REVIEW: PREVALENCE OF BOVINE CYSTICERCOSIS

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ABSTRACT
Animal diseases are one of the most important constraints to increase productivity of food animals in all parts of the world. Parasitism is one of the major problems that affect the productivity of livestock worldwide. Bovine cysticercosis is a parasitic disease that affects the musculature of cattle and is caused by the metacestode stage of human intestinal cestode, Taenia saginata. The custom of eating undercooked or raw beef dishes such as: kourt, lebleb, kitfo and the habit of defecating in open fields coupled with the tradition of allowing cattle to grazing fields made cysticercosis of cattle and taeniasis of human common in developing countries. Cysts of human intestinal parasites found all over the world, which have shown efficacy against bovine cysticercosis including, Niclosamide, Praziquntel, Mebendazole and Albedazole. However, at present, it is not feasible to treat animals due to high cost and the possible public health significance of dead calcified cyst in the meat. Strict attention of personal hygiene, environmental sanitation and protection of cattle from contact with human excretion that protection of cattle from grazing on feces or sewage polluted grass, not using untreated human feces as fertilizer for pasture land which may contain segments and ova are some of the preventive measures of the disease.

KEYWORDS: Bovine, Cysticercosis, Raw, Taenia saginata.

INTRODUCTION
The nation’s domestic meat consumption of about 45% comes from cattle, which generates export income mainly from the sale of live animals. In foreign trade, although the country is ideally placed to export live animals to the big markets of the Middle East and substantial markets of North and West Africa, export earning is relatively low. This is mainly due to the presence of a number of unimproved animal health problems, among which, Taenia saginata (T. saginata) or Cysticercus bovis (C. bovis) is one that remains a major public and animal health problem.[1]

Animal diseases are one of the most important constraints to increase productivity of food animals in all parts of the world. Parasitism is one of the major problems that affect the productivity of livestock worldwide. Among many parasitic problems of domestic animals, tapeworms are an economically important intestinal parasites found all over the world, which have infected human beings for thousands of years.[2]

Bovine cysticercosis is a disease that affects the muscle of cattle and is caused by the metacestode stage of the human intestinal cestode, T. saginata. It is cosmopolitan in its distribution and it occurs in developing as well as in developed countries. The adult Taenia infection in man is referred to as Taeniasis and that due to the larval stage cysticercosis.[3] The distribution is associated with economic conditions, religious beliefs and close proximity of humans to cattle in utility function. T. saginata is wider in developing countries where hygienic conditions are poor and where the inhabitants traditionally eat raw or insufficiently cooked meat.[4] The infection is also a problem in developed countries where undercooked beef steak is consumed. It is important to note that eggs have been demonstrated to survive almost all stages of sewage treatment. It is significant to that even the high standard of meat inspection in abattoirs of highly developed countries that are expected to identify measly beef carcasses has not succeeded in eliminating this parasite.[5]

Taenia saginata/Cysticercus bovis is important from the standpoint of the health of cattle because of consequences for the meat supply and, more importantly, from the direct effects on the well-being of humans who, almost universally, consume beef as a source of protein and other minerals.[6]

Its life cycle is entirely dependent on the link between man and cattle; so that any break in this link can result in the total elimination of the parasite. Cysts of Cysticercus}
bovis can be found anywhere in the carcass and viscera, but there seems to be special affinity towards some parts which are described as sites of predilection (masseter, tongue, heart, triceps, intercostal muscles and the diaphragm). Most of these organs except the heart are consumed raw or under cooked and could be a potential public health hazard in contracting taeniasis.[6][7]

In Africa, inadequate health education and low availability of taenidical is the major obstacles for the control of the disease. The variations in the epidemiological patterns of Taeniasis/ Cysticercosis throughout Africa are a reflection of the numbers and distribution of human and cattle populations.[8] In East African countries prevalence rates of 30 to 80% have been noted.[9] Bovine cysticercosis is very common in Africa and is endemic in areas of Central and East African countries like Ethiopia, Kenya and Zaire.[8] The custom of eating raw or undercooked beef dishes such as kourt, lebleb, kitfo and the habit of defeating in open fields coupled with the tradition of allowing cattle to graze in such fields made taeniasis of human and cysticercosis of cattle are common in Ethiopia.[10] A high prevalence of human infection in different agro-climatic zones of the country has been reported.[11] Estimates made by different investigators on prevalence of taeniasis in Ethiopia vary widely from 2% - 16% to over 70%.[12]

The prevalence of C. bovis reported by different individuals was 3.2% in different agro-climatic zones of the country,[9] 2.2-3.2% in Addis Ababa abattoir[10], 19.4% in Bahirdar[12], 21.17% in Nekemte[11], 13.85% in Debre Zeit[11] and 2.99% in Gondar.[13] In Ethiopia, cattle are mainly raised under extensive husbandry practice by the rural communities. Existence of higher population density, raw meat consumption, poor hygiene and sanitary infrastructure may facilitate the transmission of the disease between animals and human beings in the rural area. Taenia saginata, is a great problem in developing countries like Ethiopia due to the culture of eating raw meat inform of kourt and kitfo as routine dish and during holidays prompted human taeniasis.[14]

The economic losses due to bovine cysticercosis are associated with total condemnation of carcasses with generalized infestation and downgrading carcasses which are subjected to refrigeration, in addition to the cost of refrigeration and extra handling and transport.[15] The parasite is provide to be controlled by routine meat inspection, restriction of raw or undercooked beef consumption, utilization of latrine, treating infected human and public awareness about the life cycle and control measures.

Therefore, the objective of this paper was:
- To provide the concise review on bovine cysticercosis.
- To highlight public health and economic importance of the disease.

LITERATURE REVIEW

Etiology
Bovine cysticercosis is a disease that affects the musculature of cattle and is caused by the metacestode stage of human intestinal cestode, Taenia saginata.[17]

Taxonomic classification
Taenia saginata and its metacestode, Cysticercus bovis, the unarmed beef tapeworm, is classified under the kingdom of Animalia, phylum of Platyhelminthes, class of Cestoda, order of Cyclophyllidea, family of Taeniidae, genus of Taenia and species of Taenia saginata.[18]

Morphology
Adult worm
The adult tapeworm, Taenia saginata, is a large ribbon shaped, multi segmented, white flat worm usually 4-15 m long consisting of thousands of segments (proglottids) arranged in a chain.[18][19] The body is divided in to three distinct parts consisting of head (scolex), neck and strobila.[20] The head or scolex bearing attachment organs, a short unsegmented neck and chain of segments. The chain is known as strobila and each segment as proglottids. Unlike other taenids, the head (scolex) has no rostellum or hooks. The proglottids are continually budded from the neck region and become sexually mature as they pass down the strobila. Each proglottid is hermaphrodite with one or two sets of reproductive organs. Gravid segments usually leave the host singly and often migrate spontaneously from the anus. [21] The number of lateral branches of uterus, presence of vaginal sphincter muscle, bilobed ovary and spontaneous leaving of gravid segments from the host in T. saginata helps for differentiation of T. saginata from Taenia solium (T. solium).[22]

Egg stage
Taenia eggs passed in the faeces or discharge from ruptured segments are sub spherical to spherical in shape and very resistant, remaining viable for 6 months in pasture and vegetables, 5 weeks in water, 10 weeks in stool or hay and 12 weeks in silage sludge. Taenid eggs measure about 30-45 µm in diameter; contain an oncosphere (hexacanth embryo) bearing three pairs of hook; have a thick, brown, radially striated embryosphere or ‘shell’ composed of hooks; and there is an outer, oval, membranous coat, the true egg shell, that is lost from fecal eggs.[23]

Larvae
The cysticerci or larval stage is formed over a period of 3-4 months, after egg is ingested by intermediate host and may viable in the intermediate host for up to 9 months or even up to the entire life of the host.[23] They are contained in a thin, host-produced fibrous capsule.[23] The infestation in the intermediate host with the larval stage is referred to as bovine cysticercosis. In the bovine animal, the mature cysticercus is grayish white, small, pea-sized oval, about 0.5cm-1.0x0.5cm
long, and filled with fluid in which the scolex is usually clearly visible.\cite{17}

**Epidemiology**

**Host range**

Cattle are the preferred intermediate hosts and humans are the only final hosts of *T. saginata*. Cattle of all ages are susceptible; however young age groups are more susceptible. Parasitism is sometimes observed in other ruminants (sheep, goats, antelopes, gazelles, buffaloes).\cite{24}

**Geographical distribution**

*Taenia saginata* occurs where cattle are raised, human feces is improperly disposed off, meat inspection programs are poor and meat is eaten without proper cooking.\cite{2} Geographic distribution and status of the taeniasis is considered a serious in the developing countries but less recognized for public health problems. Bovine cysticercosis cosmopolitan in distribution and is very common Africa.\cite{11} It is highly endemic in areas of Central and East African countries like Ethiopia, Kenya and Zaire.\cite{10}

The custom of eating undercooked beef dishes such as: kourt, lebleb, kitffo and the habit of defecating in open fields coupled with the tradition of allowing cattle to grazing fields made cysticercosis of cattle and taeniasis of human common in Ethiopia. The higher prevalence of cysticercosis in developing countries is associated with poor infrastructure, low awareness and improper disposal of sewage, which pertains to Ethiopia, where the wide spread habit of eating raw meat is an additional risk factor.\cite{25}

In developed countries such as Europe, North America, Australia, and New Zealand the standard of sanitation are high and meat is carefully inspected and generally thoroughly cooked before consumption.\cite{18} *T. saginata* is unknown in North America, North of Mexico, but its prevalence seems to have increased locally in South Western United State.\cite{26}

**Table 1: Bovine cysticercosis in different parts of Ethiopia.**

<table>
<thead>
<tr>
<th>Place</th>
<th>Percent of Prevalence</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gondar</td>
<td>2.99%</td>
<td>Ambachew and Yitagel (2015)</td>
</tr>
<tr>
<td>Nekemte</td>
<td>21.7%</td>
<td>Ahmed (1990)</td>
</tr>
<tr>
<td>Wolaita Soddo</td>
<td>11.3%</td>
<td>Regassa <em>et al.</em>, (2009)</td>
</tr>
<tr>
<td>Bahir Dar</td>
<td>19.4%</td>
<td>Alemu (2005)</td>
</tr>
<tr>
<td>Debre Zeit</td>
<td>13.85%</td>
<td>Getachew (2007)</td>
</tr>
<tr>
<td>Southern Nations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mode of infection**

As man is the source of parasites, human habits are responsible for the spread of *bovine cysticercosis*. In areas with trance human or nomadic systems, these habits are conditioned by the way of life and animals are exposed to infected feces. Infection of cattle is associated with directly to the non-hygienic disposal of stool by infected humans or indirectly by the use of human sewage on pasture as fertilizer.\cite{11}

Man’s customs and traditions of consuming raw, sun-cured, and inadequately cooked beef dishes like kourt, lebleb and kitffo in Ethiopia, containing viable *cysticerci* perpetuate human infection.\cite{10}

Man cannot spread *taeniasis* to his own species. Management of animals in their natural environment predisposes them to infection. Cattle grazing communally have a higher risk of picking up *T. saginata* eggs as they are frequently in contact with the human feces compared to commercial herds. The risk of cattle coming into contact with *T. saginata* eggs is much higher when cattle are at pasture.\cite{27}

**Life cycle**

The life cycle of *T. saginata* is indirect where the definitive host is human and intermediate hosts are cattle.\cite{18} Typically, the tapeworm life cycle consists of an adult tapeworm in the final host (i.e. human). The worms produce segments (proglottids) containing a considerable number of eggs which are shed on defecation. *Taenia* eggs containing an embryo (or oncosphere) are spread into the environment through sewage and may be orally ingested by the intermediate hosts (i.e. cattle). In cattle the embryo move from the intestine to striated musculature. Here they develop into small vesicles called *cysticerci* containing one protoscolex, head of the future adult tapeworm.\cite{27} The metacestode are found throughout the edible parts of the carcass which included masseter muscle, shoulder muscle, diaphragm, intercostal muscle, liver, heart and tongue.\cite{11} Man becomes infected by ingesting of raw or inadequate cooked meat and it takes 3 months for the *Taenia* develops.\cite{29}
Clinical signs

Cysticercus bovis is not pathogenic for cattle and usually the infection causes no clinical signs, unless a vital organ (e.g. the heart) is massively infected, which is very unusual. In case of massive infections muscle stiffness has been reported. Live cattle having C. bovis shows no symptoms, however, heavy infestation by the larvae may cause myocarditis or heart failure. Light or moderate cysticercosis in cattle is not usually associated with any defined clinical picture. Heavy infections, those induced experimentally by 200,000 to 1,000,000 T. saginata eggs, may give rise to fever, weakness, profuse salivation, anorexia, increase heart and respiratory rate and a dose of one million or more eggs may cause death between 14 to 16 days due to a degenerative myocarditis. The clinical manifestations in humans include abdominal pain, nausea, debility, weight loss, and diarrhea or constipation. A patient may have one or several of these symptoms and a high percentage of patients experience gastric hyposecretion.

Pathogenesis

Under natural condition the presence of the cysticerci in muscle of cattle is not associated clinical sign although experimentally, calves given, massive infestations of T. saginata eggs have developed severe myocarditis and heart failure associated with developing of cysticerci in the heart. Cattle become infested when ingesting food or water contaminated with eggs or gravid segments of Taenia saginata. Contamination of cattle feed can occur through undue defecation of humans in the pastures or stables, but also indirectly through irrigation with contaminated human sewage. The eggs can remain infective for more than six months. Once ingested by cattle the young larvae hatch out of the eggs in the gut, go through the intestinal wall, reach the blood stream and migrate to a muscle, where they encyst. The cysts need 10 to 12 weeks to complete development. The cysts may remain infective for humans for up to one year.

Diagnosis

The routine Meat Inspection is the only diagnostic procedure in use in Ethiopia for the diagnosis of bovine cysticercosis. This method is insensitive and inaccurate and thus the reported prevalence of this infection in different regions of country may be an underestimate. To effectively improve meat, there is a need to increase the area and number of predilection sites observed during inspection procedures.

Metacestodes (Cysticercus bovis) of T. saginata usually occur in the striated muscles of cattle (beef measles), but also buffalo, reindeer and deer. They are oval, about 0.5–1 × 0.5 cm long, translucent and contain a single white scolex that is morphologically similar to the scolex of the future adult tapeworm. They are contained in a thin, host-produced fibrous capsule.

The gravid proglottid of T. saginata has 15 to 35 lateral branches of the uterus on each side of the main uterine stem. Uterine branches also can be seen by gentle pressing the proglottid between two microscope slides and holding them in front of a bright light. If the scolex is present, the four characteristic hook less suckers can be used as a distinguishing feature for identification.

Meat inspection relies exclusively on visual examination of the intact and cut surfaces of the carcass (eye-and-knife method) in the slaughterhouse by meat inspectors who follow officially laid-down procedures.
The following are laid as normal routine inspection of carcasses by the Ministry of Agriculture in Ethiopian Meat Inspection Regulation Notice Number 428 of 1972: Visual inspection, palpation of the surfaces and a longitudinal ventral incision of the tongue from the tip of the root. One deep incision into the triceps muscles of both sides of the shoulder, extensive deep incision into external and internal muscles of masseter parallel to the plane of the jaw, visual inspection and longitudinal incision of the myocardium from base to apex are performed during inspection of carcass.\textsuperscript{[33]}

**Table 2: Characteristics for differentiating \textit{Taenia saginata}, and \textit{Taenia solium}.\textsuperscript{[4]}**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>\textit{Taenia saginata}</th>
<th>\textit{Taenia solium}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate host</td>
<td>Cattle, reindeer</td>
<td>pig, wild boar</td>
</tr>
<tr>
<td>Development site</td>
<td>Muscle, viscera, brain</td>
<td>Brain, skin, muscle</td>
</tr>
<tr>
<td>Suckers</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Rostellum</td>
<td>Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Hooks</td>
<td>Absent</td>
<td>present</td>
</tr>
<tr>
<td>Ovary</td>
<td>2 lobes</td>
<td>3 lobes</td>
</tr>
<tr>
<td>Vaginal sphincter</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Egg size</td>
<td>40-50 micrometer</td>
<td>40-50 micrometer</td>
</tr>
<tr>
<td>Cysticercus size</td>
<td>10 mm by 6 mm</td>
<td>20 mm by 10 mm</td>
</tr>
<tr>
<td>Uterine branches</td>
<td>23(14-32)</td>
<td>8(7-11)</td>
</tr>
<tr>
<td>Passing of proglottids</td>
<td>spontaneously, singly</td>
<td>passively in groups</td>
</tr>
</tbody>
</table>

**Treatment**

Chemotherapy of cattle for bovine cysticercosis is not common in Ethiopia. However, such treatment has been tried in other countries and treatment with a drug was suggested to be economical where prevalence of bovine cysticercosis is very high.\textsuperscript{[27]}

Drugs which have shown efficacy against bovine cysticercosis including, Niclosamide, Praziquantel, Mebendazole and Albedazole. However, at present, it is not feasible to treat animals due to high cost and the possible public health significance of dead calcified cyst in the meat.\textsuperscript{[34]} Praziquantel kills both the adult and larvae. Most of the larvae are killed even when encysted and disintegrated within 5 months.\textsuperscript{[35]}

**Control and Prevention**

Attempts to control and eliminate taeniasis usually interrupt the links between the hosts of the tapeworm via diagnosis and treatment of taenia carriers, education of human to use latrines, avoid eating of raw meat and backyard slaughter, serological test of cattle and postmortem inspection of carcass for presence of \textit{C. bovis}. Cattle older than six weeks are inspected for cysticercosis in skeletal and cardiac muscles; a generalized infection of the carcass is deemed unacceptable for human consumption, but a localized infection can be refrigerated for a period of time to be rendered safe.\textsuperscript{[8]}

**Differential diagnosis**

In cattle \textit{C. bovis} should be differentiated from: \textit{Cysticercus dromedarius (C. cameli)} the larval form of \textit{Taenia hyaenae}. The identification of \textit{C. cameli} is by double row of hooks on the lateral invaginated scolex and its length being twice as large as \textit{C. bovis} measuring 12-18 mm in length and pearly white in color. \textit{Sarcocystis bovisfis} (\textit{Sarcocystis hirustia}), which is a soft bradyzoite cyst, very large and visible to the naked eye whitish streaks running in the direction of the muscle fibers. The cyst ranges from 0.1 mm to 5 mm in length. \textit{Onchocerca duki}, which measures 3 mm to 6 mm in diameter, from intramuscular and subcutaneous nodules that are firm to touch.\textsuperscript{[18]}

In Ethiopia bush defecation, the habit of eating raw beef dishes such as kitfo and kourt, and backyard slaughter might have contributed for the high prevalence of bovine cysticercosis. Farmers should be supported and informed of the life cycle of \textit{T. saginata} and potential risk factors for cattle to become infected.\textsuperscript{[11]}

In developed countries the control of bovine cysticercosis depends on a high standard of human sanitation, on the general practice of cooking meat thoroughly (the thermal death point of cysticerci is 57°C) and on compulsory meat inspection.\textsuperscript{[6]}

Preventive measures include strict attention of personal hygiene, environmental sanitation and protection of cattle from contact with human excretion that protection of cattle from grazing on feces or sewage polluted grass, not using untreated human feces as fertilizer for pasture land which may contain segments and ova.\textsuperscript{[36],[37]}

Deep freezing of meat will kill all cysticerci in 24 hrs, but a whole carcass has to be frozen for about 21 days before all parts reach the correct temperature as a meat is a good insulator. The infectiousness of cysts in beef is affected by temperature and other kinds of treatments. Chemotherapy in humans reduces the spread of eggs and infection in cattle.\textsuperscript{[22]}
Importance of the Disease

Public health importance

Bovine cysticercosis is food-borne parasitic zoonosis caused by the larval stage of the tapeworm *Taenia saginata* commonly referred to as the beef tapeworm. This larva is meat-borne and human infection results from the ingestion of raw or undercooked beef. *Taenia saginata* in the small intestine of man absorbs digested food and its proglottids migrate to different organs causing different signs. [18]

Adult *Taenia saginata* can live up to 30 to 40 years in the small intestine of its human host. Most humans who carry an adult tapeworm are asymptomatic. Patients may intermittently pass proglottids either with their stool (*T. solium*) or spontaneously (*T. saginata*). [5]

Economic Importance

The economic losses due to bovine cysticercosis are associated with total condemnation of carcasses with generalized infestation and downgrading carcasses which are subjected to refrigeration, in addition to the cost of the refrigeration and extra handling and transport. [16]

Evaluation of the economic impact of taeniasis/cysticercosis is very difficult particularly in developing countries like Ethiopia, where necessary information is so scant and considerable proportions of infected people treat themselves with traditional herbal drugs like “Kosso” and others. [19]

However, country’s high cattle population, poor hygiene, and common occurrence of bovine cysticercosis reflect heavy losses. Attempts to reduce the prevalence of *T. saginata* in humans and their *cysticerci* in cattle may have a considerable impact on the economics of meat production industries.

Cysticercosis in cattle is a significant food safety problem and causes economic loss in food production. This will be particularly important where export industries are involved, since most importing countries have stringent regulations designed to prevent the importation of infected meat. [8]

CONCLUSION AND RECOMMENDATIONS

Among animal diseases, Cysticercus bovis is one of the major problems that affect livestock productivity, highly economically important and have public health significance worldwide.

In Ethiopia, the disease is common in human and animals and also difficult to control, because of inadequate health education, culture of eating raw meat, habit of defecating in open field, traditional grazing system of cattle and low availability of taenicidal.

Based on this conclusion, the following points were recommended.

- Creating community awareness about importance of raw meat consumption.
- Collaboration of veterinary and medical professionals is needed.
- Educate people to use toilet.
- Strict routine meat inspection of slaughtered animals should be carried out.

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