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Causes of dromedary (*Camelus dromedaries*) carcass and organ condemnation at slaughter and its economic importance: 5-year retrospective study, Isfahan province, Iran

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ABSTRACT

A 5-year retrospective study in dromedaries (*Camelus dromedarius*) slaughtered in abattoirs was carried out in Isfahan province, central Iran to identify the major causes for condemnation of carcasses and viscera. The economic importance of lost meat and offal also were estimated. Between April 2014 and April 2019, 17,336 dromedaries were slaughtered in the study area; the lungs of 4,002 (23.08 %, Mean ± SEM: 27.27 ± 2.2), the livers of 1,726 (9.96 %, Mean ± SEM: 13.65 ± 1.42), the carcasses of 46 (0.27 %, Mean ± SEM: 0.37 ± 0.06) and the kidneys of 113 (0.65 %, Mean ± SEM: 0.75 ± 0.11) of these animals were condemned. More organs and carcasses were condemned in spring (43.71 %) and winter (39.35 %) than in summer or autumn ($p < 0.001$). Condemnation of lungs and livers was primarily attributed to cystic echinococcosis with a rate of 22.49 % and 8.92 %, respectively. In contrast, carcasses and kidneys were condemned for non-parasitic causes related to cachexia (0.16 %) and nephritis (0.37 %), respectively. Parasitic and non-parasitic causes were respectively responsible for 31.43 % and 2.53 % of all condemned organs and carcasses, with a retail value (based on market prices in 2019) of RIAL 4,977,200,000 (USD 35,551.42) and RIAL 2,283,800,000 (USD 16,312.85), respectively. The findings of this study provide baseline data for future monitoring to assess the impact of education and training. In addition, the data on the cost of these infections at slaughter can be used in education programs to encourage changes in management which also could impact overall health of the dromedaries.

1. Introduction

Iran, with 31 provinces and an area of 1,648,195 km^2, is one of the important livestock production regions in the Middle East. In addition to cattle, sheep and goats, Iran has over 170,000 dromedaries (*Camelus dromedarius*) which serve as important sources of milk and meat for human consumption and wool and hides for clothing and other textile articles (Agriculture-Jahad Ministry of Iran, 2016). Dromedaries also are widely used in transportation and other working activities in Iran. Dromedaries can be found in 21 of the 31 provinces with the majority in hot and arid or semiarid provinces such as Isfahan, Khorasan Razavi, south Khorasan, Semnan, Sistan-Baluchestan and Yazd (Anvari-Tafti et al., 2013). Due to its physiological attributes, the dromedary is the most suitable domestic mammal for use in these climatic extremes. In these regions, free grazing patterns predominate and dromedaries share grazing land and water resources with other animals, shepherds and villagers. These shared resources provide opportunities for disease transmission between animal species and between dromedaries and people, via direct contact and via milk or meat consumption. Some of the zoonoses of concern include leptospirosis, brucellosis, echinococcosis, linguatulosis and toxoplasmosis (Sazmand et al., 2019; Mohammadpour et al., 2020).

Meat inspection at abattoirs with condemnation of infected organs plays an important role in prevention of transmission of parasitic and

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other diseases from animals to people. These inspection data can be a source of valuable information on the incidence and epidemiology of animal diseases and extent the public is exposed to certain zoonotic diseases (Alton et al., 2010). Also, abattoir data on the condemnation of organs and carcasses can be used to estimate the level of food wastage (meat) and financial losses incurred from parasitic and other diseases. Food wastage from diseases and the related financial losses have been documented to vary widely by region, animal and production methods (Ansari-Lari and Moazzeni, 2006; Alton et al., 2010; Borji and Parandeh, 2010; Ahmadi and Meshkehkar, 2011; Borji et al., 2012; Oryan et al., 2012; Tembo and Nonga, 2015; Madzingira et al., 2018; Molla et al., 2019; Wilson et al., 2019). Of the various production animals, there are less data available for dromedaries. These data are needed to understand the importance of intervention programs, assess cost of interventions versus cost of meat waste and to assess risk of zoonoses.

2. Materials and methods

2.1. Study area

This 5-year retrospective study was conducted using data from April 2014 to April 2019 from seventeen abattoirs in the seventeen districts of Isfahan province, central Iran (106786 km^2; 49° 36′ and 55° 21′ E longitude and 30° 43′ and 34° 27′ N latitude). The climate of the study area is arid to semi-arid; the mean monthly temperature reaches its maximum (28.8 °C) during July to August and its minimum (3.3 °C) in January. Mean annual temperature is 10.8 °C. Rainfall is seasonal with 80 % occurring between January and April. The mean annual rainfall is 70 mm (Isfahan meteorological office internal reports).

Isfahan province abattoirs process approximately 15–19% of the dromedaries brought to slaughter in Iran, based on data from 2016 to 2018 (Statistical Centre of Iran, 2017, 2018). Most of the dromedaries presented to the Isfahan abattoirs are from the province with a smaller percentage from surrounding provinces.

2.2. Data collection and categorization

The data in this study included inspections of all dromedaries (17,336) slaughtered from April 2014 to April 2019 at the 17 abattoirs in Isfahan province. Each of the abattoirs included in this study follow the same guidelines and regulations for meat inspection with experienced veterinarians assessing organs and carcasses and recording reason for condemnation using standardized data sheets. Monthly reports from all dromedary meat inspections were provided to the researchers, uploaded into Microsoft Excel version 16 and checked for missing data and data entry accuracy. Reason for condemnation was then categorized as parasitic (*Echinococcus* cyst, *Fasciola*, and *Cysticercus tenuicollis* (metacestode of *Taenia hydatigena*)) or non-parasitic (abscess, necrosis, pneumonia, nephritis, cachexia, cirrhosis, and oedema). Data on age and sex of animal were not included in the study data set. Since all abattoirs followed the same inspection guidelines and there were no data suggesting differences in the source or management of the dromedaries presented to each abattoir, all data were combined to represent the province.

2.3. Direct financial losses

Direct financial losses were estimated using information from local butchers and customers obtained in March 2019 regarding the average cost of dromedary lung, liver and kidney (per organ) and carcass (per kg). The average price and the quantity of organs or kg carcass was then multiplied. For example, the average price for lung and the total number of lungs condemned were multiplied to determine the cost of loss. The prices used were RIAL 800,000, 1,200,000, 200,000 and 1,200,000, for lungs, liver, kidney and kg of carcass, respectively. For cost calculations, a currency exchange rate of USD 1 = RIAL 140,000 was used.

2.4. Statistical analysis

Once the data set was complete, descriptive statistics using proportions and percentages were used to determine condemnation rates for carcasses and organs by year, season and cause. Data were imported into Statistical Package for Social Sciences (SPSS) version 21 for statistical analysis. Data were tested for normality using the One-Sample Kolmogorov-Smirnov test. Due to the abnormal distribution of the data, the nonparametric Kruskal-Wallis method was used to compare several independent groups and the Dunn-Bonferroni post hoc method was performed following a significant Kruskal-Wallis test. The Mann-Whitney *U* test was used to compare two independent groups (parasitic versus non-parasitic condemnation). Friedman's test was used to compare several related samples and in order to compare the two related groups the Wilcoxon Signed-Rank test was used. Significance in all statistical tests was set at $p < 0.05$ or $p < 0.01$, depending on the number of tests.

3. Results

Of the 17,336 dromedaries slaughtered during the study period, 5,887 (33.95 %) had one or more parasitic or non-parasitic infections leading to partial or total condemnation of organs or carcasses (Table 1). During the 5-year period, the proportion of condemned lungs (23.08 %) was significantly greater than those of condemned livers (9.95 %) and the rest of the condemned parts (0.91 %) ($p < 0.01$). The annual rate of condemned organs and carcasses due to parasitic and non-parasitic infections varied year to year with decreases from 2014 to 2016 (31.81 % to 27.91 %) and increases in 2018 and 2019 (44.89 % and 54.11 %, respectively). Over the study period, the highest rate of condemnation was in spring (43.71 %), followed by winter (39.35 %) ($p < 0.01$) (Table 1). There were seasonal differences between the study years with some years having higher rates in summer than winter; however, autumn consistently had the lowest condemnation rate. Seasonality was driven primarily by the parasitic causes of condemnation, with much less seasonal variation in the non-parasitic causes (Table 2).

Whole carcasses and kidneys were only condemned due to non-parasitic causes with cachexia and nephritis being the primary causes, respectively. However, for organs overall, condemnation due to parasitic infection (mean ± SEM; 37.89 ± 3.01) was significantly more than that due to non-parasitic infection (1.50 ± 0.50) ($p < 0.001$) (Table 3). For livers and lungs, the main cause of condemnation was cystic echinococcosis (8.63 %; $p = 0.000$, 2.81 ± 0.28 and 22.49 %; $p = 0.010$, 26.62 ± 16.84) (Table 4). The other parasites, *Fasciola* in liver and *C. tenuicollis* in liver and lungs, were rarely causes of condemnation. The second most common reason for condemnation of liver was the presence of abscesses (4.4 %) ($p = 0.53$; 0.44 ± 0.73) and, for lungs, was pneumonia (0.37 %; $p = 0.077$, 0.41 ± 0.62).

Economic losses related to condemnation of organs or carcasses from the 5-year data were estimated to be RIAL 7,258,600,000 (USD 51,847.14). This included financial losses associated with condemned organs, which were calculated as RIAL 5,293,000,000 (USD 37,807.14) and carcass weight losses amounting to RIAL 1,956,600,000 (USD 14,040). The main condemned organ was lung, responsible for losses of up to RIAL 3,201,600,000 (USD 22,868.57), of which RIAL 3,120,800,000 (USD 22,291.42) was associated with cystic echinococcosis only. When considering all condemnations and related economic loss, parasitic infection (RIAL 4,977,200,000 or USD 35,551.42) was greater than non-parasitic infection (RIAL 2,283,800,000 or USD 16,312.85). In these calculations of the cost of the losses, it is important to note that prices used were market averages. Hence, if condemned carcasses were from very young or very old animals (less valuable meat), the cost of losses could be overestimated. Conversely, if most condemned carcasses were of the most desirable age ranged, using an average price could underestimate losses.

Table 1
Number (percent) of dromedary (*Camelus dromedaries*) carcasses or organs condemned by cause at abattoirs of Isfahan province, Iran from April 2014 to April 2019.

Year	Season	N	Carcass			Liver						Lung				Kidney		Total
			Oe	Ca	W (Kg)	Fa	Cyst	Cy	Ab	Nec	Ci	Cyst	Cy	Ab	Pneu-monia	Neph	Hn	
2014-2015	Spring	1085	3	1	130	0	32	0	3	1	4	265	0	4	4	6	0	324 (29.9)
	Summer	961	2	2	73	3	72	0	20	16	3	145	0	4	9	8	2	286 (29.8)
	Autumn	1276	2	1	135	4	39	0	15	16	2	196	0	3	7	6	5	296 (23.2)
	Winter	1235	2	0	45	1	84	0	14	12	4	407	0	4	1	6	9	544 (44.0)
	Total	**4557**	**9 (0.2)**	**4 (0.1)**	**383**	**8 (0.2)**	**227 (5.0)**	**0**	**52 (1.1)**	**45 (1.0)**	**14 (0.3)**	**1013 (22.2)**	**0**	**15 (0.3)**	**21 (0.5)**	**26 (0.6)**	**16 (0.4)**	**1450 (31.8)**
2015-2016	Spring	1264	0	0	0	0	81	0	4	2	3	292	0	3	3	2	4	394 (31.2)
	Summer	815	1	0	26	2	65	0	2	1	3	159	0	3	3	2	1	242 (29.7)
	Autumn	1502	1	0	60	1	72	0	3	3	4	228	0	3	2	5	2	324 (21.6)
	Winter	1335	0	0	0	1	210	0	4	5	1	267	0	0	4	1	0	493 (36.9)
	Total	**4916**	**2 (0.04)**	**0**	**86**	**4 (0.1)**	**428 (8.7)**	**0**	**13 (0.3)**	**11 (0.2)**	**11 (0.2)**	**946 (19.2)**	**0**	**9 (0.2)**	**12 (0.2)**	**10 (0.2)**	**7 (0.1)**	**1453 (29.6)**
2016-2017	Spring	808	0	2	50	2	108	1	0	1	0	293	0	1	4	6	0	418 (51.7)
	Summer	874	1	2	48	0	56	1	0	3	2	88	0	3	5	6	7	174 (19.9)
	Autumn	1448	0	5	80	2	57	2	0	0	0	196	2	0	3	5	0	272 (18.8)
	Winter	1076	0	1	45	1	71	0	0	0	0	232	1	0	1	1	2	310 (28.8)
	Total	**4206**	**1 (0.02)**	**10 (0.2)**	**223**	**5 (0.1)**	**292 (6.9)**	**4 (0.1)**	**0**	**4 (0.1)**	**2 (0.04)**	**809 (19.2)**	**3 (0.1)**	**4 (0.1)**	**13 (0.3)**	**18 (0.4)**	**9 (0.2)**	**1174 (27.9)**
2017-2018	Spring	310	1	2	120	8	84	0	2	0	1	152	0	0	6	2	2	260 (83.9)
	Summer	348	1	2	157	3	53	0	1	1	1	84	0	1	3	1	1	152 (43.6)
	Autumn	615	0	1	20	2	47	0	2	1	2	109	0	1	1	1	1	168 (27.3)
	Winter	560	1	2	75	3	61	0	1	1	1	164	0	3	1	1	4	243 (43.4)
	Total	**1833**	**3 (0.2)**	**7 (0.4)**	**372**	**16 (0.9)**	**245 (13.4)**	**0**	**6 (0.3)**	**3 (0.2)**	**5 (0.3)**	**509 (27.8)**	**0**	**5 (0.3)**	**11 (0.6)**	**5 (0.3)**	**8 (0.4)**	**823 (44.89)**
2018-2019	Spring	367	0	2	50	8	96	0	1	0	1	166	0	1	2	1	2	280 (72.3)
	Summer	410	0	2	159	3	65	0	1	1	1	146	0	1	3	1	2	226 (55.1)
	Autumn	453	2	1	226	2	43	0	2	0	3	126	0	0	1	1	1	182 (40.2)
	Winter	594	1	2	135	1	100	0	1	1	1	183	0	2	1	2	4	299 (50.3)
	Total	**1824**	**3 (0.2)**	**7 (0.4)**	**570**	**14 (0.8)**	**304 (16.7)**	**0**	**5 (0.3)**	**2 (0.1)**	**6 (0.3)**	**621 (34.2)**	**0**	**4 (0.2)**	**7 (0.4)**	**5 (0.3)**	**9 (0.5)**	**987 (54.1)**
All years 2014-2019	Spring	**3834**	4	7	350	18	401	1	10	4	10	1168	0	9	19	17	8	1676 (43.7)[a]
	Summer	**3408**	5	8	463	11	311	1	24	22	10	622	0	12	23	18	13	1080 (31.7)[b]
	Autumn	**5294**	5	8	521	11	258	2	22	20	11	855	2	7	14	18	9	1242 (23.5)[c]
	Winter	**4800**	4	5	300	7	526	0	20	19	7	1253	1	9	8	11	19	1889 (39.4)[a]
	Total	17366	**18 (0.1)**	**28 (0.2)**	**1171**	**47 (0.3)**	**1496 (8.6)**	**4 (0.02)**	**76 (0.4)**	**65 (0.4)**	**38 (0.2)**	**3898 (22.5)**	**3 (0.02)**	**37 (0.2)**	**64 (0.4)**	**64 (0.4)**	**49 (0.3)**	**5887 (35.0)**

N: Number of examined animals; Oe: Oedema; Ca: Cachexia; Fa: *Fasciola*; Cyst: *Echinococcus* cysts; Cy: *Cysticercus tenuicollis*; Ab: Abscess; Nec: Necrosis; Ci: Cirrhosis; Neph: Nephritis; Hn: Hydronephrosis.
Spring: April-June; Summer: July-September; Autumn: October-December; Winter: January-March.
Values with diff ;erent letters (a–c) are statistically diff ;erent ($P < 0.01$).

Table 2
Number (percent) of dromedary (*Camelus dromedaries*) organs and carcasses condemned for parasitic (P) versus nonparasitic (NP) causes by season at abattoirs (17) of Isfahan province, Iran, April 2014 to April 2019.

Year	Spring			Summer			Autumn			Winter		
	N	P	NP	N	P	NP	N	P	NP	N	P	NP
2014–2015	1085	297 (27.4)	27 (2.5)	961	220 (22.9)	66 (6.9)	1276	239 (18.7)	57 (4.5)	1235	492 (39.8)	52 (4.2)
2015–2016	1264	373 (29.5)	21 (1.7)	815	226 (27.7)	16 (2.0)	1502	301 (20.0)	23 (0.01)	1335	478 (35.8)	15 (1.1)
2016–2017	808	404 (50.0)	14 (1.7)	874	145 (16.6)	29 (3.3)	1448	259 (17.9)	13 (0.9)	1076	305 (28.3)	5 (0.5)
2017–2018	310	244 (78.7)	16 (5.2)	348	140 (40.2)	12 (3.4)	615	158 (25.7)	10 (0.2)	560	228 (40.7)	15 (2.7)
2018–2019	367	270 (73.6)	10 (2.7)	410	214 (52.2)	12 (2.9)	453	171 (37.7)	11 (2.4)	594	284 (47.8)	15 (2.5)
All years 2014–2019	3834	1588 (41.4) 1676 (43.7)[a]	88 (2.3)	3408	945 (27.7) 1070 (31.4)[b]	135 (4.0)	5294	1128 (21.3) 1242 (23.5)[c]	114 (2.2)	4800	1787 (37.2) 1889 (39.4)[a]	102 (2.1)

N: number of carcasses/organs examined.
Spring: April-June; Summer: July-September; Autumn: October-December; Winter: January-March.
P: Total number of organs and carcasses condemned due to parasitic infection (*Cysticercus tenuicollis*, *Fasciola*, and *Echinococcus* cysts).
NP: Total number of organs and carcasses condemned due to non-parasitic infection (oedema, cachexia, abscess, necrosis, cirrhosis, pneumonia, nephritis and hydronephrosis).

Table 3
Number (percent) of dromedary (*Camelus dromedaries*) organs and carcasses condemned for parasitic (P) versus nonparasitic (NP) causes at abattoirs (17) of Isfahan province, Iran, April 2014 to April 2019.

Year	N	Carcass	Liver		Lung		Kidney	Total	
		NP	P	NP	P	NP	NP	P	NP
2014–2015	4557	13 (0.3)	235 (5.2)	111 (2.4)	1013 (22.2)	36 (0.8)	42 (0.9)	1248 (27.4)[a]	202 (4.4)[b]
2015–2016	4916	2 (0.04)	432 (8.8)	35 (0.7)	946 (19.2)	21 (0.4)	17 (0.3)	1378 (28.0)[a]	75 (1.5)[b]
2016–2017	4206	11 (0.3)	301 (7.2)	6 (0.1)	812 (19.3)	17 (0.4)	27 (0.6)	1113 (26.5)[a]	61 (1.5)[b]
2017–2018	1833	10 (0.5)	261 (14.2)	14 (0.8)	509 (27.8)	16 (0.9)	13 (0.7)	770 (42.0)[a]	53 (2.9)[b]
2018- 2019	1824	10 (0.5)	318 (17.4)	13 (0.7)	621 (34.2)	11 (0.6)	14 (0.8)	939 (51.5)[a]	48 (2.6)[b]
2014–2019	17336	46 (0.3)[c]	1547 (8.9)[a] 1726 (10.0)[b]	179 (1.0)[b]	3901 (22.5)[a] 4002 (23.1)[a]	101 (0.6)[b]	113 (0.7)[c]	5448 (31.4)[a] 5887 (34.0)	439 (2.5)[b]

N: number of carcasses/organs examined.
P: Total number of organs and carcasses condemned due to parasitic infection (*Cysticercus tenuicollis*, *Fasciola*, and *Echinococcus* cysts).
NP: Total number of organs and carcasses condemned due to non-parasitic infection (oedema, cachexia, abscess, necrosis, cirrhosis, pneumonia, nephritis and hydronephrosis).
Values with diff ;erent letters (a–c) across rows within categories (carcass, liver, etc.) are statistically diff ;erent ($P < 0.01$).

Table 4
Comparative frequency (number (percent)) of causes of dromedary (*Camelus dromedaries*) liver and lung condemnation at abattoirs (17) of Isfahan province, Iran, April 2014 to April 2019.

Year	Liver							Lung				
	Fasciola	Cyst	Cy	Abscess	Necrosis	Cirrhosis	Total condemned	Cyst	Cy	Abscess	Necrosis	Total condemned
2014–2015	8 (2.3)	227 (65.6)	0	52 (15.0)	45 (13.0)	14 (4.1)	346	1013 (96.6)	0	15 (1.4)	21 (2.0)	1049
2015–2016	4 (0.9)	428 (91.6)	0	13 (2.8)	11 (2.4)	11 (2.4)	467	946 (97.8)	0	9 (0.9)	12 (1.2)	967
2016–2017	5 (1.6)	292 (95.1)	4 (1.3)	0	4 (1.3)	2 (0.7)	307	809 (97.6)	3 (0.4)	4 (0.5)	13 (1.6)	829
2017–2018	16 (5.8)	245 (89.1)	0	6 (2.2)	3 (1.1)	5 (1.8)	275	509 (97.0)	0	5 (1.0)	11 (2.1)	525
2018–2019	14 (4.2)	304 (91.8)	0	5 (1.5)	2 (0.6)	6 (1.8)	331	621 (98.3)	0	4 (0.6)	7 (1.1)	632
All years 2014–2019	47 (2.7)[b]	1496 (86.7)[a]	4 (0.2)[c]	76 (4.4)[b]	65 (3.8)[b]	38 (2.2)[b]	1726	3898 (97.4)[a]	3 (0.1)[c]	37 (0.9)[c]	64 (1.6)[b]	4002

Cyst: *Echinococcus* cyst; Cy: *Cysticercus tenuicollis*.
Values with diff ;erent letters (a–c) across rows within categories (*Fasciola*, cyst, etc.) are statistically diff ;erent ($P < 0.01$).

4. Discussion

The present study revealed that several different conditions result in the wastage of organs and carcasses, thereby reducing the availability of dromedary meat and depriving farmers and dromedary traders of income. Infections which cause considerable economic loss in livestock at slaughter also can cause reduced weight gain and milk production (Ezatpour et al., 2014). Therefore, it is justifiable to find reliable data such as abattoir inspection records, for monitoring epidemiologic aspects of parasitic and other diseases and prepare baseline data for future

comparison (Ansari-Lari and Moazzeni, 2006; Wilson et al., 2019). Although there are some limitations in making comparisons across abattoirs and regions due to differences in inspection procedures which can influence detection rates of disease, the data presented here, with a large number of inspected carcasses, can be used to build baseline data for dromedaries and understand differences with other livestock.

In comparison with other abattoir studies with dromedaries, most either have few animals or focus on specific organs or only parasitic causes. However, in general, results from these other studies are similar to the findings presented here. The rate of carcass condemnation found is higher than that determined by Borji and Parandeh (2010) with dromedaries in northwestern Iran and lower than that found by Tenaw et al. (2015) at Akaki Abattoir, Addis Ababa, Ethiopia. The condemnation rate of organs and carcasses is lower than reported by Tenaw et al. (2015) but higher than Lemma et al. (2016) in the same abattoir and the proportion of lung to liver condemnation is in line with the studies by Tenaw et al. (2015).

The rate of carcass condemnation in this study is higher than that determined for cattle, sheep and buffalo in southwestern and northwestern Iran, although, in general, organ and carcass condemnation rates have been found to be lower in dromedaries compared to other livestock (Borji and Parandeh, 2010; Borji et al., 2012; Ahmad and Eisharawy, 2018). The present study showed that condemned organs due to parasitic infection are significantly higher than those due to non-parasitic infections, which also is consistent with studies in dromedaries and in other livestock (Getaw et al., 2010; Borji et al., 2012; Molla et al., 2019; Wilson et al., 2019). Kidney condemned due to nephritis and hydro-nephritis also is similar to what has been found in other livestock (Madzingira et al., 2018; Molla et al., 2019). In contrast to parasitic causes in organ condemnation, cachexia and edema are the primary causes of carcass condemnation in the study presented here, which is in agreement with livestock in other regions including Ethiopia and Namibia (Madzingira et al., 2018; Molla et al., 2019). However, parasitic infections, specifically cysticercosis and sacrocystosis, were the main cause for livestock carcass condemnation in southwestern and northwestern Iran (Borji and Parandeh, 2010; Borji et al., 2012).

In the study presented here, a common cause of lung and liver condemnation was cystic echinococcosis, caused by larval stages of most likely *E. granulosus* genotype 1 or *E. canadensis* genotype 6, both of which are zoonotic and present in the region albeit with genotype 1 predominating (Karamian et al., 2017; Khademvatan et al., 2019). In general, infections can be higher in older animals due to increased exposure over time with the prevalence a reflection of animal age at slaughter. The high prevalence of cystic echinococcosis in this study suggests that communal pastures are contaminated with feces from dogs or other canids that serve as the final host for *Echinococcus* and that there is a lack of effective control strategies, insufficient coverage of anthelmintic use and lack of awareness among dromedary producers. Backyard slaughtering, poor public awareness and the feeding of dogs with offal containing *Echinococcus* cysts promotes the life cycle of the parasite. Due to its zoonotic importance, public awareness and livestock extension services need to be implemented to reduce the disease burden on the human population (Tembo and Nonga, 2015).

Pneumonia, abscess and *C. tenuicollis* were other causes of lung condemnation. Pneumonia could be due to exposure of animals to bacterial or viral origin infections on which further research is needed, stress factors including exposure to dust and starvation. Moreover, penetration of lung tissue by foreign body, adverse weather condition or accidental inhalation of liquid may cause pneumonia and abscess. In regards to *C. tenuicollis*, dromedaries have been suggested as an aberrant host with infections being rare, as is the case in the data from Isfahan presented here. Given the rarity of this infection, future studies should include molecular characterization which could assist in confirming the genus and species, determine if these are actual cases or misidentification of, for example, *C. dromedarii*, and provide more information on the true occurrence in dromedaries.

The occurrence of fasciolosis (0.27 %) in the present study is low compared to the average of 5.3 % seen in livestock in southwestern Iran (Borji et al., 2012) and is on the low side of the range (0–5.3%) found by Sazmand and Joachim (2017) in a review of parasitic diseases of dromedaries in Iran and the range of 0.24–1.07% found by Ansari-Lari and Moazzeni (2006) in other livestock in south Iran. The low occurrence may be due to limited presence of intermediate hosts and control strategies in other livestock in the study area; however, to better understand the epidemiology and relation to infections in other livestock in the area, species determination (*F. hepatica* or *F. gigantica*) is needed.

Seasonal differences in the rate of condemned organs and carcasses in this study are consistent with studies carried out by Alton et al. (2010). This may be due to seasonal differences in the quality of animals being submitted to the abattoir. Animals slaughtered during the winter may reflect those animals which grew more slowly due to health issues causing delayed market readiness, thus, resulting in more condemnations at slaughter during this season (Alton et al., 2010). In regards to annual differences in condemnation rates, it is difficult with five years of data to determine if the increases in 2018 and 2019 are a potential trend or if these could have been influenced by climatic differences impacting parasite development with the years with lower condemnation being drier and those with higher condemnation having more rainy days and more rainfall.

This is the first study to produce an estimate of the annual economic burden of carcass and organ condemnation in dromedaries in Iran and the results are similar to those in other dromedary studies and other livestock with the economic losses caused by parasitic infection greater than non-parasitic infections (Alton et al., 2010; Borja and Parandeh, 2010; Borji et al., 2012; Molla et al., 2019). The greatest financial losses were due to the condemnation of lungs, primarily attributable to the presence of *Echinococcus* cysts which again is similar to other studies (Borji et al., 2011; Gizachew et al., 2013; Jahed Khaniki et al., 2013; Hayer et al., 2014; Lemma et al., 2016). Parasitic infections are known to decrease production and increase production costs in livestock; hence, addressing these causes of carcass and organ condemnation via improved management of the dromedaries could decrease not only the direct losses from wastage of meat but also improve overall animal welfare, feed conversions, reproduction, weight gain and milk production.

5. Conclusion

The present study demonstrated that in dromedaries slaughtered at abattoirs of Isfahan provinces, Iran, parasitic infections resulted in more condemnation of organs than non-parasitic infections, although whole carcass condemnation and kidney condemnation was due to non-parasitic causes. These infections result in considerable economic losses due to meat wastage and likely also have a high economic cost during animal production. Decreasing these diseases requires cooperation between the public health and official veterinary authorities as well as dromedary and dog owners. Efforts to decrease *Echinococcus* cysts and other parasite infection in dromedaries, via education on proper disposal of condemned offal or meat, minimizing pasture contamination by promoting regular treatment of dogs with praziquantel, targeted treatment for other parasites in dromedaries and improved management, could have broader implications since many parasites infect not only dromedaries but also other livestock. Data on cost of these diseases can be used in educational programs to emphasize the importance of adapting different management systems. Follow-up abattoir studies can be used to assess the impact of educational and intervention measures and enable adaption and transfer to other dromedary production regions. While this study determined that parasites were a primary cause of loss at the abattoir, studies to determine the bacterial and viral causes of loss and means to prevent via management also could improve overall welfare and production.

Authors' contributions

NH designed the study, drafted and revised the manuscript. NH, HR and RM examined the samples and recorded on data sheets. MS analyzed the collected data and JK edited and revised the manuscript.

Declaration of Competing Interest

The authors report no declarations of interest.

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