Estimated annual economic loss from organ condemnation, decreased carcass weight and milk yield due to bovine hydatidosis (*Echinococcus granulosus*, Batsch, 1786) in Ethiopia

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Abstract

Post-slaughter survey data collected over a period of 15 years (1985-1999) by the Faculty of Veterinary Medicine (FVM), Addis Ababa University (AAU) were used as a basis for the analysis of estimation of the economic significance of bovine hydatidosis in Ethiopia. The analysis output revealed a 35.15% mean annual prevalence of bovine hydatidosis. The total estimated economic loss from organ condemnation, carcass weight and milk yield decrease amounts to 1,691,266,200 ETB (101,203,734 USD). This is equivalent to a loss of 475.40 ETB (28.45 USD) per every infected slaughtered cattle and 249.00 ETB (14.90 USD) per every infected milking cow. The results of the present study showed that hydatidosis is a highly prevalent cattle disease in Ethiopia with considerable direct and indirect economic losses. The magnitude of loss per infected subject warrants the need to mount an integrated nation-wide hydatidosis control program involving public education, canine health care, proper handling and disposal of infected organs, stray dog population management and institution of strict standard operating procedures (SOPs) in slaughterhouses and public health legislative reinforcements. The authors recommend that hydatidosis control program should be designed and implemented in the context on 'One Health' initiative by integrating it with other zoonotic disease control program and in partnerships with animal and public health actors as well as other relevant stakeholders. .

Keywords: *Echinococcus granulosus*, Hydatidosis, economic significance, cattle, Ethiopia

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Introduction

Hydatidosis or larval echinococcosis is a cyclzoonotic infection caused by the metacestode stage of *Echinococcus granulosus,* known to occur in various visceral organs of domestic herbivores and humans. The disease is characterized by the presence of cysts containing numerous tiny protoscoleces that most often develop in the liver and lung, but also in spleen, kidney, heart, CNS and skeletal system as well as other rare sites such as thyroid gland, subcutaneous tissue, body cavity and musculature (Abdel-Hafez and Al-Yaman., 1989; Mendy, 1975).

The disease is known to inflict considerable direct and indirect economic losses in the livestock industry. The direct loss is related to the death, premature slaughter and organs condemnation, while the indirect is result of decreased meat, milk and wool production due to infection (Beller, 1977; Polydorou, 1981; Romazanov, 1983; Ahmadi and Meshkehkar 2011). It was indicated that hydatid cyst in the liver, lung, kidney and heart is the major causes of organ condemnation in slaughterhouses (Asegedech Sirak 1996; Getaw *et al*., 2010). Previous studies showed a reduction of up to 5% in meat and 10% in milk production (Polydorou, 1981), and a 20% decrease in hide value and 11% decrease in fecundity (Romazanov, 1983) due to hydatidosis. Estimated global annual overall losses from the burden of human cystic echinococcosis (CE) and livestock-associated losses were reported to be $1,918,318,955 and $2,190,132,464, respectively (Budke *et al*., 2006). Previous study conducted in three selected regions of Ethiopia also estimated a loss of at least 20 USD per every hydatid infected animal (Yilma Jobre *et al*., 1996).

Echinococcus granulosus remains as a cause of a persistent and reemerging problem in low income countries where resources for an intensive control program are not available. Future control programmes for human echinococcosis are also likely to depend on the reduction of transmission of the parasite from animals to humans (Robinson and Dalton, 2009). Echinococcosis has long been considered to be an eradicable disease and eradication of *Echinococcus granulosus* infections has been achieved in several countries/regions including Iceland, Tasmania, New Zealand, Cyprus and the Falkland Islands as a result of concerted efforts in the field and long-term political support (Jenkins et al. 2005). One of the major drives for hydatid disease control is the huge economic losses inflicted by the disease, the figures of which are not well-known to farmers and governments of developing countries (Heath, 2006). Therefore, availing national estimates of prevalence and economic impact

evaluations are essential in analysing the cost-benefits and for prioritization of control measures for cystic echinococcosis (hydatidosis). Even though several fragmented studies have been conducted on hydatidosis in different parts of Ethiopia, particularly through the externship program of the Faculty of Veterinary Medicine (FVM) of Addis Ababa University (AAU), very few attempts were made to estimate the economic loss at the national level based on compiled and aggregated mean prevalence rate of the disease. Therefore, the present study was made to estimate on the economic loss, at a national scale, resulting from organ condemnation, decreased carcass weight and milk yield due to bovine hydatidosis in Ethiopia.

Materials and Methods

Estimation of annual prevalence rate

The mean annual prevalence of hydatidosis in Ethiopia, and levels of organ involvement were calculated based on previous slaughterhouse surveys carried out in Addis Ababa (Gemeda, 1988), Awassa (Getachew Jember,1991), Arba Minch (Mohammed Alyie, 1988), Assela (Alemayehu Lemma, 1990; Dessie Shiferaw, 1992; Fekadu Olika, 1997), Bahr Dar (Musie Hailemelekot, 1995; Nebiyou Gesese, 1990), Bale Robe (Woubet Sinishaw, 1988), Debre Berhan (Tsegaye Tadesse, 1995), Dire Dawa (Daniel Ferede, 1995; Woubet Mulugeta, 1987), Gondar (Roman Tiruneh, 1987; Tamene Melkamu, 1986), Jimma (Abduljewad Ahmed, 1988), Kombolcha (Asrat Goshime, 1996; Yilkal Asfaw, 1989), Konso (Fikre Lobago, 1994), Mekele (Hagos Yhidego, 1997), Melgue Wondo (Getahun Demeke, 1987), Nazareth (Yemane Gidey,1990), Nekempte (Feyessa Regassa, 1987) and Wollaita Soddo (Abdul Jelal, 1992, Abel Mersie, 1985).

Estimation of economic losses

Direct annual economic loss

The estimated direct annual economic loss due to hydatidosis is computed based on the measurement of the following parameters:

- level of organs (lungs, liver, spleen, kidney and heart) condemnation based on 2.1 above,
- average local retail prices of a healthy organs
- estimation of mean annual slaughter rate of 4,920,635 heads of cattle calculated based on the estimated 620,000,000 kg annual beef production

(Alemayehu Mengistu, 2006**)** and a dressed carcass weight of 126 kg for Ethiopian zebu cattle (ILCA , 1979).

These parameters were then fed to the following formula in order to compute the economic loss due to organ condemned, as unfit for human consumption, due to cystic echninococcosis.

$$\mathbf{X} = (AS \times C_{Lu} \times P_{Lu}) + (AS \times C_{Li} \times P_{Li}) + (AS \times C_{Sp} \times P_{Sp}) + (AS \times C_{Kid} \times P_{Kid}) + (AS \times C_{Hr} \times P_{Hr}).$$

Where: AS= Estimated mean annual kill; P_{Lu}= Percent involvement of the lung; C_{Lu} = Local retail price of a lung; P_{Li} = Present involvement of the liver; C_{Li}= local retail price of a liver; P_{Sp}= Present involvement of the spleen; C_{Sp}=Local retail price of a spleen; P_{Kid}= Percent involvement of the kidney; C_{Kid} =Local retail price of a kidney; P_{Hr}= Percent involvement of the heart; C_{Hr} =Local retail price of a heart

Indirect annual economic loss

An estimation of the indirect loss due to the decrease in carcass weight and milk yield was made based on the following considerations:

- A reduction of 5% in meat and 10% in milk production established by Polydorou (1981)
- The reported 620,000,000 kg of mean annual meat production (Alemayehu Mengistu, 2006)
- The reported 448 liters of milk production per lactation per head of milking cow (Behnke, 2010)

The above two study reports are actual figures and did not considered the reductions due to any disease entity. The mean annual meat and milk production, in the absence of hydatid disease were thus calculated by multiplying the reported figures by 100/95 and 100/90, respectively. Based on these considerations and the derived mathematical findings, the following input parameters were used to calculate the indirect losses due to hydatidosis:

- The estimated mean annual meat production, in the absence hydatidosis, is 652,631,579 kg.
- 20.6% of total cattle herd of the country (48,202,500) are milking cows (Behnke, 2010), which is equivalent to 9,929,715 cows
- The estimated milk yield per lactation per cow is 498 liters in the absence of hydatidosis

- The current mean retail market price of a kilogram of beef is 68 ETB (Muluken Yewondwossen, 2011)
- The current mean retail market price of a liter of milk (5 birr) (Behnke, 2010)

These parameters were computed using the following formula:

AMP x P_f x 5% x C_{Bf} = Economic loss from meat production, *Where AMP = estimated mean annual meat production in the absence the disease; Pf = Overall prevalence of hydatidosis in cattle; 5% = Percent reduction in meat caused by hydatidosis;* C_{Bf} *= Mean retail price of a kilogram of beef;*

AM x MMY x P_f x 10% x C_M = Economic loss from milk production, *Where AM = Annual milking heads of cattle; MMY = mean annual milk yield per head; 10% = Percent reduction in milk yield due to hydatidosis and* C_M *= Mean retail price of a liter of milk.*

The total annual direct and indirect economic loss due to bovine hydatidosis was then computed as a summation of the losses due to organ condemnation, carcass weight loss and reduced milk yield described herein above.

Results

Overall prevalence

From the total of 22863 cattle examined in 18 surveyed abattoirs located in different parts of Ethiopia, 8036 (35.15%, CI = 34.53-35.77%) were found harboring hydatid cysts. Besides, 6397(27.98%), 4211(18.42%), 392(1.71%) and 190 (0.83%) of the hydatid cysts were located in the lungs, liver, spleen, kidneys and heart, respectively.

Estimated economic loss

Direct loss

The calculated mean annual slaughter rate is 5,636,364 heads of cattle. The mean retail price of bovine lung, liver, spleen, kidney, heart and a kilogram of beef is 10, 30, 3.6, 6.8, 9.2 and 68 ETB, respectively. These parameters and percent involvement of each organ were used in the estimation of the financial loss from organ condemnation. Accordingly, the estimated annual loss due to organ condemnation was:

(AS x C_{Lu} x P_{Lu}) + (AS x C_{Li} X P_{Li}) + (AS X C_{Sp} X P_{Sp}) + (AS x C_{Kid} x P_{Kid}) + (AS X C_{Hr} X P_{Hr}) = (5,636,364 x 10 x 27.98%) + (5,636,364 x 30 x 18.42%) + (5,636,364 x 3.6 x 1.71%) + (5,636,364 x 6.8 x 1.22%) + (5,636,364 x 9.2 x 1.22%) = ***48364287 ETB (2894072 USD[1])***

Direct loss

The loss from carcass weight decrease due to bovine hydatidosis is:

AMP x Pf x 5% x CBf = 652,631,579 kg x 35.15% x 5% x 68 ETB/kg = ***779, 960, 000 ETB (46,672,052 USD)***

The loss from milk yield reduction is:

AM x MMY x Pf x 10% x CM = 9,929,715 x 498 x 35.15% x 10% x 5 ***= 869,083,411 ETB (52,005,111 USD).***

The total estimated economic loss from organ condemnation, carcass weight and milk yield decrease is thus 1,697,407,698 ETB (101,571,235 USD). This is equivalent to a loss of 475.40 ETB (28.45 USD) per every infected slaughtered cattle and 249.00 ETB (14.90 USD) per every infected milking cow.

Discussion

An annual infection prevalence of 35.15% bovine hydatidosis was found in the present study based on retrospective surveys previously conducted in 16 slaughterhouses located in different parts of Ethiopia. Comparable prevalence of bovine hydatidosis were reported in isolated recent studies in the country: 34.05% from Bahir Dar (Nigatu Kebede et al., 2009), 32.11% from Mekelle (Gebretsadik Berhe *et al*., 2010) and 29.69% from Ambo (Endrias Zewdu *et al*., 2010). Slightly higher prevalence rates of 46.8% from Nazareth (Getaw *et al.*, 2010) and 52.69% from Hawassa (Feyessa Regassa *et al*., 2010) were reported. A prevalence of 22.1% from Tigray region (Kebede, W. et al., 2009), 16.85%, 16% and 15.4% from Wolayita Sodo by Jemere Bekele and Berhanu Butako (2011), Nigatu Kebede et al. (2009) and Alemayehu Regassa et al., 2009 respectively, 15.2% from Birre-Sheleko and Dangila Abattoirs (Nigatu Kebede *et al*., 2011) and 13.86% were also reported from 7 export abattoirs (Solomon Hailemariam, 1975). Studies in other countries reported prevalence of 31.6% from Niger (Arene, 1985) 48% from Tanzania (Ernest *et al*., 2004), 6.6% from Libya (Mohammed, 1985) and 8.28% from Saudi Arabia (Ibrahim, 2010). In Greece, a prevalence of 82% was reported before the introduction of a control

1 The official exchange rate of 1 USD = 16.7115 Ethiopian Birr (March 28, 2011) was used in this study

program in 1984 that successfully reduced the prevalence to 0% (Sotiraki *et al*., 2003). The difference in infection prevalence of bovine hydatidosis in different countries is a function of the control measures in place, animal husbandry practices, levels of education and economic status of the population and the farming community.

In the present study a total annual economic loss from organ rejection at postmortem as well as the indirect loss as a result of reduction in carcass weight and milk yield reduction due to bovine hydatidosis was reported based on the aggregated prevalence rate of cystic echinococcosis and the current retail market prices amounts to 1,691,266,200 ETB (101,203,734 USD). This is equivalent to a loss of 475.40 ETB (28.45 USD) per every infected slaughtered cattle and 249.00 ETB (14.90 USD) per every infected milking cow. A prior study in Ethiopia estimated the loss of at least 20 USD per every hydatid infected subject (Yilma Jobre *et al*., 1996). Other studies in Ethiopia on direct and indirect economic loss from organ condemnation and reduced carcass weight were also conducted (Getaw et al., 2010; Endrias Zewdu *et al*., 2010; Nigatu Kebede *et al*., 2011). Estimated global annual overall losses from the burden of human cystic echinococcosis and livestock-associated losses were reported to be $1,918,318,955 and $2,190,132,464, respectively (Budke *et al*., 2006). The overall economic loss attributable to cystic echinococcosis in humans and animals in 2005 in Spain was estimated at 148,964,534 euros (€) (Benner *et al*., 2010). An estimated nation-wide annual economic loss of US$ 32.4 million from Turkey (Sariozkan and Yalcin, 2009) and 10.8 million € from Greece (Tsaglas, 1985) were also reported due to hydatidosis. Annual economic loss of U.S. $903,649 (95% CI U.S.$717,158–1,113,354) from discarded livers, decreased reproduction, and decreased carcass weight in sheep, goats, and yaks was reported in addition to decreased value of sheep and yak hides where a loss of U.S.$8.44 per individual infected yak due to discarded liver alone was also estimated (Budke *et al*., 2005). Differences between the quantities of losses amongst the countries could be due to different livestock population, prevalence rates, methodologies employed, input parameters measured for the analyses, differences in productivity of animals and retail prices. The indirect loss accounts for 97.5% of the total cost associated with bovine hydatidosis, whereas the direct losses were 2.5%. This is in general agreement with the reported 99% of the total loss associated with indirect loss (Benner *et al*., 2010)

The present study demonstrated that bovine hydatidosis is widespread and a highly prevent parasitic disease in Ethiopia inflicting considerable direct and indirect economic loss (nearly 100 million USD per year) from organ condemnation, decreased carcass weight and reduced milk yield. The figure would have been much bigger if other input parameters such as mortality, losses from reduced work efficiency, reduced fecundity and burden on the public health were measured and considered in the economic estimation. This study is a graphic illustration of the importance of endoparasitism on the productivity of livestock in Ethiopia, a sector that hardly receives attention by the veterinary services. The new 'One Health' initiative is about effectively dealing with zoonotic disease entities by bringing public and animal health actors to improve epidemiological understanding and packaging interventions in the animal-human-environment interfaces.

The magnitude of loss per infected subject warrants the need to mount an integrated nation-wide hydatidosis control program involving public education, canine health care, proper handling and disposal of infected organs, stray dog population management and institution of strict standard operating procedures (SOPs) in slaughterhouses and public health legislative reinforcements. The authors recommend that hydatidosis control program should be designed and implemented in the context on 'One Health' initiative by integrating it with other zoonotic disease control program and in partnerships with animal and public health actors as well as other relevant stakeholders.

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