari (46) in Azerbaijan province. The prevalence of hydatid cysts was higher here than in Khorramabad, where sheep and goats were more prevalent. It is worth noting that the majority of cattle processed in this slaughterhouse are older females. Consequently, as mature animals are more prone to coming into contact with contaminated grass because of their heightened mobility, these findings are satisfied (34). The prevalence of hydatid cysts is higher in the northwestern regions and much less in the southern regions of Iran (31). These distributions align with the elevated prevalence values reported for human cases in the northern and western regions of Iran (31). Reports on the prevalence of hydatid cysts in slaughterhouses have been contradictory in different countries. This discrepancy may stem from variations in the knowledge of slaughterhouse health inspectors, inadequate carcass inspection facilities, regional differences in disease prevalence rates, and diverse research methods (13). Hydatid cysts are detected in the organs of livestock during post-mortem inspection of meat that the affected organ is either turned into pet food or rendered - a process in which moisture evaporates from the organ and the fat and protein content are separated to make meat powder, tallow, and manure (47). Hydatid cysts are mainly found in the liver (50–77%) and lungs (15–47%) of intermediate hosts (48). However, it has been found to a lesser extent in other organs such as the spleen (2-4%) and kidneys (0.5-8%). Therefore, a hydatid cyst can cause a wide range of different complications (49). The characteristics of cultural health and the economic situation in a society lead to the occurrence of this disease (50). Hydatid disease has notable global direct economic losses, for example, condemnation and degradation of organs and probable indirect losses such as decreased carcass weight or meat grade (51). To effectively control and prevent hydatidosis in this province, several measures are essential. These include long-term planning, adequate government financing, raising public awareness about hydatidosis, daily inspection of meat sources and slaughterhouses, restricting the movement of stray dogs near slaughterhouses, and implementing proper vaccination, such as EG95 for sheep (48).

Dicrocoelium spp. is a parasite with a complex life cycle, thus facets that can affect the existence of the intermediate or final host and change its prevalence. Many studies have reported the high prevalence of *Dicrocoelium* spp. infections in numerous provinces of Iran, especially in the northern (16), northwestern (17), and northeastern areas (52). In the course of this investigation, we have observed seasonal variations in the overall prevalence rate of *Dicrocoelium* spp. among slaughtered ruminants. However, it is important to note that these variations did not yield statistically significant differences, as illustrated in Fig 4. In the case of goats, the highest incidence rate of this parasitic infection was in autumn, which was higher than in other seasons, which was different from the results reported by Ezatpour, Hasanvand (2), but in cattle, the prevalence was higher in autumn and winter. Three ruminants have shown different sensitivities over ten years. The prevalence of this disease in cattle also followed the seasonal pattern, therefore the disease was prevalent only in autumn when it rains. Another reason for the lower prevalence of *Dicrocoelium* spp. is drought conditions that affect the intermediate hosts of snails (2). In other studies, the annual prevalence rate of the parasite has been investigated during a 9-year period, which generally reported a decreasing trend in the prevalence of this disease ($p<0.01$) (53). Jahed Khaniki, Kia (54) found that the average prevalence of dicrocoeliosis in the liver of animals slaughtered in Iran from 2014 to 2016 was 3.65%, 2.66%, and 2.19% in cattle, sheep, and goats, respectively. Furthermore, these findings align with Khanjari, Bahonar (55) research which indicated a prevalence of 6.6% in slaughtered sheep and goats in Amol, Mazandaran province.

Studies have shown that the northern areas of Iran are highly contaminated with *Dicrocoelium* spp. In a study that investigated the prediction of geographical distribution and environmental suitability of *Dicrocoelium* spp.; the Caspian Sea coast has been declared a high-risk area due to its high regional prevalence (36.7% and 6.1% for sheep and cattle) (16). The northern regions of Iran are suitable environmental conditions for the growth of *Dicrocoelium* spp. intermediate hosts due to more water resources in the plains and lowlands, also, mountainous heights (16). However, the parasite rate was down in the central (56) and southern provinces of Iran (29), therefore, the results of the present study are acceptable due to the relative drought conditions in recent years and their effect on the intermediate host of the snail, although the weather reduces the prevalence of this disease (53). As per the data presented in Fig 4, there has been a decrease in the prevalence of this parasite since 2013. This trend aligns with the findings illustrated in Fig 5, which indicate a reduction in precipitation.

Various factors are involved in the prevalence of dicrocoeliosis following the type of soil (alkaline or calcareous soils), ecological elements, regional environment, the low humidity requirements of *Dicrocoelium* intermediate hosts (57), rainy seasons, the existence of green pastures and the large number and diversity of livestock in the area, the age of infected animals, stress factors such as transportation of animals, and finally, cold temperatures (increased egg production and depression in the immune system in animals) (58).

Seasonal pattern changes lead to the movement of livestock from downstream areas to higher elevations where mountain grasses are used by livestock and ants living in this area cause livestock infection (59). Regarding the epidemiology of *D. dendriticum*, it should be added that the hosts of this Platyhelminthes do not need a humid environment and are also widely distributed in grasslands. In addition, its eggs are highly resistant and can survive in grasslands for months (59).

The semi-intensive system, the most common farming system, combines extensive and intensive systems, allowing parasites from grazing fields to be easily transmitted by infected animals to susceptible animals in the herd. Parasite prevalence in livestock under the extensive system was relatively higher than in other systems, indicating infections were mainly acquired from grazing fields. Dirt floors, the most common housing type, likely provide ideal conditions for parasite growth compared to concrete and wooden floors. Adequate moisture, temperature, and humidity levels are necessary for oocysts and parasite eggs to develop into infective forms (60), conditions best met in soil. During the rainy and cold seasons (autumn and winter), ruminants in this province are kept semi-intensively. It is not surprising that parasites such as *Dicrocoelium* spp. and *Fasciola* spp. exist in livestock kept in a semi-intensive system and on the floors of earthen houses. Regularly removing animal manure from corrals and pens is essential for effectively managing gastrointestinal parasites on dirt floors. Regrettably, this approach seemed to be inadequate within the research area (61).

The presence of multiple ruminant species and herd size pose significant risk factors to consider. Managing different ruminant species or numerous animals can be challenging for farmers due to the increased skills and resources required compared to handling a single ruminant species and a smaller number of animals (61). The challenges mentioned can result in poor animal health and increased susceptibility to infections. It is crucial to consider constraints such as limited knowledge of management practices and animal health, restricted access to veterinary drugs, the presence of unapproved veterinary drugs in the market, and the inability of livestock keepers or farmers to understand veterinary drug instructions due to a lack of formal training (61-63). Ranchers must obtain the necessary knowledge, skills, and resources for the specific type of ruminant species and herd size they choose to raise. They can do this by taking advantage of training and credits offered by farmer associations, if available, undergoing formal training, and utilizing livestock services to access relevant professionals such as agricultural extension officers and veterinarians when possible. Implementing prevention and control programs in hyperendemic areas can reduce the prevalence of parasitic infections and improve economic profitability. Investing in educational programs, infrastructure development, and urban transportation can also improve health indicators and water resources, leading to better health outcomes. In less developed countries, parasitic infections cause significant economic loss for people in remote areas who rely on animal husbandry. Control programs need to focus on disrupting the life cycle of these parasites.

Conclusion

This study has provided valuable data for monitoring important parasitic diseases in ruminants in Lorestan province. The results showed that Platyhelminthes diseases, especially hydatid cysts, were still prevalent in the ruminants of this region, therefore, it is necessary to implement more effective control programs based on regional needs and disease outbreak seasons. The use of meat inspection records has helped to monitor the disease and show potential long-term trends. Areas with higher prevalence rates may be a potential source of disease transmission to other areas and a threat for possible further prevalence in the future. Therefore, better management practices and more awareness should be used to properly control parasitic diseases based on the season of prevalence and intermediate hosts, along with appropriate pasture management practices and strategic therapeutic.

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Ethics approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Competing interests

The authors declare no competing interests.

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