Review on Cerebral Coenurosis in Small Ruminants

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Abstract: Small ruminants are the major source of economy in the world, especially in developing countries, like Ethiopia. However, there are various parasitic diseases that affect small ruminants. One of the serious nervous diseases of livestock is cerebral coenurosis which cause high economic losses in the sheep and goat herds. Therefore, this paper is designed with objective to review the current information on the characteristics of the disease and its economic and public health importance. Cerebral Coenurosis is caused by larval stage of Taenia multiceps known as Coenurus cerebralis. The disease has worldwide distribution. The larval stage of Taenia multiceps, a global cestode, encysts in the central nervous system of sheep and other livestock. Taenia multiceps also causes zoonotic infections in humans, when man is ingested the contaminated food or water with the parasitic egg accidentally. The life cycle is commonly happens between dog and small ruminants. The adult stage of this parasite inhabits the small intestine of dogs, foxes; while larvae are found in the brain and spinal cord of intermediate hosts. Diagnosis is mostly done by history, clinical signs and post mortem examination. In conclusion, cerebral coenurosis is a major problem of small ruminants throughout the world including Ethiopia which causes considerable economic loss and public health significance. The zoonotic importance of the disease might exacerbate due to less awareness of community about disease transmission and hygienic problem. Community awareness about the public health importance and transmission way of the disease should be increased.

Key words: Brain - Coenurus cerebralis - Small ruminants - Taeniamulticeps - Zoonosis

INTRODUCTION

Small ruminants are important domestic animals in the animal production systems of the world [1]. Especially within the African society sheep and goat comprise a greater proportion of the total wealth of poor families because of low input requirements such as small initial capital, fewer resources and maintenance cost, ability to produce milk and meat using marginal lands and due to they need only short periods to reconstitute flocks after disaster and respond quickly to the demand [2]. Ethiopia has about 29.33 million heads of sheep and 29.11 million heads of goat population, playing an important role in the livelihood of resource-poor farmers [3].

Even though animal production is important for generation of income, helminth parasite is the main disease that affects sheep and goat productivity in the world as well as in Ethiopia [4]. Among helminthes parasites larva of Taenia multiceps (T. multiceps), known as Coenurus cerebralis (C. cerebralis) is the major disease affecting sheep and goat production and causes disease known as cerebral coenurosis in these animals [5]. Taenia species are long, segmented, parasitic tapeworms. Species of Taenia cause significant health problems and considerable socio-economic losses when infecting humans and livestock [6].

Cerebral coenurosis is distributed worldwide and it is responsible for high mortality and morbidity in small ruminants, causing great economic losses, mainly in developing countries in Africa and southwestern Asia [7]. The adult worm inhabits the small intestine of domestic and wild canids. Dogs are the most frequent definitive [8]. The larval stage of this cestode, known as C. cerebralis, affects the Central nervous system (CNS), particularly the brain of sheep and gives rise to the neurological signs of Coenurosis (gid or stagger) [9].

The occurrence of non-cerebral coenurosis in goats has been confirmed [10]; while the geographical distribution of the disease in both goats and sheep covers a wide range of tropical countries in Asia, Middle East and Africa [11]. Wide range of herbivores including sheep, goats, cattle, horse and human are the intermediate...
hosts. Dogs fed on the heads containing *C. cerebralis* develops adult tapeworm in the small intestine of the final host and the life cycle is completed approximately 42-60 days after ingesting the *Coenurus* cysts [12].

The major economic losses associated to coenurosis of small ruminants for the export are abattoir brain condemnation, time and loss of energy to dissect the brain of small ruminants for export purpose during the identification of the animal health [13]. Human beings can be infected with this disease if accidentally ingest the egg of this parasite [14]. Clinical sign is based on location and size of the *Coenurus* cyst in the brain and spinal cord [15]. The surgical removal of the cyst is the treatment of choice [16], mixture of anthelmintic agents (albendazole, praziquantel, fenbendazole) in treating Coenurosis is another method in the early stage of infection [17]. It has been found that the disease is maintained by close interactions between the definitive (dogs) and intermediate hosts (sheep and goats). The main important method to control the disease is understand the causative agent and transmission [18]. So, education of the community and giving of recommendation about the disease is very important.

Therefore; the objective of this paper is:

- To review the current information on the general characteristics, economic and public health significance of cerebral coenurosis in small ruminants

**Cerebral Coenurosis:** The cestode *T. multiceps* belonging to the genus *Taenia*, from this genus there are a number of *Taenia* species. Coenurosis also known as gid or stagger is a disease caused by *C. cerebralis*, the larval stage of *T. multiceps*, particularly affects sheep and goats [19]. The clinical signs of the disease develop when the CNS of the sheep/goat is invaded by *C. cerebralis* cyst and depend on location and size of the *Coenurus* cyst in the brain. It can occur in both acute and chronic disease form. Acute coenurosis occurs during the migratory phase of the larvae, usually about 10 days after the ingestion of large numbers of the tapeworm eggs. Young lambs/kids aged 6-8 weeks are most likely to show signs of acute disease and the signs are associated with an inflammatory and allergic reaction [15].

**Aetiology:** The species *T. multiceps* belongs to phylum Platyhelminthes, class cestoda, order cyclophyllidea, family taeniidae and genus *Taenia*. The adult tapeworm of *T. multiceps* found in the small intestine of the definitive hosts while; the larval stage located in the central nervous system of the intermediate hosts. Morphologically the adult worms are whitish, dorso-ventrally flattened, segmented and measure up to 100 cm. The larval stages (*C. cerebralis*), are round or oval, white, have translucent structures, large and bladder-like, filled with fluid and have several protoscolices attached to inner side of cyst wall [20].

Cerebral coenurosis is caused by *C. cerebralis* cyst, which is a metacestode or larval stage of *T. multiceps* and particularly affects sheep and goats [21]. Cysts are approximately 0.8-6.5 cm in diameter and are filled with large amount of fluid. In addition, they contain numerous microscopic invaginated scolices. Microscopically the scolices shows the C-shaped suckers and a rostellum armed with typical taenia hooks arranged in double rows [19].

**Life Cycle:** Adult stage of *T. multiceps* lives in the small intestine of dogs and other canids. Different species of tapeworms occur in different vertebrates and they cycle through three stages, that means eggs, larvae and adults. They all require definitive and intermediate hosts in order to complete their life cycle [22]. In the definitive host, mature proglotid segments are liberated from the body of tapeworm and eggs are discharged into the environment with the faeces. Within the eggs are oncospheres, six hooked embryos. Eggs are surrounded by hundreds of tiny blocks held together with cement called eggshell [23].

A susceptible intermediate host ingests *T. multiceps* eggs with contaminated food or water and by the action of digestive enzymes in the small intestine, the eggshell is dissolved and the oncosphere is released. The oncosphere penetrates the intestinal wall with the help of its six embryonic hooks and migrates through the circulation and lymphatic system to the predilection sites develop to form metaccestodes and nervous symptoms and death [23].

The oncosphere of *T. multiceps* has a specific affinity for nervous tissue and eventually lodges in two predilection sites (Brain or spinal cord). This is due to the Cerebrospinal fluid (CSF) is required for the differentiation, nourishment and growth of the metacestode and the scolices develop from the base of the invaginated outer surface of the metacestode wall [24]. The cyst takes approximately eight months to mature, during which it becomes progressively larger, as the volume of the fluid increases. When mature cyst is eaten by definitive host scolexexvaginate and attached to small intestinal wall of definitive host turn into adult parasite and the cycle continue [13].
Fig. 1: Life cycle of *Taenia multiceps*

Sources:- CDC, [25]

**Epidemiology**

**Distribution and Occurrence:** Cerebral coenurosis has been documented in scattered foci throughout the world, including the Americas and parts of Europe and is probably distributed worldwide [26,27]. In Africa, the disease (coenurosis) has been documented in Ethiopia, Ghana, Mozambique, Uganda, Egypt [20], Democratic Republic of Congo, Senegal, Sudan, Chad, Angola, Kenya and Southern Africa [28]. Despite the few studies conducted in Africa, there are estimates that the cerebral coenurosis presents a serious threat to nearly three-quarters of the population of small ruminants in this continent [26].

Studies to determine the prevalence of coenurosis in small ruminants show high variability in their results. In Tanzania a *C. cerebralis* prevalence of 44.4% in small ruminants (45.6% in sheep and 43.3% in goats) was determined [20,29], while in Ethiopia, between 1992 and 2015, the levels of prevalence of *C. coenurosis* ranged between 2.3% and 37.4% [30,13]. Due to the long period needed for cyst development, the onset of clinical signs normally occurs after 2-8 months of post-infection [13]. This variation could be attributed to numerous factors, such as the nature of the production system, the types of husbandry, the presence and abundance of dogs or other intermediate hosts, the practice of deworming, the characteristics of the slaughter process and the feeding habits of carnivores. Besides the above mentioned aspects mainly related to the hosts, sociological and economic factor, geographic location and ecological diversity, also play an important role in the epidemiology of *T. multiceps* [27].

**Host Range:** Domestic and wild canids such as dog, fox, wolf and jackals constitute the definitive hosts; while dog is the most common definitive host for this parasite due to more exposure to the brain of sheep and goat. Wide range of herbivores including sheep, goats, cattle, buffaloes, camels, yak, human and equines are the intermediate hosts. Coenurosis quite common in sheep and goat compared to the other animals. Acute coenurosis occurs during the migratory phase of the larvae, usually about 10
days after the ingestion of large numbers of the tapeworm eggs. Young lambs/kids aged 6-8 weeks are most likely to show signs of acute disease and the signs are associated with an inflammatory and allergic reaction [31].

Risk Factor: The coenurus cysts develop slowly over several months to become mature and result in the onset of clinical signs. As the cyst matures, it develops into a large, delicate, thin translucent fluid containing cyst, measuring commonly up to 6.5 cm in diameter. The survival of the taenia eggs in pasture, distribution of the final host and grazing behavior of the intermediate hosts are factors that influence the rate of infection [20].

The presence of shepherd or free range dogs on grazing land as well as in paddocks, greatly contributes to the existence of the disease. Dogs are frequently fed on viscera, trimmings and heads of butchered animals and they are not treated for parasitic diseases, thus maintaining C. cerebralis and T. multiceps life cycle. Introduction of dog or sheep with T. multiceps or C. cerebralis in to an area where the disease is less prevalent, could pose a considerable risk for the existence of coenurosis into the new area [32].

Eggs contaminate the environment and waters then it resist for 15 days under dry conditions, or in the high level of humidity it can stay 30 days. At high temperatures, they died in a few hours. The cyst takes approximately eight months to mature, during which it becomes progressively larger, as the volume of the fluid increases. When mature cyst is eaten by definitive host scolexexvaginate and attached to small intestinal wall of definitive host turn into adult parasite and the cycle continue [12].

Farmer or the animal owner often facilitate the contamination of the environment by opening the skull of infected sheep and goats leaving the Coenurus cyst free to be eaten by dogs or, feeding them directly to the definitive host [33]. The higher percentages of ecological variables (rainfall, relative humidity and air temperature) are considered to be the influencing factors for Coenurosis. In rainy season, rain causes spread of feces of dog, fox (final host) over the grasses and these contaminate are responsible for the increased occurrence of the disease (Coenurosis) during rainy season [34].

Source of infection and transmission: Factors such as close contact between dogs and small ruminants, lack of knowledge of the population about how coenurosis occurs, free access of dogs to the head of ruminants, containing coenurosis vesicles, the absence of regular deworming of dogs are the most important drivers for perpetuation of T. multiceps cycle and the persistence of cerebral coenurosis [29].

The transmission cycle of infection by T. multiceps takes place between dogs and domestic herbivores. Human is an accidental host and does not play any role in the epidemiology of the disease. The main factor in maintaining the parasitosis in nature is access by dogs to the brains of dead or slaughtered domestic herbivores that were infected with C. cerebralis. Taenia eggs expelled in the feces of infected dogs or other canids are the source of infection for human and for the other intermediate hosts. In general, the eggs are eliminated by the definitive host in the proglottids. Since these dry out rapidly and are destroyed outside the host, the eggs are released and dispersed by the wind, rain, irrigation and waterways [35].

Pathogenesis and Clinical Signs Coenurosis:
Pathogenesis: Cerebral coenurosis pathogenesis could be divided in two phases: the migratory and the growth phase. The early stages of migration through nervous tissue usually pass unnoticed, but in heavy infestation, meningoencephalitis may develop and it is difficult to diagnose. Most signs are caused by the mature cyst. Coenurosis bladder cysts grow gradually and the increasing pressure on nervous tissue in inflammation and eventual necrosis [36]. The cerebral form of the coenurosis is referred to as either acute or chronic cerebral coenurosis; while the chronic form is more common than acute one [37].

Acute coenurosis occurs as the result of larval migration in the central nervous system when several viable eggs are ingested by herbivore animals [12]. Consequences of migration of larvae in the brain causes liquefactive necrosis associated with thin walled larvae and infiltration of inflammatory cells, hemorrhage and necrosis. Liquefactive necrosis with mild to moderate infiltration of the inflammatory cells such as eosinophils, lymphocytes, macrophages and neutrophils seen in the cerebellar cortex [38].

Clinical Signs: Clinical syndrome is based on location and size of the coenurus cyst in the brain or spinal cord [15]. The time taken for the larvae to hatch, migrate and grow large enough to present nervous dysfunction varies from 2 to 8 months [39]. Both acute and chronic forms of coenurosis can occur in animal, although chronic disease is more readily identified and more frequently reported [33]. An acute meningoencephalitis may develop if a large
number of immature stages migrate in the brain and young lambs/kids aged 6-8 weeks are most likely to show signs of acute disease [39].

The signs are associated with an inflammatory and allergic reaction. Chronic coenurosis typically occurs in sheep of 16-18 months of age. The earliest signs are often behavioural, with the affected animal tending to stand apart from the flock and react slowly to external stimuli. As the cysts grow, the clinical signs progress to depression, unilateral blindness, circling, altered head position (head aversion), incoordination and paralysis [24].

**Diagnosis:** The disease is more complicated and severe when the oncospheres settle in the CNS tissue. Diagnosis of the *C. coenurosis* is dependent on the basis of history, clinical manifestations, ultrasound examination and post-mortem examination. [40,41].

According to Miran and his colleagues (21) post-mortem examination for the diagnosis of coenurosis is as the following: The heads of slaughtered sheep and goats collected, followed by skin removal and careful opening of the skull using a machete. Clinical syndrome is based on location and size of the *Coenurus* cyst in the brain or spinal cord [15]. In addition to the above mentioned diagnosis of coenurosis can be best achieved by a combination of history of the problem, findings of detailed location of the cyst, using ultrasound examination and evaluation of cerebrospinal fluid samples as there is a consistent association between increased eosinophil concentration in cerebrospinal fluid and parasitic infection of the central nervous system [16].

**Treatment:** Treatment of the cerebral coenurosis includes chemotherapy with antiparasitic drugs and surgery. Chemotherapy could be applied only in migration stages of the parasite, because when the *C. cerebralis* is formed, rupture of the cyst after treatment could be very dangerous [42]. Combination of fenbendazole together with praziquantel and albendazole is effective against the Coenurosis [17].

The most effective treatment to cure it is surgical removal of cyst. The surgical treatment of coenurosis in small ruminants is limited and is not recommendable in field conditions. Surgical removal of the coenurus cyst after general anaesthesia of the animal, achieves a very good success rate, especially after accurate anatomic localization of the lesion within the brain [16]. Surgery of the skulls and brains of sheep with cerebral coenurosis would be effective up to 90%, if the brain and skull are first tested by magnetic resonance imaging or ultrasonography [43].

**Public Health Importance of Cerebral Coenurosis:** Human coenurosis is a zoonotic disease caused by the larval stages of *Taenia multiceps*. The definitive hosts are canids such as dogs, coyotes and foxes and intermediate hosts include sheep, goats, human, cattle, camel, rabbits and rodents. Cestodes of family Taeniidae infect dogs as the definitive host and are transmitted to a wide range of intermediate host species where it causes cerebral coenurosis. The larval stage of *Taenia multiceps* are not only public health importance, but also veterinary significance because it cause economic losses due to condemnation of infected offal or meat and the infection may lead to lower production and even death of the animals in cases of heavy infection [44].

*Coenurus cerbralis* in human beings diagnosed for the first time in 1913 in Paris, when a man presented symptoms of CNS nerve degeneration. The infected individuals had been exposed to wild dogs in regions where canid tapeworm is considered endemic and probably ingested the parasite accidently through contact with contaminated food or water [45].

Human infection occurs if eggs are accidentally ingested as result of poor personal hygiene after being shed in the faces of the dog. The ingested eggs release oncospheres in the host intestine that penetrate the intestinal wall and migrate toward target organs, where they develop into large, cystic larvae, through the bloodstream, usually lodging in the brain, spinal canal, or eye. In the brain, the coenurus causes inflammation (coenurosis) in the parenchyma and its presence along the cerebrospinal fluid pathways eventually leads to basal arachnoiditis or ependymitis[46]. Symptoms that may be observed consist of headache, vomiting, paraplegia, hemiplegia, aphasia and epileptic form of seizures. Papilledema is a sign of increased intracranial pressure. The prognosis for coenurosis of the nervous tissue is always serious and the only treatment is surgery, although recently, the testing of treatment with praziquantel or albendazole has begun [14].

**Economic Importance of Cerebral Coenurosis:** Small ruminants are the major source of economy in the world, especially in the rural area due to low in put requirements but they can be affected by the disease due to management problem [2]. In developing countries like
Ethiopia there is close contact between dogs and small ruminants, lack of knowledge of the population about how coenurosis occurs, free access of dogs to the head of ruminants, containing coenurosis vesicles, the absence of regular deworming of dogs are the most important drivers for perpetuation of *T. multiceps* cycle and the persistence of cerebral coenurosis that leads to high economic losses of the country [9,29].

Cerebral coenurosis is an economically important disease as it causes serious problems especially in the sheep industry and breeding. Economic losses results from prolonged disease course, low productive performance, cost of treatment, death of untreated sheep and goats [47]. Some researchers stated that cerebral coenurosis is highly prevalence in turkey and Tanzania that causes major economic losses due to mortality of sheep and goats [21,48].

In Ethiopia, according to the Deressa and his colleagues reported total annual financial loss due to brain/animal condemnation was estimated as 8330 Ethiopian Birr (490 US$). The main causes of brain condemnation were due to brain with a higher *C. cerebralis* cyst. In addition to the above report another study done on *C. cerebralis* in sheep and goat in and around Yabello district of Borana zone in Ethiopia shows that economic implication of coenurus presented with the direct losses due to death of sheep and goat and reduction in market prices due to aesthetic values [30].

**Status of Cerebral Coenurosis in Ethiopia:** The metacestode of *T. multiceps* is not only zoonotic but it also responsible for severe tissue damage, reduction in milk and meat production and considerable economic loss due to condemnation of the infected organs of the herbivorous animals. Coenurosis is an endemic disease in Ethiopia, especially in the highland sheep where 75% of the population is found. The presence of shepherd dogs on grazing land greatly contributes to the existence of the disease. Dogs are routinely fed on offal, including sheep and goats head and are not dewormed. According to a study conducted on sheep and goats slaughtered at Hashim Export Abattoir in DebreZeit, 3.78% of sheep and goats were found to be infected with *Coenuruscerebralis* [13].

Another study by Achenef and his colleagues carried out an investigation at DebreBerhan, Ethiopia between 1996 and 1997, in the epidemiology of coenurosis in Menz and Horro breeds of sheep. A total of 37 heads from clinically sick and 183 heads from apparently healthy sheep were examined postmortem for the presence of the cystic larvae of *T. multiceps*, of which 37 and 5 heads, respectively contained 1 to 8 coenurus cysts [35].

Deressa and his colleagues[30] reported that from a total of 445 sheep heads examined, 21(4.7%) were found to be affected by coenurus from sheep brain harvested at Ethiopian Health and Nutrition Research Institute. According to [49] from 339 examined sheep and goats from different areas of yabello and surrounding areas for slaughtering 46 of them were found to be infected with *coenuruscerebralis* in different part of the brain. Also other researcher reported that from the total of 412 sheep and goats examined for *C. cerebra* in and around LegaHida district of Bale zone, 52 of them were found with *C. cerebralis* cyst in one or different parts of the brains [50].

**Control and Prevention:** Knowledge on cause and the mode of transmission is very important in the control of the disease [18]. Control of coenurosis in livestock relies on the same measures as those used to prevent other metacestodes [22]. Cerebral coenurosis can be controlled by regular anthelmintic treatment of dogs at 6-8 week intervals, by using an effective taenicide and correct disposal of sheep and goat brain after slaughtering or death of animals to prevent scavenging by dogs belonging to the general public, which may not receive regular anthelmintic treatment [16]. Effective control measures can also be taken by methods such as prohibition of backyard slaughtering, disposal of heads and public awareness of the epidemiology of the *C. cerebralis*[48].

Communities and governments can make sure their water supply remains sanitary and free of dog feces. Communities can control number of stray dog populations. Individuals should wash all fruits and vegetables thoroughly before eating and make sure their dogs are not infected with tapeworm [45]. For human, individual prevention from coenurosis consists of avoiding the ingestion of raw food or water that may be contaminated with dog feces [14].

**CONCLUSION AND RECOMMENDATIONS**

Cerebral coenurosis is a major problem of small ruminants throughout the world including Ethiopia, which causes considerable economic loss and public health
significance. Economic losses are mortality and condemnation of edible parts at slaughter and this may affect the productivity and hindrance to export market of small ruminant meat. Clinical signs, neurological examination and explorative surgery are the main diagnostic methods of the disease. Surgical removal of the cyst and combination of fenbendazole together with praziquantel and albendazole remains the treatment measures. The disease has zoonotic importance. Human being can acquire the infection through ingestion of food and water contaminated by infected faeces of dog. This is due to less awareness of community about disease transmission and hygienic problem. So, detail understanding knowledge on cause and the mode of transmission is very important in the control of the disease. Therefore; based on the above points the following recommendations are forwarded:

- Infection of dog should be prevented by regularly deworming and pasture areas should not be contaminated by dog feces.
- To interrupt the life cycle of parasites, carcasses or offal and brains of the intermediate host should not be fed to dogs nor left for wild carnivores and contact between dogs and small ruminant animals should be restricted.
- Dog owners must be made aware about the danger of feeding their dog on uncooked lung and head from slaughter sheep and goats,
- Public education programmes, especially targeted to in developing countries like Ethiopia, should convey the message that dogs infected with tapeworm present a danger to the human population and livestock.
- In order to improve the surveillance and control of the parasite, development of a specific diagnostic method for *T. multiceps* infection in both definitive and intermediate hosts should be investigated.

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