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ANALYSIS OF THE ECONOMIC IMPACT OF CYSTIC ECHINOCOCCOSIS IN SLAUGHTERED RUMINANTS IN DUHOK PROVINCE, KURDISTAN REGION, IRAQ.

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ABSTRACT

The objective of current study was to determine the prevalence of hydatidosis that is responsible for condemnation of slaughtered animals' viscera and to estimate the livestock-associated monetary losses attributable to cystic echinococcosis, in Duhok Province, Kurdistan region, northwestern Iraq and some nearby area for 8 years (2011-2018). Livestock-associated losses were estimated using data from 7 abattoirs belong to Duhok Veterinary Directorate. Between January 2011 and December 2018, 1,229,669 livestock (852,187 Sheep, 157,311 goats, and 220,171 cattle) were slaughtered with total infection rate of 8.04% (98,919/1,229,669; 95% confidence interval [CI]: 8.03% - 8.04%); and ratios of 9.49% (80,834/852,187; 95% CI: 9.45% - 9.51%), 4.81% (7,561/157,311; 95% CI: 4.79% - 4.84%) and 4.78% (10,524/220,171; 95% CI: 4.76% - 4.81%) in sheep, goats and cattle respectively. The total loss from the condemned organs was 1,218,757$ from about 150 tons of 98,919 different organs, with the highest been in liver which was 951,568$ from 90 tons of 50,461 livers then in liver & lungs together (226,504$ from 37 tons in 13,025 animals), while in lungs the loss was 34,519$ from 22 tons of 34,005 lungs then from kidney (5,048$ from 0.5 ton of 1,148 kidneys) and finally the loss from spleen which was 1,117$ from 0.1 ton of 280 spleen. The infected rate (condemned) liver in sheep and goats was significantly greater than other organs, while in cattle the lung was dominant organ (53.35%, 53.29% and 48.25% respectively). This parasite clearly remains the most common in animal production, causing considerable economic loss in Duhok Province and, presumably, other areas of Iraq.

KEYWORD: **Echinococcosis, Cystic Echinococcosis, Hydatid cysts, Economic loss, Hydatidosis, Zoonosis.**

INTRODUCTION

Animal's production play an important role in human nutrition and socio-economic development. Meat, milk, eggs and even ruminant offal are source of protein, energy, calcium and micronutrients, forming around 28% of protein and 13% of calories worldwide (Herrero and Thornton 2013). In developing countries, livestock act as a direct source of income; contribute to crop production through the provision of manure and traction power (Randolph *et al.* 2007). These countries have 2/3 of the livestock population in the world, but theirs meat production less than a third and a fifth of world's milk (Pradere 2014).

Hydatidosis is one of the important parasitic diseases of livestock that has both economic and public health significance. It is associated with severe morbidity and disability, and is one of the world's most geographically widespread zoonotic diseases (Kebede *et al.* 2009).

Cystic echinococcosis (CE), caused by the larval stage of the taeniid tapeworm *Echinococcus granulosus*, and considered as a public health challenge in many parts of the world. The adult parasite inhabits the small intestine of the dog which considers as a definitive host, the eggs are shed into the environment by the dog's feces. The ingestion of these eggs by the livestock and humans, the infection is occurred and then the cysts develops in the liver, lungs, or other organs (McManus 2003, Torgerson 2003).

Recently, the World Health Organization (WHO) considered CE in as a Neglected Tropical Diseases (NTDs) to be addressed within its 2008–2015 strategic plan for control of

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NTDs (WHO 2007 and Budke *et al.* 2009). Costs associated with CE have a great impact on affected individuals, their families' economy as a whole (Torgerson 2003 and Budke *et al.* 2006).

Cystic echinococcosis considered as a cosmopolitan zoonosis, with highly endemic areas especially South America, China, North Africa, and the Middle East (Eckert and Deplazes 2004). The CE induced production losses in ruminants are losses of offal (liver, lung, etc.), productivity losses (reduction in carcass weight, milk production and fleece value), and fertility losses (Sarıözkan and Yalçın 2009).

In some countries, the production losses due to CE were estimated in various species such as sheep, goats, cattle and yak. Under this concept, CE decreased the commercial value of infected sheep by 10% under Italian field conditions (Mantovani 1980), In China, carcass weight due to CE was reduced 7.2 kg per infected cattle, and 1.1 kg per infected sheep (Yang 1992). In Portugal, the estimation of the reduction in carcass weight, milk production and fleece value as 5–20%, 7–10% and 10–40%, respectively (Houin 1998).

In Spain, (Jimenez *et al.* 2002) reported the reductions in carcass weight and milk production of sheep due to CE and found them 5 and 10%, respectively. In Extremadura, Spain, the costs of condemned viscera were found at approximately 2% of the total yearly costs of CE (Battelli 2004). Monetary losses due to CE have been estimated for Spain (Benner *et al.* 2010), Uruguay (Torgerson *et al.* 2000), Peru (Moro *et al.* 2011), for a highly endemic area of the Tibetan plateau (Budke *et al.* 2005, Yang *et al.* 2010), Tunisia (Majorowski *et al.* 2005), Jordan (Torgerson *et al.* 2001) and Turkey (Sarıözkan and Yalçın 2009).

In Iraq, parasites considered as a most causative agent of the public health diseases (Hussein and Meerkhan 2019), while hydatidosis is considered as one of the most serious helminthic diseases with important socio-economic problem, and the cost was estimated in Iraq as millions dollars (Saeed *et al.* 2000 and Meerkhan and Mero 2018). Its effect is due to the destruction of some animal viscera or the whole carcass, when heavily infected; also the animal milk production, wool and meat are decreased. It is most common in area where sheep/dog cycle operates and it occurs in all Iraqi provinces and territories (Saeed *et al.* 2000). Many epidemiological studies indicated that CE is endemic in Kurdistan, with high variability rates among livestock such as, sheep, goats and cattle (Ghaffar 2008, Meerkhan and Abdullah 2012, Hama 2013, AL-Bosely 2014, Hassan 2017, Meerkhan and Mero 2018).

The novelty of this study is to estimate the economic impact of all loss components of slaughtered ruminant in districts (Amedy, Mankesh, Zakho, Akry, Bardarash and Semel) and some nearby areas of (Shingal, Shekhan, Zummar and Fayda) for the period from 2011 to 2018.

MATERIALS AND METHODS

1. Description of the study area:

The present study was conducted from 2011 to 2018 in Duhok, Kurdistan Region, Iraq. It is a northern Province, most of the population is found in the main districts of cities of Amedy, Mankesh, Zakho, Akry, Bardarash and Semel in addition to some nearby areas of Nineveh province close to Duhok Province, were also included such as, Shingal, Shekhan, Fayda and Zummar.

2. Data Collection:

The data of slaughtered animals, infected organs and their infection rates were gathered from the official records of Duhok Veterinary Directorate. The prices of the different organs for each year were gathered from Duhok traditional Directorate.

3. Economic loss estimation:

The assessment of the direct economic loss attributed to hydatidosis was suggested by (Yemane 1990) and maintained by (Getaw, Beyene *et al.* 2010).

$$\text{Annual loss} = (N_{ps} \times I_{O1} \times C_{O1}) + (N_{ps} \times I_{O2} \times C_{O2}) + \ldots\ldots (N_{ps} \times I_{On} \times C_{On}).$$

Where Nps: total number of positive animal slaughter, I_{O1}: prevalence of organ$_1$ hydatidosis, I_{O2}: prevalence of organ$_2$ hydatidosis, I_{On}: prevalence of final organ hydatidosis, C_{O1}: cost of organ$_1$, C_{O2}: cost of organ$_2$, C_{On}: cost of final organ.

4. Data analysis:

Data analysis for the prevalence was calculated according to the proportion of the infection rates in slaughtered animals. The total losses were calculated using the weight and prices of each organ of each host.

Abattoir survey data were recorded into a MS Excel sheet, and all descriptive analyses were made using the software SPSS (version 19 for Windows). Analysis of variance was assessed to compare several groups using ANOVA according to the infected organ(s). In all tests, P. value of <0.05 was considered indicative of a statistically significant difference. All statistical tests were performed using SPSS 24 software.

RESULTS AND DISCUSSIONS

1. The number of slaughtered animals, infected animals and the infected rates distributed on years discussion:

From a total of 1,229,669 animals slaughtered, the overall prevalence rate was 8.04%. with respect to the years (2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2018), rates of infections were 5.28%, 12.71%, 12.33%, 4.90%, 4.96%, 7.95%, 7.92%, and 7.99%, respectively, with the highest rate in the year, 2012 (Figure 1).

The infection rates in different slaughtered animals were shown in the figure 1, the highest infection rate in sheep was found in the year 2012 and the lowest infection rate was found in the year 2014 (16.51% and 6.37% respectively) which agreed with the results published by (Meerkhan and Abdullah 2012) and (Abdullah 2010), on the other hand, they were disagreed with that published by (Meerkhan and Mero 2018) and (Singh *et al.* 2014), while in goats, the highest infection rate was found in the year 2017 and the lowest infection rate was found in the year 2015 (8.38% and 1.91% respectively).

These results agreed with the results published by (Meerkhan and Abdullah 2012) and (Abdullah 2010), on the other hand, they were disagreed with that published by (Meerkhan and Mero 2018).

Concerning cattle, the highest infection rate was found in the year 2012 and the lowest infection rate was found in the year 2014 (6.96% and 1.36% respectively), these results agreed with the results published by (Meerkhan and Abdullah 2012) and (Abdullah 2010), on the other hand, they were disagreed with that published by (Meerkhan and Mero 2018).

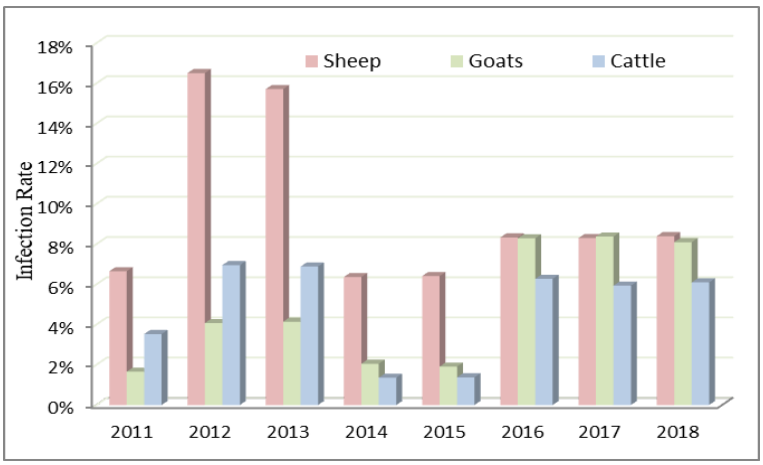

Fig (1): The infection rate of slaughtered animal over years and hosts

2. The number, the weight and the cost of slaughtered animals distributed on years:

During the eight years of this study period, the weight of the total 1,229,669 slaughtered animals and consumed by the Duhok and nearby area inhabitance was shown in table 2 and found 64,822 tons in a cost of 764,892,772 US$ distributed in sheep, goats and cattle (weight:

23,676 tons, cost: 285,345,790 US$; weight: 4,480 tons, cost: 52,179,615 US$ and weight: 36,666 tons, cost: 427,367,368 US$ respectively).

Concerning different animals, the heights weight of consumed meat of sheep and its cost was found in the year 2018 (4,127 tons in 50,333,339 US$), while the lowest weight and its cost was found in the year 2011 (1,702 tons in 20,615,914 US$), with respect to goats, the heights weight of consumed meat and its cost was found in the year 2013 (712 tons in 8,253,383 US$), while the lowest weight and its cost was found in the year 2011 (423 tons in 4,925,612 US$), concerning cattle, the heights weight of consumed meat and its cost was found in the year 2015 (5,800 tons in 65,585,865 US$), while the lowest weight and its cost was found in the year 2011 (2,712 tons in 31,121,863 US$) (Figure 2).

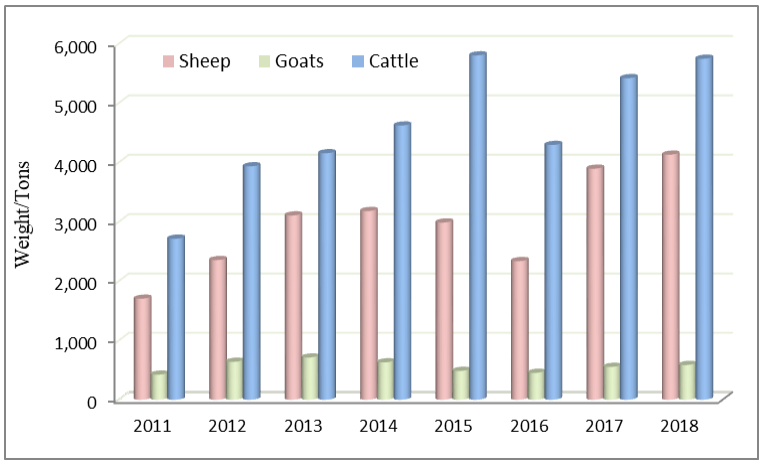

Fig (2): The weight of slaughtered animal distributed on years and hosts

3. The number, infection rate, weight and cost of different lost (infected) organs in slaughtered sheep:

From the total of 80,834 infected sheep, the more infected organ was liver then lungs then (Liver and lungs) then kidney and finally spleen (53.35%, 32.68%, 12.59%, 1.08% and 0.3% respectively) (Table 1 and Figure 3). The lost amounts of liver, lungs, (Liver and lungs), kidney and spleen of sheep were 62.233 tons, 10.653 tons, 18.731 tons, 0.218 tons and 0.071 tons respectively, and lost costs of (658,298 US$, 16,803 US$, 113,709 US$, 2,223 US$ and 729 US$). As a result of the above, the total lost from all organs of sheep was 91.905 tons with a cost of 791,762 US$ (Table 1).

Table (1): The total loss from contamination organs in sheep

	Liver	Liver & Lungs	Lungs	Spleen	Kidney	Total
Infected No.	43,122	10,179	26,419	245	869	80,834
Infection rate	53.35%	12.59%	32.68%	0.3%	1.08%	100%
Tons	62.233	18.731	10.653	0.071	0.218	91.905
Ton Price$	10,600 ± 119	6,077 ± 68	1,555 ± 17.3	10,241 ± 115	10,191 ± 111	
Total$	658,298	113,709	16,803	729	2,223	791,762

4. The number, infection rate, weight and cost of diffirnt lost (infected) organs in slaughtered goats:

From the total of 7,561 infected goats, the more infected organ was liver then lungs then (Liver and lungs) then kidney and spleen (53.29%, 33.17%, 12.21%, 1.2% and 0.13% respectively) (Table 2 and Figure 3). with lost amounts of (5.574 tons, 0.985 tons, 1.644 tons, 0.024 tons and 0.003 tons respectively) and lost cost of (59,025 US$, 1,526 US$, 9,970 US$, 246 US$ and 31 US$). As a result, the total lost from all goats was 8.229 tons with a cost of 70,799 US$ (Table 2).

Table (2): The total loss from contamination organs in goats

	Liver	Liver & Lungs	Lungs	Spleen	Kidney	Total
Infected No.	4,029	923	2,508	10	91	7,561
Infection rate	53.29%	12.21%	33.17%	0.13%	1.2%	100%
Tons	5.574	1.644	0.985	0.003	0.024	8.229
Ton Price$	10,597 ± 116	6,081 ± 68	1,565 ± 17.1	10,307 ± 112	10,257 ± 115	
Total$	59,025	9,970	1,526	31	246	70,799

5. The number, infection rate, weight and cost of diffirnt lost (infected) organs in slaughtered cattle:

From the total of 10.524 infected cattle, the more infected organ was lungs then liver then (Liver and lungs) then kidney and finally spleen (48.25%, 31.45%, 18.27%, 1.97% and 0.24% respectively) (Table 3 and Figure 3) with lost amounts of (10.374 tons, 22.036 tons, 16.87 tons, 0.247 tons and 0.034 tons respectively) and lost costs of (16,189 US$, 234,245 US$, 102,825 US$, 2,580 US$ and 357 US$). As a result, the total lost from all organs of cattle was 49.561 tons with a cost of 356,196 US$ (Table 3).

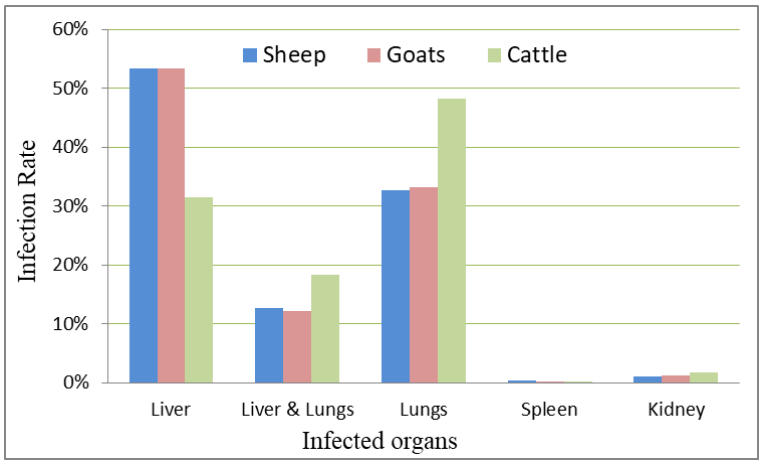

Fig (3): The infection rates in different organs of intermediat hosts.

Table (3): The total loss from contamination organs in cattle

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	Liver	Liver & Lungs	Lungs	Spleen	Kidney	Total
Infected No.	3,310	1,923	5,078	25	188	10,524
Infection rate	31.45%	18.27%	48.25%	0.24%	1.79%	100%
Tons	22.036	16.87	10.374	0.034	0.247	49.561
Ton Price$	10,652 ± 117	6,114 ± 66	1,575 ± 16.8	10,450 ± 117	10,400 ± 116	
Total$	234,245	102,825	16,189	357	2,580	356,196

6. The over all numbers, infection rates, weights and costs of diffirnt lost (infected) organs of all slaughtered animals.

As a total, 98,919 infected animals were found during the study period, the more infected organ was liver then lungs then (Liver and lungs) then kidney and spleen (51.01%, 34.38%, 13.17%, 1.16% and 0.28% respectively) (Figure 4), these results take the same mode of data published by (Borji, Azizzadeh *et al.* 2012) and (Getaw, Beyene *et al.* 2010).

The lost amounts of liver, lungs, (Liver and lungs), kidney and spleen of sheep were 89.843 tons, 22.012 tons, 37.245 tons, 0.488 tons and 0.107 tons respectively, and lost costs of (951,568 US$, 34,519 US$, 226,504 US$, 5,048 US$ and 1,117 US$). As a result, the total lost from all organs of all infected animals was 149.695 tons with a cost of 1,218,757 US$.

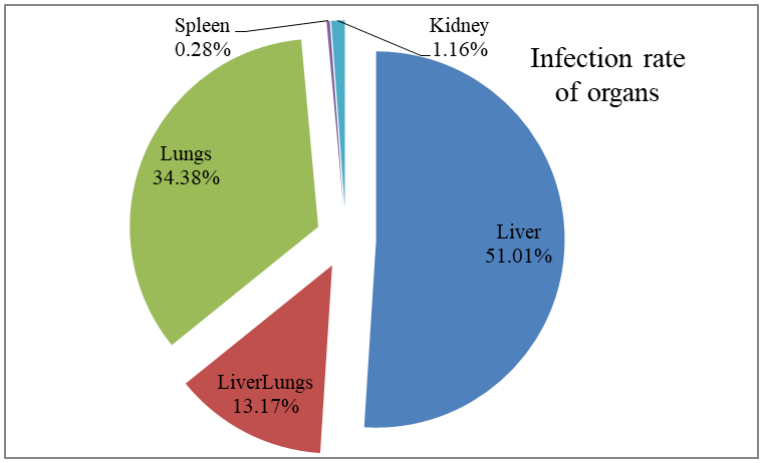

Fig (4): The infection rates in different organs of intermediat hosts.

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