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Review

Livestock Hydatid Disease (Cystic Hydatidosis) in Libya: A Review

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Abstract: Cystic hydatid disease is an infection caused by the larval stage of a cestode parasite called *Echinococcus granulosus*. Hydatid cysts are one of the major parasitic infections in Libya that causes many health problems to human and responsible for economic losses because of the condemnation of the slaughtered animals infected viscera as well as reducing the quality and quantity of the livestock other productions such as milk, wool and meat. Many abattoir investigations in Libya have revealed that, cystic hydatidosis is a disease which infect a wide range of animal species with variable rates of infection, for example, sheep (1.6 to 40%), goats (5.6 to 70%), cattle (2.7 to 56%) and camels (2.7 to 48%). Based on the available abattoirs data, cystic echinococcosis in livestock can be classified as hyper endemic in the country as the infection rate in all animal species reached almost 50% or over which fulfill the WHO criteria. Because of the absence of accurate and updated government records in all abattoirs, it is difficult to estimate the exact economic losses due to cystic hydatidosis in livestock. Diagnosis of the parasite larval stage (hydatid disease) in the living intermediate hosts (ante mortem) is basically by using imaging and serological methods, while after slaughtering the animals (post mortem), the examination of hydatid cysts can be by inspection of several expected infected organs mainly liver and lungs and to some extent other organs including spleen, kidneys, heart, brain and bones of the animal carcasses. Prevention of cystic hydatid disease primarily focusing on veterinary investigations for controlling the extent and the intensity of echinococcosis in the definitive host populations, which indirectly may lead to control the prevalence of hydatid disease in the intermediate host animals. Treatment of cystic hydatidosis in livestock is still under investigation but anti-helminthes drugs can be used. Regular treatment, taking high degree of precautions when handling pets or dealing with animal meat must be taken into consideration to minimize the level of infection and egg excretion as well as the vaccination of ruminant intermediate hosts, are all in evaluation.

Keywords: Cystic Hydatidosis, Dogs, Echinococcosis, Libya, Livestock, Prevalence

Introduction

Cystic Echinococcosis (CE), cystic hydatid disease, or cystic hydatidosis all are terms used to identify infection caused by a tape worm parasite called *Echinococcus granulosus.* CE is a zoonosis and has been reported to occur in all continents of the world. The highest level of cystic hydatid disease recorded in South America, the Mediterranean region including North Africa, Eastern Europe, the Middle East and Far East countries, (Fig. 1), (Eckert *et al*., 2001a). To complete its life cycle, the parasite needs two mammalian animals (hosts); the first is a definitive host, which is usually a domestic/wild carnivore for the adult stage of the parasite and the second is an intermediate host, which is usually domestic/wild ungulates for the larval

(hydatid cyst) stage (Fig. 2). Various species of livestock in Libya known to harbour hydatid cysts such as sheep, goats, cattle and camels, however, these species are the main sources of infection with echinococcosis in dogs. Other animals can be acting as intermediate hosts such as horses, donkeys, pigs, etc. also involved in the life cycle in many other parts of the world (Dalimi *et al*., 2002; Lahmar *et al*., 2004; Daryani *et al*., 2006; Acosta-Jamett *et al*., 2010).

The adult stage of the parasite is approximately 3-7 mm long with typically three segments as well as other cestode morphological features and characteristics which help in species diagnosis (Fig. 3A), (Thompson, 1995). The parasite lives attached to the small intestinal wall of a carnivore definitive host using their hooks and in this place, adult worms produce a large number of eggs (Fig. 3B), which are periodically shed in the faeces and scattered in the environment by birds, insects, wind and water. Eggs also can be carried by uninfected pets on their fur if they get contact to the faeces of infected wild hosts and this is possibly more common in dogs which may roll on contaminated ground and therefore, they become a source of infection to the intermediate hosts. Intermediate hosts became infected when they ingest viable eggs in their foods such as vegetables, fruits and herbs, or drunk in contaminated water or through contaminated hands in case of human hydatidosis for example, pets an infected dogs or cats, handles an infected wild animals or its carcasses, touches contaminated soil with the parasite eggs.

Once the eggs ingested by a suitable intermediate host, they hatch in the duodenum releasing their hexacanth embryos (the oncospheres) which immediately penetrate the intestinal wall towards the mesenteric vessels where they picked up and carried by blood stream to the major filtering organs mainly liver and lungs. Other sites like abdominal wall, brain, kidneys bones, muscles and orbits may also be involved (Polat *et al.*, 2003; Bal *et al*., 2008). The oncospheres requires about one year time to transform and develop into full larval hydatid cysts (Fig. 3C) with a numerous tiny tapeworm heads called protoscoleces that are formed via asexual reproduction (Fig. 3D).

The parasite life cycle to be completed, viable hydatid cysts containing fully developed protoscoleces must be ingested by dogs the definitive hosts and the released protoscoleces then attached themselves to the dog's intestinal lining and start to develop into mature adult tapeworms within 25-80 days depending on the species and the parasite strain. Infected human is the 'dead-end' host for *E. granulosus,* since the life cycle of the parasite is usually completed when carnivores are getting access to infected herbivores organs (McManus *et al*., 2003; Zhang *et al.*, 2003). There may be exceptional circumstances when infected human could also serve to complete the parasite life cycle, for example in some countries in Africa especially in the war regions, where killed people remained unburied for long time and therefore, dogs and other wild carnivores can access to those dead bodies (Macpherson *et al*., 1983).

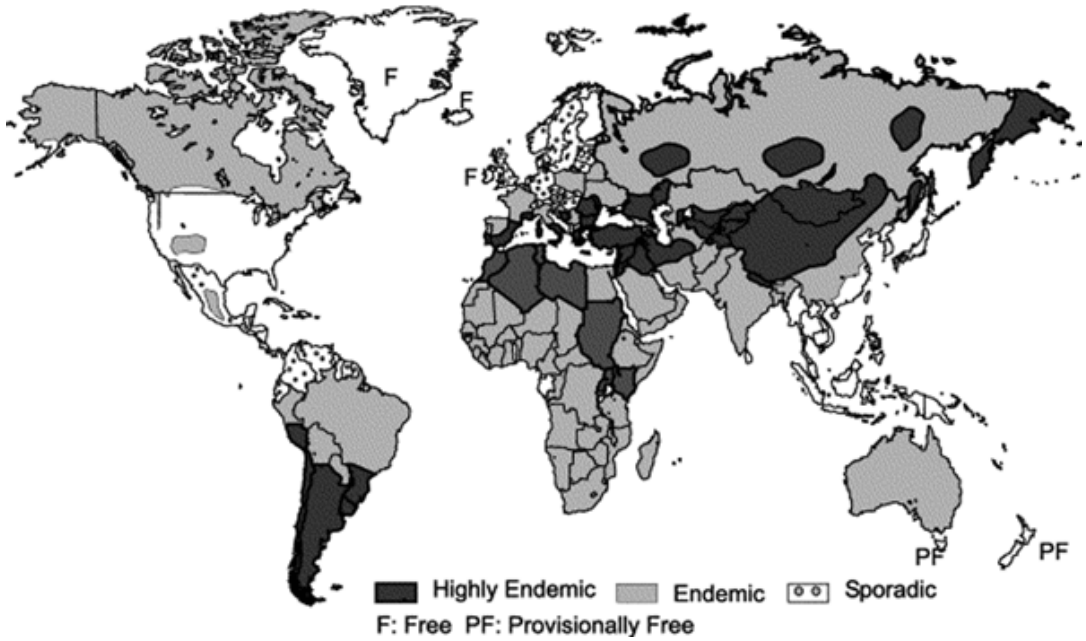


Fig. 1. Geographical distribution of *E. granulosus*. The highest frequency of cystic hydatid disease (*E. granulosus*) is in South America, North Africa, the Mediterranean littoral, Eastern Europe and the Middle and Far East (Adapted from Eckert and Deplazes, 2004)

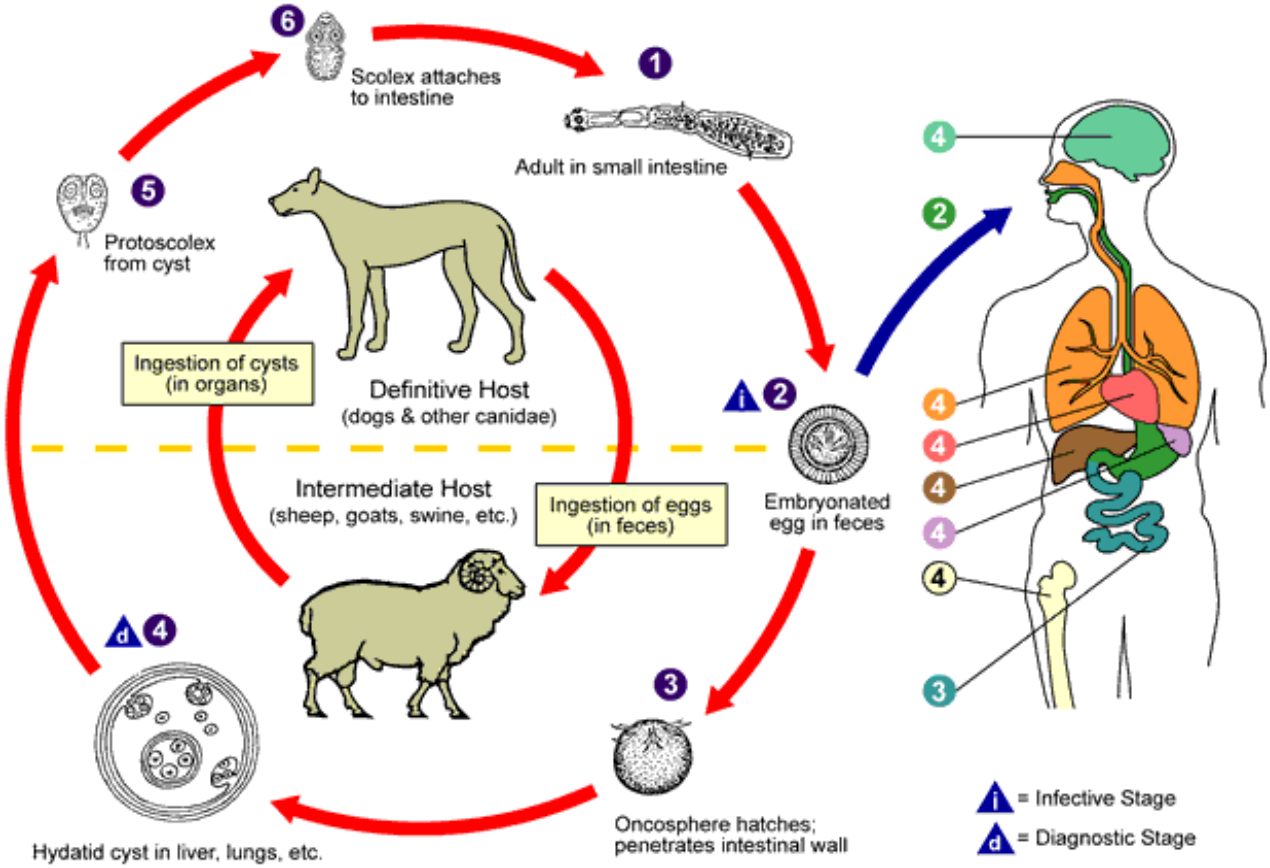


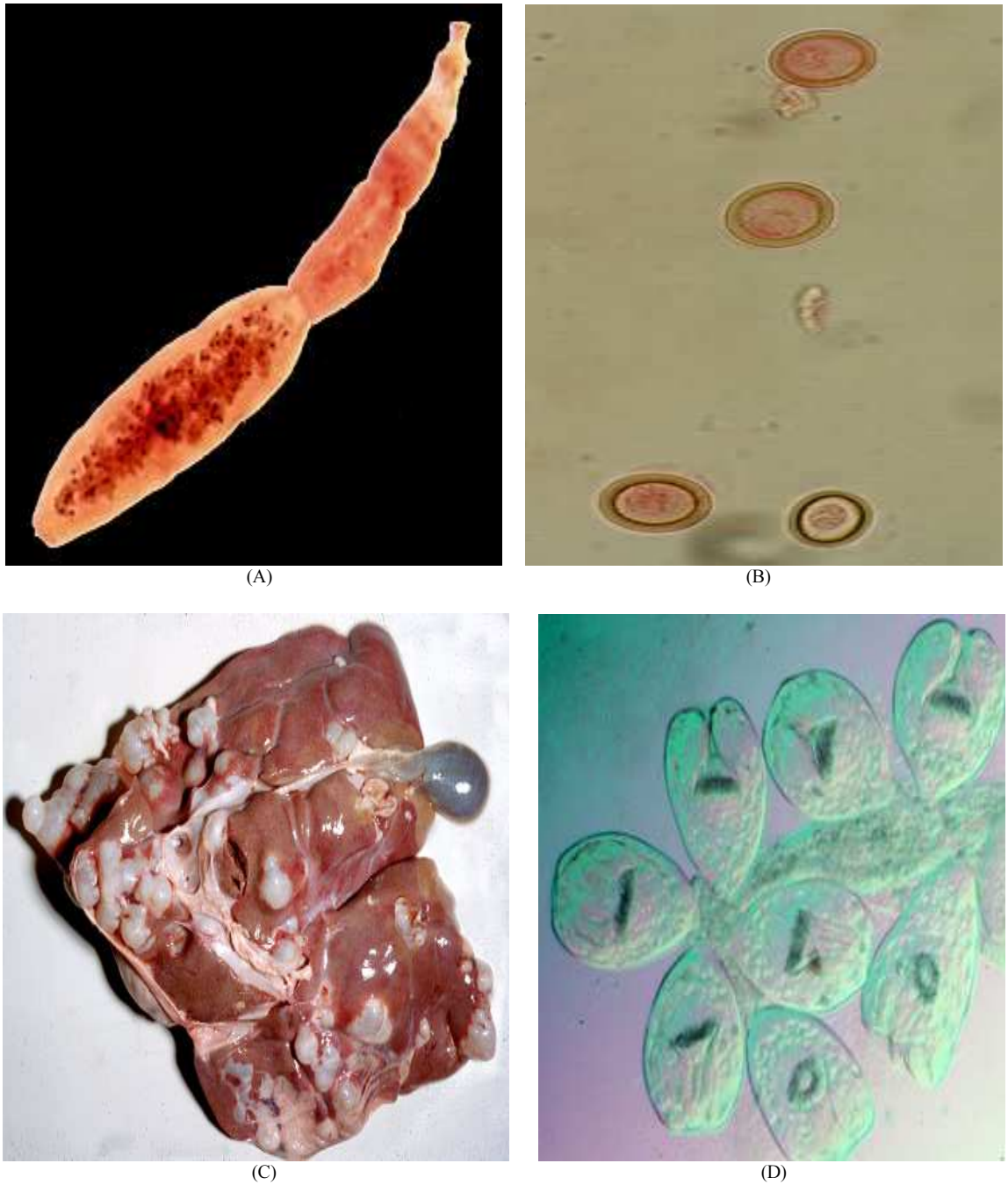
Fig. 2. The adult *Echinococcus granulosus*[1] resides in the small bowel of the definitive hosts, dogs or other canids. Gravid proglottids release eggs[2] that are passed in the feces. After ingestion by a suitable intermediate host (sheep, goat, swine, cattle, horses, camel), the egg hatches in the small bowel and releases an oncosphere[3] that penetrates the intestinal wall and migrates through the circulatory system into various organs, especially the liver and lungs. In these organs, the oncosphere develops into a cyst[4] that enlarges gradually, producing protoscolices and daughter cysts that fill the cyst interior. The definitive host becomes infected by ingesting the cyst-containing organs of the infected intermediate host. After ingestion, the protoscolices[5] evaginate, attach to the intestinal mucosa[6] and develop into adult stages[1] in 32 to 80 days. [2] Humans can become infected on the same way of livestock, [3] hatched oncospheres in the small intestine, [4][4][4][4][4][4] the possible infected organs (courtesy of DPDx)[5]

The aim of our review is to describe the prevalence and history of hydatid disease in livestock along the past few decades in Libya. The review also discusses aspects of the parasite life cycle, transmission, risk factors, economic importance, improved diagnosis, treatment and control and prevention of the disease.

Prevalence and the History of Hydatid Disease in Livestock

Cystic echinococcosis in livestock was first reported in Libya by Medulla (1931) who stated that, CE is common in camels. Three decades later, Cicogna (1961) made a study on the prevalence of hydatid disease in sheep and cattle around Tripoli area and reported that, 40 and 70% of the examined animals were infected with hydatid disease respectively, (Table 1). Abattoir data collected from Benghazi area eastern of the country from 1975 to 1977, indicated that, the rate of infection with CE in imported animals was 0.8% in sheep, 0.0% in goats, 3.1% in cattle and 20% in camels; while in local reared animals, the rate of infection with CE was 2.7% in sheep, 7.9% in goats, 11.2% in cattle and 16.1% in camels, (Table 2), (Gebreel *et al*., 1983). Similar study has been carried out in Tripoli area and the obtained abattoir data on CE in imported animals were 25.8% in sheep, 3.8% in cattle and 26.4% in camels, while in local reared animals, the infection rate was 4.3% in sheep, 6.6% in cattle and 27.2% in camels, (Table 1), (Aboudaya, 1985). Two years later, Gusbi *et al*. (1987) examined 5118 sheep at ten abattoirs around the country and found that, 7.85% of the inspected animals were

infected with hydatid disease, among this number 12.74% were adults and 0.29% were lambs (Table 4). Gusbi *et al*. (1990) also conducted an extensive study on CE in other livestock including 2295 goats, 1023 cattle and 998 camels from 14 abattoirs around the country and reported that, 1.5, 5.4 and 35.9% respectively were infected with hydatid disease (Table 4). Eight years later, Ibrahem and Craig (1998) examined 514 camels, 367 sheep and 184 goats slaughtered in six abattoirs at Zawia, Tripoli, El-Khumes, Misurata, Sirt and Benghazi abattoirs and found that, 15.8, 3.8 and 48%, of sheep, goats and camels, respectively were infected with CE (Table 4).



(A) (B) (C) (D)

Fig. 3. Illustrations showing: (A) Whole mount of adult *E. granulosus* worm, (B) Taeniid species eggs, (C) Heavily infected sheep liver with hydatid disease and (D) Protoscoleces from human infected liver, (A, C and D from Dr. John Walker, Sydney Medical School, University of SYDNEY and B from Jesper Monrad and Christina Thoisen Department of Veterinary Disease Biology, Faculty of Life Sciences - University of Copenhagen, Denmark)

Table 1. Abattoir data on the prevalence of cystic hydatidosis in livestock from Tripoli region

Animal species	Prevalence (%)	Reference
Sheep	40.0	Cicogna (1961)
Cattle	70.0	
Sheep (imported)	25.8	Aboudaya (1985)
Cattle =	3.8	
Camels =	26.4	
Sheep (local)	4.3	
Cattle =	6.6	
Camels =	27.2	

Table 2. Abattoir data on the prevalence of cystic hydatidosis in livestock from Benghazi, Al-Jabel Al-Akhder (Shahat) and Bayada regions

Animal species	Prevalence (%)	Reference
Sheep (imported)*	0.80	Gebreel *et al*. (1983)
Goats =	0.00	
Cattle =	3.10	
Camels =	20.00	
Sheep (local)	2.70	
Goats =	7.90	
Cattle =	11.20	
Camels =	16.10	
Sheep*	20.00	Tashani *et al.* (2002)
Goats	3.40	
Camels	13.60	
Cattle	11.00	
Sheep**	8.70	Al-Khalidi (1998)
Goats	5.40	
Cattle	6.40	
Camels	35.00	
Sheep***	56.00	Ekhnefer (2014)
Goats	40.00	
Cattle	28.57	

*Data from Benghazi region, **Data from Al-Jabel Al-Akhder (Shahat) region, ***Data from Bayada region

Table 3. Abattoir data on the prevalence of cystic hydatidosis in livestock from Misrata and Sirt regions

Animal species	Prevalence (%)	Reference
Sheep*	16.75	Elmajdoub *et al*. (2007)
Cattle	14.62	
Camels	12.96	
Camels*	3.62	Kassem and Gdoura (2006)
Sheep**	4.90	Kassem *et al*. (2013)
Goats	2.40	
Camels	2.70	
Cattle	15.00	

*Data from Misrata region, **Data from Sirt region

Table 4. Abattoir data on the prevalence of cystic hydatidosis in livestock from 30 slaughterhouses around the country

Animal species	Prevalence (%)	Reference
Sheep	7.85	Gusbi *et al.* (1987)
Goats	1.5%	Gusbi *et al*. (1990)
Cattle	5.4%	
Camels	35.9%	
Sheep	15.8	Ibrahem and Craig (1998)
Goats	3.8	
Camels	48	
Sheep	10.52	Elmajdoub and Rahman (2015)
Camels	12.54	
Cattle	10.56	

In the same year but further eastern of the country, data from Shahat abattoir, Al-Jabal Al-Akhdar indicated that, 48/554(8.7%), 18/338(5.4%), 8/124(6.4%) and 14/40(35%) of examined sheep, goats, cattle and camels respectively were infected with hydatid cysts, (Table 2), (Al-Khalidi, 1998). Few years later, Tashani *et al*. (2002) examined 1087 sheep, 881 goats, 428 camels and 614 cattle at post mortem in Benghazi abattoirs eastern of the country and found that, 20, 3.4, 13.6 and 11%, respectively were infected with CE (Table 2). Kassem and Gdoura (2006) examined 1380 local bred camels (*Camelus dromedaries*) slaughtered at Sirt abattoirs middle of the country and found that, 3.62% of the animals were infected with hydatid cysts (Table 3). One year later, investigation on the prevalence of CE in livestock was conducted by Elmajdoub *et al*. (2007) at Misurata abattoirs about 200Km east of Tripoli the capital; the obtained results showed that, 16.75% of 6935 sheep, 14.62% of 1901 cattle and 12.96% of 1863 camels were infected with hydatid cysts (Table 3). In a recent study, also from Sirt abattoirs, Kassem *et al*. (2013), published data on CE in sheep, goats, camels and cattle, the data indicated that, 4.9, 2.4, 2.7 and 15% of examined sheep, goats, camels and cattle respectively were infected with hydatid cysts (Table 3). Further eastern of the country again, data collected from Bayada city abattoirs (Alkhlele and Atellal) showed that, 56%, 40 and 28.57% of examined sheep (715), goats (500) and cattle (350) respectively were infected with hydatid cysts, (Table 2), (Ekhnefer, 2014). Lastly, a study by Elmajdoub and Rahman (2015) who examined 32,971 livestock animals including 25314 sheep, 7496 camels and 161 cattle from different government abattoirs all around the country, the overall prevalence rate of infection with CE was 10.06% and among the individual group of animals, the rate of infection with cystic hydatidosis was 10.52% in sheep, 12.54% in camels and 10.56% in cattle (Table 4). Blood samples from 214 lambs, 2030 sheep and 364 goats originally from the north west of Libya, naturally exposed to the infection with CE were tested serologically for the presence of anti-hydatid antibodies using camel AgB in ELISA and the obtained results were 18, 60 and 27% of lambs, sheep and goats respectively were seropositive, (Table 4), (Ibrahem and Ibrahem, 2015). The reported differences in the rate of prevalence of CE between the different areas and also between the different intermediate hosts could be due to the differences in the environmental factors effecting the parasite eggs, such as temperature, humidity and the nature of the pasture between those areas as well as the existence of different strains of *E. granulosus* morphologically and biochemically adapted to each farm species (Fromsa and Jobre, 2011). Such differences are agreed to those reported from other African countries (Njoroge *et al*., 2002; Ernest *et al*., 2009).

Significant seasonal variations in the prevalence of cystic hydatidosis were also recorded through Libyan abattoir meat inspection and this could be due to the differences in the environmental conditions between the different areas of the country along the different seasons, (Elmajdoub and Rahman, 2015) and these findings agreed to those reported in other countries (Ansari-Lari, 2005; Ibrahim, 2010). In addition, other environmental factors such as high altitudes and increasing annual rainfall are also associated with the variable rates of the prevalence of CE in livestock (Acosta-Jamett *et al*., 2010; Fromsa and Jobre, 2011). Moreover, exposing of the parasite eggs to hostile environmental conditions will reduce their infective capacity (Torgerson *et al*., 1998).

The age of the intermediate hosts are largely recognised as an infection determinant for many animal species. Several studies have recorded higher CE prevalence in old animals compared to young ones (Islam *et al*., 2003; Banks *et al*., 2006; Lahmar *et al*., 2007; Christodoulopoulos *et al*., 2008). However, small animals like sheep and goats at the age of 3 years or over are at higher risk compared to the younger animals (Marshet *et al*., 2011). Furthermore, the number of hydatid cysts in infected animals has been reported to be related to the age of the animals (Cabrera *et al*., 1995; Umur and Kaaden, 2003; Ibrahim, 2010; Zewdu *et al*., 2010).

The highest rate of infection with CE was frequently observed with sheep and camels and they are found to be the most important intermediate hosts for *E. granulosus* (Himonas *et al*., 1994; Tashani *et al*., 2002; Grosso *et al*., 2012). It has been reported that, camels and cattle are usually slaughtered for meat production at older age than the other ruminants and because of this, they have an increased chance of exposure to *E. granulosus'* eggs and therefore they are at high risk during their lifetime. In comparison to sheep, camels and cattle, goats show a lower rate of infection with CE and this possibly because of their grazing type as they are browsers and eat the most distal parts of plants where there is a very little chance of exposure to the parasite eggs.

Factors Influencing the Transmission of CE between Dogs and Livestock

Cystic echinococcosis is one of the parasitic diseases occur in many species of farm animals in Libya with variable rates of infection, but it is observed more regularly associated with the level of infection with *E. granulosus* in dogs in each area. Camels are the most important host and sheep, goats and cattle comes second in the role of transmission and maintenance of *E. granulosus* in the country (Ibrahem and Gusbi, 1997). Many epidemiological factors are found to be associated

with the increasing risk of CE in livestock, such factors include, hosts availability, the contamination level of the environment with the parasite eggs, livestock management, slaughtering of animals without meat inspection. Human behaviour also plays a key role in the distribution and transmission of cystic echinococcosis, such behaviour includes human cultural and economical backgrounds, (Dunn, 1979; Macpherson, 2005). In Libya, human behaviour play an important role in the increasing risk of infection with CE to livestock such as feeding of hydatid infected organs to dogs especially in socio-cultural occasions such as the festival of marriage and the religious day (EID Al-UDHA). During these occasions, hundreds of thousands of animals may be slaughtered in a single day under no veterinary inspection which therefore, maintains a highly infected dog population, the majority of which are farm and strays. In addition, lack of anti-helminthic treatment for infected dogs and dog owners' poor health education are all factors influencing the transmissions of CE between the definitive and intermediate hosts. However, general lack of people knowledge and awareness about infection factors may facilitate the transmission of CE in Livestock and the epidemiological models such as number and age of hosts, geographical location, species of hosts and the farming management type can identify them, (Otero-Abad and Torgerson, 2013).

Economic Importance of Livestock Hydatidosis in Libya

The levels of infection, particularly with *E. granulosus* hydatid cysts, impose an enormous medical, social and economic burden in the affected areas. Losses due to hydatid disease are largely economic through damage to domestic animals with the possible bans of import and export animals and their products especially from endemic areas (Battelli, 2009; Sariozkan and Yalcin, 2009).

For instance, previous reports from the abattoirs around the country showed high rates of infection with CE in slaughtered animals, however, such a situation has a critical economic impact due to the disease causing not only losses of internal animal organs and other products such as milk and meat, but also productivity in general (Lahmar *et al*., 1999).

Estimates of economic losses as a result of destroying the infected organs or the whole animal carcasses due to CE in Libya are not known because of the unavailability of governmental and abattoir records, however, the high level of infection with CE reported in livestock along the last few decades indicate the possible higher economic losses which may reach hundreds of thousands of Libyan dinars annually.

Diagnosis of CE in Livestock

Diagnosis of hydatid disease in livestock is usually based on post mortem investigation which provides an important epidemiological data that can be used to understand the level of infection pressure (Ming *et al*., 1992; Cabrera *et al.*, 1995). Examination of the slaughtered animals viscera such as liver, lungs and other organs is the only practical way for the diagnosis of the hydatid disease, but the problem is that, very small lesions are not always be possible to discover or to differentiate from other helminthic parasites like *Taenia hydatigena*; therefore, extra histopathological investigation may be needed (Lloyd *et al*., 1991; Maxson *et al.*, 1996). Some studies suggested the possibility of using ultrasonography to provide data on the number, size, site and condition of CE in sheep and goats (Maxson *et al*., 1996; Sage *et al*., 1998; Njoroge *et al*., 2000; Lahmar *et al*., 2007) and found to be a sensitive method for the diagnosis of liver CE in sheep. Using this technique alone or together with testing of biochemical parameters reflecting the liver functions could be helpful tools for the diagnosis of CE in the sheep liver, (Hussein and Elrashidy, 2014).

In comparison with human CE, little researches have been employed on the development of immunodiagnostic techniques for CE infection in livestock. Development of sensitive and specific serological assay for the diagnosis of hydatid disease in livestock would provide useful epidemiological information for the ante-mortem study and for control of hydatid disease. Different diagnostic assays including, intradermal (Casoni) Test (ID), indirect immunoelectrophoresis (IEP), counter immunoelectrophoresis (CIEP), double diffusion (DD) and indirect haemagglutination (IHA), have been used for the serodiagnosis of CE, but showed some cross-reactions with other Taeniid cestodes including, *T. hydatigena* and *T. ovis* (Yong *et al*., 1984; Lightowlers and Gottstein, 1995; Sbihi *et al*., 2001). Enzyme-linked immunosorbent assay (ELISA) is a technique developed for the diagnosis of parasitic diseases including CE, although, many conflicting reports have been issued on the suitability of ELISA for the immunodiagnosis of hydatid disease (Farag *et al*., 1975; Iacona *et al*., 1980). Recent researches on the other hand suggested that, ELISA may be successfully performed for the diagnosis of hydatid disease as its sensitivity and reliability are related to the composition, concentration and stability of the antigen used (Sbihi *et al*., 2001; Ibrahem *et al.*, 2002; Nasrieh and Abdel-Hafez, 2004).

Natural infection in livestock showed very poor antibody responses compared to that obtained in human infection (Lightowlers and Gottestein, 1995). In sheep, the main intermediate host for *E. granulosus* in most endemic regions of the world; antibodies to various parasitic antigens were detected in sera of some, but not

all infected animals (Jenkins and Rickard, 1986). Detection of circulating antigen found to be useless for the diagnosis of CE in animals as it has been reported with human (Eckert *et al*., 2001b). Hydatid cyst fluid antigen B from camels and sheep, as well as a recombinant form of AgB (r-AgB) has been used in an ELISA, to test serum samples from slaughtered camels and sheep naturally infected with CE, the test seroreactivity, however, was variable. Antigen B from camel hydatid cyst fluid gave the highest test sensitivity 97% for camel CE and 92 to 95% for sheep CE from three origins (Libya, UK and Iran) while its specificity was 99% for both camel and sheep CE. Lower sensitivity 84% and 28% for camels and sheep CE respectively was obtained with r-AgB. r-AgB was, however, highly specific, yielding 90 and 95% for natural camels and sheep CE infections respectively (Ibrahem *et al*., 1996; 2002). A study carried out by Kittelberger *et al*. (2002) aimed to develop an immunological assay which would allow the monitoring of animals imported to countries free from hydatidosis and to help countries where control schemes for the disease are in operation. The study include three testing ELISAs, 8 kDa AgB from hydatid fluid (8kDa-ELISA), EG95 from oncospheres protein (Onco-ELISA) and crude protoscoleces preparation (Prot-ELISA), the tree assays used against sera from naturally or experimentally infected sheep with CE as well as from non-infected sheep. The highest sensitivity 51.4 to 62.7% was obtained with Prot-ELISA and the assay sensitivities being lower with 8kDa-ELISA and Onco-ELISA. Diagnostic specificities with all three assays were very high 95.8 to 99.5%, though a small number of serum samples from sheep infected with *T. hydatigena* and *T. ovis* were found to be seropositive. Due to its low diagnostic sensitivity, the assay would be only useful for the detection of the presence of infection in sheep on flock basis but not for reliable identification of individual animals. Antigenic characteristic of sheep hydatid cyst fluid was investigated by SDS-PAGE to evaluate its sensitivity and specificity in ELISA and immunoblotting against sheep CE and one antigen with molecular weight of 116 kDa showed 88% sensitivity and 84% specificity in the immunoblot assay (Simsek and Koroghlu, 2004).

More recently, ELISA and Western Blotting (WB) have been evaluated for the serodiagnosis of CE in sheep and goats; the ELISA sensitivity was 66% in sheep and 54% in goats and the specificity was 86% in sheep and 73% in goats; while WB showed 71 and 69% sensitivity in sheep and goats respectively and 65 and 72% specificity in sheep and goats respectively, (Luka *et al*., 2008). In another study, it has been found that, 66 kD fraction of sheep hydatid cyst fluid is the best reactable part and the total IgG in sheep and cattle are the best antibodies for evaluation or diagnosing purposes, however, ELISA and western blotting are reliable enough when using sheep CHCF antigen as the source of antigen in either research or diagnostic evaluation programs (Fallah *et al*., 2014).

Treatment of Cystic Hydatidosis in Livestock with Reference to Human Infection

It has been identified by WHO-IWGE that, the best approach for treatment of CE in human should be based on the image and the cysts stage, which however, help in choosing one of the following treatment options; percutaneous, surgery, anti-infective drug or watch and wait (Brunetti *et al*., 2010). Puncture aspiration, re-aspiration, injection and chemotherapy, also available for treatment (Pawloeski *et al*., 2001). Percutaneous drainage has many advantages and has been used in the treatment of CE in human as alternative to surgery (Yorganci and Sayek, 2002), however, with this method, it is impossible to remove cyst membranes, (laminar and germinative layers). The procedures of this method include puncture of the cyst wall, aspiration of its contents then injecting scolicidal agents and finally re-aspiration of the injecting fluid, as described by Ben-Amor *et al*. (1986), or by catheterization, as described by Akhan and Özmen (1999). Surgical procedures on the other hand start basically with inactivation of the cyst contents and finished with removal of all cyst components (Yorganci and Sayek, 2002; da Silva, 2003).

Chemotherapy as a treatment option of CE started decades ago when a new anti-helminthes drug was introduced. Benzimidazole and praziquantel as example of chemotherapy were introduced in the 1970 s; the first has proved effective against the larval stages of *E. granulosus* in both animals and humans and the second found to be effective on protoscoleces (Heath and Chevis, 1974; Schantz *et al*., 1982). In addition to killing the entire larval stage of the parasite, benzimidazole also inhibit formation of microtubules, thus, reducing uptake of glucose and then interfere with the parasite homeostasis (Lacey, 1990).

Most studies indicate that, the effectiveness of albendazole on CE is generally less than 30% under ideal circumstances, however, continuous treatment with albendazole for a period of up to 6 months is recommended and praziquantel may increase the effect of treatment, especially in the case of cyst spillage (Teggi *et al*., 1993). Generally, 60% of cysts show some response during the course of therapy, including shrinkage in size or separation of the cyst components from its wall. It has been suggested that, albendazole should be used on the daily bases for up to 4 to 6 weeks period and should be repeated further 2 to 3 times.

Because the disease response to most chemotherapy treatment agents is poor, therefore, surgery is considered to be the principle treatment way for cystic echinococcosis. However, using chemotherapy remains an important tool for protection against spillage when removing the cysts, for the treatment of cases when surgery is difficult to perform, or for use in areas where sufficient surgical facilities are unavailable.

Oxfendazole like albendazole has been used in veterinary medicine to control nematode infections and both are similar in their antimicrobial spectra, but oxfendazole has a much longer half-life (Marriner and Bogan, 1980; 1981). In addition, oxfendazole, unlike albendazole, is effective against *E. granulosus* as well as other cestodes in the gastrointestinal tract (Gemmell *et al*., 1979) and thus could be used to treat infection in dogs, the principal reservoir for the infection to the intermediate hosts. Only one study has examined the effect of the drug on the tissue stage of tapeworm infections, this study showed that a single dose of 30 mg/kg of body weight of oxfendazole in pigs completely eliminated all tissue cysts of *Taenia solium*, an important human tapeworm (Gonzales *et al*., 1996). Though, hydatid cyst is much larger than and structurally different from the cyst of cysticercosis, this result prompted a trial of oxfendazole for the treatment of hydatid disease. Similar studies carried out by Blanton *et al*. (1998) and Njoroge *et al*. (2005) using oxfendazole at the same dose on goats and sheep, the obtained results after postmortem examination showed that, 97 and 93.3% of the cysts contain dead protoscoleces or even absent compared to 28 and 27.3% of non treated cysts from control animals respectively. In addition, 53% of treated cysts found to be greatly degenerated and the cysts appeared to be potentially viable, there was sign of severe damage to its wall, the adventitial layer was severely disorganized with invasion of inflammatory cells and in some cases, the cysts were completely dead (Blanton *et al*., 1998). Further study on the evaluation of oxfendazole against CE in sheep showed decreasing in the number of fertile cysts and increasing in the number of degenerated cysts and it was more effectual 91.8-100% against liver cysts and 49.6-61.2% against lung cysts (Gavidia *et al*., 2009).

Based on the reported findings, oxfendazole appeared to be encouraging drug for treatment of cystic hydatidosis and might be used for control programs as an additional strategy.

Control and Prevention of Cystic Hydatidosis

Different genotypes of *E. granulosus spp.* complex have been reported to be the cause of CE to humans and until now 10 genotypes have been characterized by using mitochondrial data. Such species complex involved 4 sub-species; *E. granulosus sensu stricto,* include sheep strain (G1), Tasmanian sheep strain (G2) and buffalo strain (G3); *E. granulosus equines,* include horse strain (G4); *E. granulosus ortleppi,* include cattle strain (G5) and *E. granulosus Canadensis,* include camel strain (G6), pig strain (G7 and G9) and cervid strain (G8 and G10) and among these genotypes G5 strain found to be genetically very distinct from the others (Thompson, 2008). In Libya, G1-G3 complex of *E. granulosus sensu stricto* and G6-G10 complex of *E. granulosus canadenesis* found to be the cause of most human cases (Abushhewa *et al*., 2010).

Cystic hydatid disease continues to be the major source of morbidity and mortality in many areas of the world. It is difficult to completely eliminate CE in the nearest time and by using the available control options, it will take decades of continuous attempts to achieving such a goal (Craig *et al*., 2007).

Dogs as the definitive hosts are the essential part in *E. granulosus* transmission to the intermediate hosts including humans and livestock, therefore, vaccination of dogs will provide efficient and cost-effective prevention programme. A study by Wenbao *et al*. (2006) revealed that, vaccination of dogs with soluble proteins from *E. granulosus* protoscoleces caused a significant suppression of both worm growth and egg production. In addition to vaccination, control plans needs to concentrate on careful analysis of the local situations such as the cycle, ecology and ethology of the animal hosts and the behavioural characteristics of the population at risk. Also using newly developed tools including immunology, molecular biology and imaging in both human and animals are important for each control programme. Moreover, control of slaughtering, anti-parasitic treatment, control of the definitive hosts, health education and vaccination of the intermediate hosts are very crucial in each control programme (Akira *et al*., 2003).

As it is difficult to completely avoid exposing to *Echinococcus spp.* eggs which are transmitted by a wild animals; therefore, precautions regarding food safety and good hygiene must be taken into consideration; in addition, all fruit and vegetable types especially those picked up from the wild, should be cleaned thoroughly with water to insure removing the parasite eggs if any. People who are dealing with handling pets, farming, gardening or preparing food, should wash their hands carefully before eating. Furthermore, fences should be built around vegetable and fruit gardens to keep dogs and other canids, away from the premises. Untreated water from sources such as lakes may also contain *Echinococcus* eggs and therefore should be avoided.

Unfortunately, there have been no CE control programmes in Libya in the past decades, but the high

incidence of hydatid infection in human 1.4-2% (Shambesh *et al*., 1999) and over 50% in some species of livestock as reported by many researchers and the high rate of infection in dogs suggested the need for a control programme. Control programme is the most effective strategy when implemented on a community, area, or county-wide basis and must include; de-worming of all dogs that may have access to livestock offal and this must be repeated at any time after any possible exposure. In some areas with a big problem with the parasite, programmes have been set up in which dogs are dosed praziquantel every 6 weeks. Proper disposal of dead animals or animal viscera containing hydatid disease to prevent dogs from access to eating it is another way of controlling the spread of the disease. Furthermore, elimination of stray dogs, keeping all dogs away from defecating in and around children's play areas, personal hygiene (hand washing) after handling or playing with dogs also help in reducing the chance of the disease endemicity.

There is a concern that, hydatidosis may have become hyper endemic in Libya due to the absence of any sign of attempt for control programme, also most of the slaughtered animals for meat consumption are occurred out of the government veterinary supervised abattoirs. There are evidences that, incidences of CE may have increased in the country in the last few years due to the major social and political changes as a result of the country government collapse; such changes could indirectly influence both veterinary and public health services.

Regular surveillance with serological tests can be helpful especially in high-risk populations who are in contact with the parasite eggs such as laboratory personnel and children who played with infected dogs and the purpose of such testing is to detect cysts in its early stages, when the treatment is more sufficient. Any control programme will be less effective without a support and commitment from dog-owners, who should have enough knowledge about the ways of disease transmission (David *et al*., 2006). Dosing of dogs with a suitable taeniacide must be involved in any control programme of hydatid disease especially in areas where home slaughter is more practiced (Watson-Jones and Macpherson, 1988). In developing countries, like Libya, effective destruction of infected offal and prevent canids from getting into the slaughterhouses will play an important role in reduction the incidence of CE in livestock (Fikire *et al*., 2012), as well as significantly reduce the disease transmission to the potential final hosts in the country.

The control procedures used to eliminate echinococcosis/hydatidosis from endemic areas are not adequately effective worldwide, however, vaccination of the grazing animals against infection with cystic echinococcosis is a further control method which targeted grazing animals instead of the dogs. Vaccination of the livestock may help in decreasing the transmission of the disease and hence reducing the prevalence of infection in human. Eg95 clone derived from *E. granulosus* oncospheres mRNA was tested and found to be most effective (Heath and Lawrence, 1996); this recombinant antigen has shown over 90% protection against challenge infections (Lightowlers *et al*., 1996). In a recent study, Eg95 approved for use on cattle, sheep, goats and camels and found to be very effective against hydatid disease as one dose provides up to 82% protection, two doses up to 97% and three doses up to 100% protection (Larrieu *et al*., 2015).

Conclusion

Cystic echinococcosis is prevalent in all domestic animals with variable rates of infection between the animal species and between the areas of Libya. According to the available data from abattoirs, the prevalence rate of infection with CE was ranged between 1.6 to 40% in sheep, 5.6 to 70% in goats, 2.7 to 56% in cattle and 2.7 to 48% in camels. Camels and sheep play an important role in the maintenance and transmission of the disease. Presented data describes the disease history along the last few decades in Libya and suggested that, the disease is continuing to spread throughout the country without any sign of control programme. Available abattoir records are important to report regularly the economic losses due to the infection with hydatid disease in livestock.

Authors' Contributions

Mohamed M. Ibrahem and Mostafa M. Abdorrahem: Developed the structure of the manuscript, carried out the literature research and draft the review.

Wafa M. Ibrahem and Kawther M. Ibrahem: Participated in co-wrote and organizes sections of the review and edited the overall manuscript.

Ethics

This review article is original and its contents have not been published before. It can be confirmed that all authors have read and approved the manuscript and no ethical issues involved.

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