Ethiopian Veterinary Association

Small Ruminant Health Management

Continuous Professional Development (CPD) Training Manual

Prepared by:

Kassahun Asmare (DVM, MSc, PhD)

Kassaye Aragaw (DVM, MSc, PhD)

June 2023

Addis Ababa, Ethiopia

Table of Contents

II. Small Ruminants Health Management Module

1. Introduction

In Ethiopia small ruminant production is an integral part of livelihood for mixed crop-livestock, agro-pastoral and pastoral production systems. The stocks in question have very indispensable role in rural household economy, *i.e.* they provide meat, milk, skin, manure for soil fertility and serve as a source of immediate income in addition to cultural and ceremonial purpose they are used for (Hirpa and Abebe, 2008). According to CSA (2021), the country has an estimated population of 42.9 million sheep and 52.5 million goats and over 99 % of these animals are of indigenous breeds (CSA, 2017). Sheep and goats in Ethiopia are raised in extensive management system and owned by 11 to 60 % of households in crop livestock regions and 41-95 % in pastoral and agro pastoral regions of the country (Gebremedhin et al., 2017; ILRI, 2020). Apart from household level utility, these animals contribute to the national economy in live animal and meat export (Jemberu *et a*l., 2022). Nevertheless, the role sheep and goats play both in food security at family level and the overall economic benefit as GDP is far below the resource potential (Legese and Fadiga, 2014). In this regard, the recent economic study that estimated an annual GDP contribution of 2% (Jemberu et al., 2022) is perhaps appropriate illustration to the existing small ruminant's economic contribution paradox in Ethiopia.

Over the years, the sub-sector's low productivity has been attributed to a range of hurdles including, poor genetic make-up for production traits, feed shortage, high diseases prevalence, weak animal health service delivery, low off-take rate, weak breeding practice, lack of dependable market, lack of investment and absence of intensification (Gizaw et al., 2009; Asmare, 2015; Haile et al., 2018). Thus, one can clearly see the multifactorial nature of the constraints that demand structured approach to rip the benefit out of the portrayed resource potential.

Animal health is one of the essential inputs in small ruminants' production value chain that worth serious attention. Ethiopia being a country of large small ruminant stock potential, diseases have repeatedly been claimed to be formidable hitch to the sector's lack of productivity (Asmare, 2015; Haile et al., 2018). In this connection the animal health yearbook of Ethiopia (2012) unveiled the presence of several small ruminant transboundary diseases including, PPR, SGP, and CCPP (MoA, 2011). Furthermore a range of parasitic, infectious and non-infectious diseases are known to prevail and constrain the sector dramatically (Asmare et al., 2017; Legesse et al., 2014). This challenge is compounded by weak animal health service sector which failed to be reflective to the existing livestock owners demands. The bottlenecks of the veterinary sector comprise, weak technical competence of the animal health experts, limited facility, scarcity of critical logistics and consumables, and limited operational budget (MoA, 2010).

2. Infectious diseases associated with pneumonia

2.1. Pasteurellosis

Pasteurellosis of sheep and goats commonly refers to bacterial infections of the lower respiratory tract (bronchopneumonia or pleuropneumonia). The disease is often caused by *Mannheimia haemolytica* (biotype A), *Pasteurella multocida*, and *Bibersteinia trehalosi* (biotype T) which are the primary pathogens that occur as a mixed-infection (McVey *et al*., 2022). *M. haemolytica* is the most commonly isolated bacterium in clinical cases, followed closely by *B. trehalosi*, with *P. multocida* occurring less frequently (Aeillo and Mosses, 2016).

The organisms are commensals of the tonsils and nasopharynx of healthy sheep and goats. To cause infection, a combination of stressors including heat, overcrowding, exposure to inclement weather, poor ventilation, handling, and transportation, leaves sheep and goats susceptible to respiratory viral infections. Parainfluenza 3, adenovirus type 6 and others cause primary respiratory infections that are rarely life-threatening but predispose sheep and goats to secondary infections by *M. haemolytica* (Constable *et al*., 2017; Aeillo and Mosses, 2016).

The main route of transmission of pneumonia and other respiratory infections is by inhalation of infective aerosols. The combination of stressors and primary infections is thought to break down the mucosal barrier integrity of the lower respiratory tract, allowing *M. haemolytica* to colonize, proliferate, and induce tissue damage. The virulence of *M. haemolytica* and *B. trehalosi* is mediated by the action of several factors, including endotoxin, leukotoxin, and capsular polysaccharide, which afford the bacteria advantages over host immunity (McVey *et al*., 2022; Aeillo and Mosses, 2016).

The organisms can cause severe fibrino-necrotic pneumonia in sheep and goats characterized by acute onset of illness, high fever, dyspnea, anorexia, and often death. Death losses are high in severely affected animals. *B. trehalosi* mainly causes septicemia and systemic pasteurellosis in sheep under two months old. The systemic form of pasteurellosis caused by *B. trehalosi* is characterized by fever, listlessness, poor appetite, and sudden death in young sheep (McVey *et al*., 2022). Diagnosis of pasteurellosis of sheep and goats is made based on clinical evaluation, including history of stressors or preceding viral respiratory insult, and clinical signs of acute bronchopneumonia and endotoxemia (e.g. dyspnea, fever, depression, anorexia, coughing, oral/nasal discharge, and increased or abnormal lung sounds) (Constable *et al*., 2017; Aeillo and Mosses, 2016).

Early identification of the disease and effective antibiotic therapy is necessary because the disease causes high mortality in severely affected animals left untreated. Ampicillin, ceftiofur, danofloxacin, enrofloxacin, florfenicol, trimethoprim-sulfamethoxazole, and tulathromycin are expected to have good efficacy. Parenteral fluids and anti-inflammatory agents are important aides to antibiotic therapy. Administering prophylactic antibiotics to at-risk lambs may be beneficial (Sherrill, 2015).

For prevention, all susceptible animals in endemic area should be routinely vaccinated preferably two to three months before the high-risk season. During an outbreak, immediate whole herd vaccination is the good alternative irrespective of previous vaccination history. Prevention of respiratory viruses using a vaccination program would be expected to decrease respiratory pasteurellosis by preventing the initial insult that opens the window for colonization. Use of prophylactic antibiotics, mainly tetracycline, during the months of the year with the highest incidence is a common management practice. Avoidance or reduction of known stressors mentioned above should also be borne in mind (Sherrill, 2015).

In Ethiopia, pasteurellosis due to *Mannheimia hemolytica* and/or *Pasteurella* infections in sheep and goats were reported from different parts of the country (Assefa and Kelkay, 2018; Berhe *et al*., 2017; Legesse *et al*. 2018; Marru *et al*. 2013; Molla and Delil, 2015).

2.2. Contagious caprine pleuropneumonia (CCPP)

Contagious caprine pleuropneumonia is a severe and highly fatal disease characterized by depression, fever, anorexia, dyspnoea, coughing, abdominal respiration, reluctance to move, bleating, extension of the neck, frothy or mucopurulent nasal discharges and subcutaneous oedema on the chest and abdomen. Stringy salivation may be observed before death. Death may occur within 2 days of the onset of the clinical signs. The disease may be acute or subacute and may involve the respiratory, alimentary and reproductive systems (Harwood and Mueller, 2018; Constable *et al*., 2017; Aeillo and Mosses, 2016).

CCPP is caused by *Mycoplasma capricolum capripneumoniae*, or Mccp (prev. *Mycoplasma* biotype F38). There are many other closely related species, such as *M. capricolumcapricolum* and members of the *M. mycoides* cluster, including *M. mycoidescapri* (prev. *M mycoidesmycoides* large colony) that can produce similar lesions (McVey *et al*., 2022; Aeillo and Mosses, 2016). Sources of the infection are the clinically sick and carrier animals and infection occurs by inhalation of infective aerosols. Overcrowding in animal sheds, communal grazing land, water points, markets and dips facilitates rapid spread of the infection within and between herds. Stress factors which compromise the immune system of the animal can activate latent infection in carrier animals which start to shed the organisms (Constable *et al*., 2017).

Macrolides, tetracyclines, fluoroquinolones, and florfenicol may successfully treat *Mycoplasma* infections if administered early in the course of disease. Tylosin (10 mg/kg, IM, every 24 hours for 3 days) or long-acting oxytetracycline (20 mg/kg, IM, once) is effective in the treatment of CCPP. Quarantine of affected flocks and strict biosecurity protocols for introduction of new animals are necessary to limit transmission and losses due to CCPP and other *Mycoplasma* spp. Vaccines are available in some countries, and good to excellent protection has been reported. The current CCPP vaccine contains inactivated Mccp suspended in saponin, has a shelf life of at least 14 months, and provides protection for over 1 year.

In Ethiopia, prevalence records that range from 31.2% to 48.3 % were reported in goats in different parts of the country in a period between 2009 and 2019 (Gizaw *et al*., 2009; Hadush *et al*., 2009, Sherif *et al*., 2012; Teshome *et al*., 2019) despite one study in which an exceptionally high seroprevalence record of 87% reported (Molla and Delil, 2015) from Dassenech district of South Omo Zone. In sheep, three studies conducted in different sites of Tigray and Borana areas of Ethiopia using CFT or c-ELISA had recorded the prevalence in the range of 7.14-18.25% (Gelagay *et al*. 2007; Hadush *et al*. 2009; Teshome *et al*. 2019).

2.3. Peste Des Petits Ruminants (PPR)

PPR is a contagious viral disease of goats and less commonly sheep characterized by fever, erosive stomatitis, enteritis, pneumonia and death. The disease is caused by aPPR virus of the genus *Morbillivirus* and family Paramyxoviridae. The source of infection is the sick or sub-clinically infected animal and the virus is discharged in milk, saliva, urine or faeces. The disease spreads primarily by inhalation but the virus can also be acquired by ingestion and penetration through the conjuctival mucosa. Animals may acquire the infection by licking or muzzling each other. Bedding, feed and water troughs can be sources of infection. Goats are highly susceptible to PPR compared to sheep, and kids under one year are most susceptible (Harwood and Mueller, 2018; Aeillo and Mosses, 2016).

The incubation period of acute PPR is about 7 days and the syndrome is characterized by severe depression, pyrexia, sneezing, dyspnoea, coughing, serous or mucopurulent occulo-nasal discharges which lead to matting of eyelids and blockage of nostrils. There may be crackling lung sounds which are clearly audible. Focal necrotic stomatitis, halitosis, anorexia, profuse mucoid diarrhoea or dysentery and tenesmus are prominent features. Abortion occurs and there may be superficial erosions on vulva or prepuce. Death of severely affected animals occurs in about 7 days after the onset of clinical signs. Mortalities of 71-100 % are not uncommon. Subacute PPR is the commonest form of the disease in sheep. Clinically, it resembles the acute syndrome of goats except that clinical signs are milder (Harwood and Mueller, 2018; Aiello and Moses, 2016).

There is no specific treatment, but treatment for bacterial and parasitic complications decreases mortality in affected flocks or herds. An attenuated PPR vaccine prepared in Vero cell culture is available and affords protection from natural disease for >1 yr.

In Ethiopia, the reported prevalence ranges from 6.98% to 50.85% in sheep and 4.53 to 71.4% in goats. The disease is noted to be one of the most widely distributed diseases in the country reported from northern, western, central, eastern and southern parts (Gari *et al*. 2017; Gelana *et al*., 2020; Molla and Delil 2015; Delil *et al*., 2012; Megersa *et al*. 2011; Alemu *et al*., 2019).

2.4. Ovine progressive pneumonia (OPP, maedi/visna)

OPP is an insidious disease of sheep mainly characterized by progressive weight loss and dyspnoea. The affected animals lag behind the flock, the nostrils are flared and inspiration is associated with rhythmic jerking of the neck. There may be nasal discharges or coughing. The animal progressively losses condition although it remains alert and maintains its appetite. Severe dyspnoea which is exacerbated by exercise develops. Chronic suppurative arthritis of the carpal and tarsal joints and mastitis are often associated with OPP (Constable *et al*., 2017; Seifert, 1996).

It is caused by an ovine progressive pneumonia virus of the subfamily Lentivirinae and family Retroviridae. The disease has been reported to occur world-wide. It is mainly encountered in adult sheep over 3 years of age. Housing and close confinement facilitate transmission of infective droplets. The virus can also be transmitted mechanically by biting insects, fleas, lice and surgical equipment (Seifert, 1996; Constable *et al*., 2017). A nervous form of the syndrome (visna) may occur. It has a shorter incubation period than the pulmonary syndrome and it is characterized initially by weakness of the hind limbs, straggling and stumbling or falling without any apparent cause. Progressive weight loss and trembling of the facial muscles may occur. There may also be ataxia, paresis, paraplegia and quadriplegia. There is no fever and the animal remains alert (Constable *et al*., 2017).

Currently, there is no practical, effective treatment for ovine progressive pneumonia, and no vaccines are available. Therefore, the only means for control and prevention are serologic testing and removal of positive animals. Because of the long incubation period and time to seroconversion, retesting animals once yearly, or even twice yearly, may be indicated. In addition to the approach of testing and culling, it has previously been recommended to raise lambs or kids from seropositive dams separately feeding colostrum from seronegative animals, or heat-treated colostrum, and raise the animals on milk replacer.

In Ethiopia, due to the limited scope of studies conducted regarding to maedi-visna, about ten published reports were available so far. Except one study with prevalence of 17.11% in goats (Mekibib *et al*., 2019), all the rest had detected the infection in sheep alone. The prevalence in Ethiopia was between 3.24% (Yizengaw *et al*., 2020) to 61.25% (Garedew *et al*., 2010). A study involving microscopic examination of pneumonic lungs from 35 sheep detected lesions well-matched with maedi-visna in 25.7% of the samples (Woldemeskel and Tibbo, 2010). An outbreak investigation of respiratory disease complex (RDC) carried out in 3641 Menz and Awassi x Menz cross sheep in Central Ethiopia using clinical, serological, microbiological, post-mortem and histopathological examinations, showed the prevalence to be as high as 17% (Tibbo *et al*., 2001).

3. Infectious diseases causing reproductive disorders

3.1. Brucellosis

Brucellosis is a disease caused by infection with bacteria of the genus *Brucella* characterized by abortion in late pregnancy and subsequent high rate of infertility. The disease is zoonotic and occupational causing undulant or Malta fever in man (McVey *et al*., 2022).

Brucellosis in goats and sheep is normally caused by*, Brucella melitensis* although *Brucella abortus* may also cause clinical brucellosis. *Brucella ovis* is a cause of epididymitis of rams but it has also been associated with abortions and infertility. *B. melitensis* infection causes a fulminating disease in man (undulant or Malta fever) characterized by intermittent fever, malaise, fatigue, night sweats, muscle and joint pains whereas, *B. abortus* causes a mild disease (Constable *et al*., 2017; Aiello and Moses, 2016).

The source of infection is the infected doe or ewe. *Brucella* spp. tend to be abundant in the placenta, placental fluid, uterine exudate and aborted fetuses. The bacteria may persist in the uterus for about 5 months after abortion. Inhalation is the most important route of infection in goats and sheep but infection may also be acquired through ingestion and by penetration through the conjunctival mucosa. The infective discharges can contaminate the environment very rapidly causing grazing animals to ingest massive numbers of the organisms. *B. melitensis* is known to be the most pathogenic of the *Brucella* spp. and is more contagious than *B. abortus.* Overcrowding of animals in houses, communal grazing areas and water sources and, poor hygiene favor the rapid spread of the disease (Aiello and Moses, 2016; McVey *et al*., 2022).

Abortion storm in late pregnancy is the principal manifestation of brucellosis. Other features include reduced milk yield and birth of weak kids or lambs which become asymptomatic carriers. An acute septicaemic form characterized by fever, depression, weight loss and sometimes diarrhea may occur. Epididymitis, orchitis, synovitis, hygromas, osteoarthritis, lameness and infertility are usually observed in male animals. *B. ovis* infection in rams causes inflammation of the scrotum which is manifested by oedema, enlarged and hard palpable epididymis (Constable *et al*., 2017; Aiello and Moses, 2016).

There is no practical treatment. Efforts, therefore, are directed at detection and prevention. Eventual eradication depends on testing and eliminating reactors. The disease has been eradicated from many individual herds and areas by this method. Herds must be tested at regular intervals until two or three successive tests are negative.

In Ethiopia, a large number of published evidences are available regarding to brucellosis in small ruminants. Most of these studies were serological, and used Rose Bengal Plate Test as screening test with additional CFT as confirmatory test. In sheep, the highest prevalence was 6.7% while the lowest was 0.49% (Amenu *et al*., 2010). Likewise, studies in goats reveal prevalence report as high as 14.4% and the lowest being 0.6% (Tegegn *et al*., 2016).

3.2. Toxoplasmosis

Toxoplasmosis is a disease caused by a protozoan parasite *Toxoplasma gondii* and is also important zoonoses world-wide, that establishes long-lasting infections in humans (Dubey, 2010). *T gondii* is transmitted by consumption of infectious oocysts from a contaminated environment, contaminated feed, and by transplacental transfer of tachyzoites from dam to fetus. After infection of a pregnant ewe, tachyzoites are transmitted via the bloodstream to placental cotyledons, causing necrosis. Tachyzoites may also be transmitted to the fetus, causing necrosis in multiple organs.

Toxoplasma, have frequently been linked clinically to abortion, stillbirth and other related disorders in small ruminants (Dubey, 2010; Constable *et al*., 2017). The reproductive wastage particularly in sheep is reportedly known to be enormous (Buxton and Losson, 2007).

For animals other than humans, treatment of toxoplasmosis is seldom warranted. Prevention of contamination of the farm environment and feed with cat feces may help reduce infection in small ruminants. Some countries have approved a vaccine to prevent abortions in sheep.

In Ethiopia, the disease has been reported for the first time by Bekele and Kassali (1989) among sheep (22.9%), goats (11.6%) and cattle (6.9%) in central Ethiopia. The last decade more and more studies were popping up reporting the presence of the infection in small ruminants with prevalence ranging between 19.7 % to 74.8% both for sheep and goats (Negash *et al*., 2004; Teshale *et al*., 2007; Zewdu *et al*., 2013; Gebremedhin *et al*., 2013; Gebremedhin and Gizaw, 2014). Apart from sero-prevalence studies, viable *T. gondii* were isolated from 47 out of 91 sheep and goats (Gebremedhin *et al*., 2014). A systematic review by Asmare (2015) revealed that the overall pooled prevalence estimate of small ruminanat toxoplasmosis was 35.2%.

4. Infectious diseases associated with foot and skin damages

4.1. Foot rot

Foot rot is a contagious infection of the feet characterized by inflammation of the skin-horn junction, under-running of the horn, ulceration and necrosis of the sensitive laminae and severe lameness. There are no characteristic pathological features associated with foot rot although grossly there is always interdigital necrosis. A characteristic black, foul smelling material is present due to the bacterial necrosis of the horn. Spread of the infection to joints may result in pyo-arthritis and accumulation of pus in the joint cavity (Aiello and Moses, 2016). Despite the high frequency of occurrence of lameness with the consequent morbidity as well as the vast clinical cases in sheep in Ethiopia, studies showing the epidemiological importance of foot rot seems to be limited (Ferede *et al*., 2014; Chanyalew and Alemu, 2014; Fesseha, 2021).

Dichelobacter nodosus, a gram-negative anaerobe and obligate pathogen, is the primary etiologic agent that must be present for foot rot to develop. *Fusobacterium necrophorum*, gram-negative anaerobic bacteria, may play a synergistic role in pathogenesis and is a normal resident of manure-contaminated environments that contributes to ovine interdigital dermatitis and footrot (Aiello and Moses, 2016; McVey *et al*., 2022).

It is a contagious infection and discharges or exudates from the affected feet contaminate the pasture or bedding. Infection occurs through contact with infected material and the organism gain entry into the body by penetration through broken skin. Prolonged wetting of the skin, scratches and bruises or surgical wounds facilitate the penetration of the bacteria and are therefore important predisposing factors. Intermingling and congregation of animals, poor floor types and poor disposal of urine and feces favor the spread of the disease. Carrier animals may harbor the organism for 2-3 years (Aiello and Moses, 2016; McVey *et al*., 2022).

D. nodosus produces a growth factor and extracellular proteolytic enzymes which facilitates its penetration, establishment and growth in the host tissues. The proliferation of the bacteria causes severe tissue destruction leading to interdigital dermatitis and suppuration (McVey *et al*., 2022). Initially, there is a moist, swollen, hyperaemic and macerated interdigital skin and later on,a foul smelling discharge from the lesion is observed. Severe lameness occurs and the affected animals become recumbent. Affected animals may be seen to graze on their knees to relieve pain in affected fore feet. There is also reduced feed intake, weight gain and milk yield. Animals may die because of starvation (Constable *et al*., 2017).

Traditionally, treatment consisted of footbaths using antibacterial solutions after careful hoof trimming to remove all dead horn and expose infected tissue and bacteria to air. However, foot soaking for 30–60 minutes has been shown to be more effective even when trimming is not done. A commonly used footbath solution is 10% wt/vol zinc sulfate with 0.2% vol/vol of laundry detergent containing nonionic surfactants such as sodium lauryl sulfate. Formaldehyde at 2%–5% and copper sulfate at 5% are also frequently used with success. The advent of long-acting antimicrobials used in combination with topical treatments has improved recovery and reduced carrier animals. Parenteral administration of a long-acting oxytetracycline or a macrolide is an effective systemic treatment. In animals with lameness, NSAIDs for pain management should be considered.

Animals from unknown premises should not be purchased. Any sheep to be added to the flock should be quarantined for several weeks to prevent the spread of footrot and other chronic diseases. Vehicles (eg, trucks or trailers) or facilities in which unknown or infected sheep have been held should be thoroughly cleaned and disinfected. Because the incubation period of footrot is ~14 days, footbaths at 10-day intervals will control spread of the organism in affected flocks during wet-condition periods. *Dichelobacter nodosus* vaccines accelerate healing in affected sheep and aid in protecting unaffected sheep

Despite the high frequency of occurrence of lameness with the consequent morbidity as well as the vast clinical cases in sheep in Ethiopia, studies showing the epidemiological importance of foot rot seems to be limited (Ferede *et al*., 2014; Chanyalew and Alemu, 2014; Fesseha, 2021).

4.2. Contagious ecthyma

Contagious ecthyma (contagious pustular dermatitis or orf) is a highly infectious disease of goats and sheep characterized by pustular and scabby lesions on the muzzle, commissures of the lips and nostrils. The disease is caused by a contagious ecthyma virus of the genus *Parapoxvirus* and family Poxviridae and, it also affects man.

Contagious ecthyma is characterized initially by appearance of erythema which later develops into papules and pustules. When the pustules rupture, the pus forms a thick layer of grey crust and later on result in discrete and thick scabs which are crumbly but adherent to the underlying tissues. Lesions usually begin at the oral commissures and then spread to the lips, muzzle, nostrils, and ears. Lesions may also occur on the coronet, interdigital cleft, skin of the udder and teats, vulva, preputial orifice, perineal area, thighs and axillae. Adjoining scabs coalesce and form continuous plaques. Fissures which occur between scabs cause soreness.

Both parenteral and topical antibiotics may help combat secondary bacterial infection of the skin lesions. In endemic areas, appropriate repellents and larvicides should be applied to the lesions to prevent myiasis. Sheep that have recovered from natural infection are highly resistant to reinfection. Single-strain live vaccines have been in use in many countries.

In Ethiopia, prevalence records of 15.5% in sheep and 8.5% in goats (Tedla *et al*., 2018); 7.18% in goats (Wondmnew *et al*., 2018) as well as 1.1% in sheep were reported from different study sites. Likewise, the presence of two virus isolates and reports of 3% morbidity was recorded in Ethiopia (Gelaye *et al*., 2016).

4.3. Goat and sheep pox

This is an acute, febrile and highly contagious disease of goats and sheep characterized by fever, cutaneous nodular or visceral eruptions. Goat and sheep pox affects animals of all ages although kids and lambs are most susceptible. Goat and sheep pox are caused by the goat and sheep pox viruses of the genus *Capripoxvirus* and family Poxviridae. The viruses closely resemble each other although they are antigenically different (Constable *et al*., 2017; Harwood and Mueller, 2018).

The disease is highly contagious and transmission occurs mainly by inhalation but animals can also be infected by drinking contaminated milk or by direct contact. Cuts and abrasions on the skin facilitate entry of the virus into the body. The virus can be spread mechanically by insects, birds and personnel. Congregation of animals in communal grazing lands, markets, dips and the dry and dusty environments are favourable for the transmission of the disease because the virus can be excreted through nasal and conjunctival discharges (Constable *et al*., 2017; Aiello and Moses, 2016).

The incubation period of goat/sheep-pox is about 2 weeks. The disease is more severe in sheep than goats and in young than adult animals. In sheep, the disease is characterized by depression, pyrexia, anorexia, laboured breathing, ocular and nasal discharges. Cutaneous nodules normally appear on hairless areas of the body such as lips, nostrils, udder, vulva, and scrotum. Severely affected animals may die before pox lesions appear. The nodules progress through vesicles, pustules and finally become scabs. Severe erosive and ulcerative plaques may be found on the buccal, oesophageal and tracheal mucosae. Lesions in the alimentary tract may lead to diarrhoea whereas; those in the genital tract can cause abortion. Secondary bacterial pneumonia and mastitis are common sequelae. In goats, lesions occur mainly on lips, eyes, scrotum, udder and medial aspects of the limbs. Severe infections in goats may extend to the neck, thoracic and abdominal organs as hard intracutaneous nodules (Constable *et al*., 2017; Harwood and Mueller, 2018).

No specific treatment is advised, but palliative treatment may be necessary in severely affected animals. Infection results in solid and enduring immunity. Live, attenuated virus vaccines induce longer immunity than inactivated virus vaccines. Live, attenuated, lumpy skin disease virus also can be used as a vaccine against sheeppox and goatpox.

5. Vector-borne diseases of major significance

Vector-borne diseases like trypanosomosis, East Coast Fever (ECF), babesiosis, anaplasmosis, ehrlichiosis, dermatophilosis and Rift Valley Fever (RVF) significantly reduce the productive and reproductive performance of small ruminants in Sub-Saharan Africa (Swallow, 2000; Taylor *et al*., 2016). Vectors involved in the transmission of these diseases include, tsetse flies (e.g. trypanosomosis), ticks (ECF, babesiosis, anaplasmosis, ehrlichiosis etc.) and a range of mosquitoes (bluetongue, rift valley fever, etc.) Worldwide vector-borne diseases are increasing problem due to climate change and increase in environmental temperature (Githeko *et al*., 2000; Purse *et al*., 2005). In Ethiopia, diseases transmitted by the aforementioned vectors are reported to be among the major animal health challenges (MoA, 2012), and research evidences are there on their presence and distribution. On the other hand, information that focuses on diseases transmitted by the vectors mentioned in small ruminants is limited (Asmare, 2015).

The few available reports focus on trypanosomosis (Dinka and Abebe, 2005; Leta and Mesele, 2010), bluetongue (Woldemeskel *et al*., 2000; Gulima, 2009), theileriosis (Gebrekidan *et al*., 2014), coxiellosis (Gumi *et al*., 2013), babesiosis, anaplasmosis (Sitotaw *et al*., 2014), and dermatophilosis (Woldemeskel and Mersha, 2010). Indeed, the diseases mentioned are of different kinds in terms of etiologic agents, clinical feature and pathology in the species of the authors concern. Nevertheless, they share an important epidemiological feature in that they are all vector-borne, that could give an opportunity for introducing similar strategy in control interventions. In the background of this fact, the authors attempted to summarize the available information on each disease, aiming to produce a document that may contribute towards understanding the current knowledge on the occurrence of vector-borne diseases in small ruminants in Ethiopia (Asmare, 2015).

5.1. Trypanosomosis

Trypanosomosis refers to a group of diseases caused by protozoa of the genus *Trypanosoma*. It is a debilitating disease of animals characterized by parasitaemia, intermittent fever, anaemia, loss of condition, reduced productivity and mortality.

It is caused by a protozoan, belonging to genus *Trypanosoma*. *T. congolense* and *T. vivax* are the main species associated with clinical disease in small ruminants in sub-Saharan Africa.

This disease in goats and sheep in sub-Saharan Africa is closely related to the ecology and distribution of the vector tsetse flies of the genus *Glossina.* Increased tsetse fly activity particularly during the rainy season is associated with increased incidence of the disease. Tsetse flies *(Glossina* spp) are the principal vectors that are the most commonly involved in sub-Saharan Africa. Other blood sucking flies may also transmit the disease (Constable *et al*., 2017; Taylor *et al*., 2016).

Several drugs can be used for treatment of trypanosomosis. Drug resistance occurs and should be considered in refractory cases. Control is ideally achieved by combining methods to reduce the tsetse challenge and with prophylactic drugs administered to the animals.

In Ethiopia, studies have confirmed about the occurrence of three trypanosome species namely, *T. congolense*, *T. brucei* and *T. vivax*. From the entomologic perspective, *Glossina morsitans submorsitans*, *Glossina pallidipes*, *Glossina fuscipes fuscipes*, *Glossina tachnoids* and *Glossina longipennis* mechanical vectors including *Tabanus*, *Stomoxys* and *Haematobia* species were reported as vectors of trypanosomosis. About an estimated 220,000 Km^2 of fertile land in the southwestern, western and northwestern part of the country is infested by *Glossina* species and hence at risk of animal trypanosomosis (Abebe, 2005).

5.2. Blue tongue

Bluetongue is an infectious, noncontagious arthropodborne viral disease primarily of domestic and wild ruminants. The disease is characterized by fever, catarrhal stomatitis, rhinitis, enteritis, abortion and lameness due to coronitis and myositis (Constable *et al*., 2017). Bluetongue is caused by a blue tongue virus of the genus Orbivirus and family Reoviridae.

The disease mainly affects sheep, and occasionally cattle. It is transmitted mainly by biting midges (*Culicoides* spp.), *Culicoides imicola* in particular. However, mechanical transmission by Sheep ked (*Melophagus ovinus*), ticks (*Amblyomma variegatum* and *Ornithodorus coviaceus*) and blood sucking flies such as *Stomoxys* spp and *Tabanus* spp may also occur (Kusiluka and Kambarage, 1996).

The course of the disease in sheep can vary from peracute to chronic, with a mortality rate of 2–90%. Peracute cases die within 7–9 days of infection, mostly as a result of severe pulmonary edema leading to dyspnea, frothing from the nostrils, and death by asphyxiation. In chronic cases, sheep may die 3–5 wk after infection, mainly as a result of bacterial complications, especially pasteurellosis, and exhaustion. Mild cases usually recover rapidly and completely. The major production losses include deaths, unthriftiness during prolonged convalescence, wool breaks, and reproductive losses.

There is no specific treatment for animals with bluetongue apart from rest, provision of soft food, and good husbandry. Complicating and secondary infections should be treated appropriately during the recovery period. Prophylactic immunization of sheep remains the most effective and practical control measure against bluetongue in endemic regions. Control of vectors by using insecticides or protection from vectors may lower the number of Culicoides bites and subsequently the risk of exposure to BTV infection.

In Ethiopia there are a couple of published evidence on bluetongue prevalence. Gulima (2009) reported a sero-prevalence estimate of 34.1 % among 860 sheep in Amhara National Regional State. Woldemeskel *et al*. (2000) on the other hand reported a seroprevalence of 9.67% in the highlands and 92.85% in the lowlands in 90 sheep.

5.3. Tick-borne diseases

Tick-borne diseases comprise of a number of infectious diseases whose etiological agents belong to either piroplasms or ricketsia. These diseases manifest different characteristics with their clinical courses varying based on the agent involved. Piroplasms, for example *Babesia* being intra-erythrocytic parasites, cause hemolysis that predispose the animal to anemia and unthriftiness (Constable *et al*., 2017). The incidence and severity of the babesiosis depends on high tick activity associated with humidity, introduction of naïve animals into endemic areas, intercurrent infections and breed differences (Kusiluka and Kambarage, 1996). Tick-borne infections due to species within the genera *Anaplasma* and *Ehrlichia* were also noted to constrain small ruminant husbandry and production in much of the Sub-Saharan Africa (Woldehiwet, 2007).

In Ethiopia there are reports of tick-borne diseases in small ruminants with causative agents including, *Theileria* spp., *Anaplasma* spp., *Babesia* spp., and *Coxiella burnetii* (Gumi *et al*., 2013; Geberekidan *et al*., 2014; Sitotaw *et al*., 2014). In addition, molecular evidence on the infection status of tick vectors were also reported (Kumsa *et al*., 2014; Tomassone *et al*., 2012; Geberekidan *et al*., 2014). There are also few reports of suspected outbreaks on babesiosis and anaplasmosis with mortality rate of 1.8% and 0.1% respectively (MoA, 2012). However, in the light of tick burden and associated risk, systematic investigations that explain the clinical relevance of tick-borne diseases are very much limited (Woldehiwot, 2007). There is lack of a published report on Ehrlichiosis (Heartwater), one of the frequent differential diagnosis listed among diseases associated with sudden death, despite the widespread prevalence of its tick vector (*Amblyomma* spp.) in the country. However, Teshale *et al*. (2015) reported molecular evidence that revealed the presence of the agent among *Amblyomma* ticks collected from sheep in Andassa and Habernossa areas suggesting that small ruminants are at high risk of contracting the disease. Likewise, Tomassone *et al*. (2012) has also reported the agent in ticks collected from districts in Filtu zone of Somali Regional State.

Dermatophilosis, the other important "tick-borne" disease of skin in small ruminants and other livestock, is caused by the bacterium *Dermatophilus congolensis*. Strictly speaking dermatophilosis is not exclusively a tick-borne disease, as it spreads by contact and involvement of other arthropod vectors such as flies (*Stomoxys* spp, *Glossina* spp and *Musca* spp), lice (*Linognathus* spp) and Sheep ked (*Melophagus ovinus*). However, tick vectors particularly of *Amblyomma* spp. plays significant role in its transmission (OIE, 2008) and therefore it is commonly clustered under tick-borne diseases. The disease occurs worldwide but is more prevalent in the tropics with higher prevalence during rainy seasons. Clinically it is characterized by exudative dermatitis with scab formation (Constable *et al*., 2017).

In Ethiopia, Asmare (2015) reviewed available reports on dermatophilosis infection in small ruminants and reported a pooled prevalence estimated of 3.1%. The findings reported that prevalence tend to increase in wet season and with poor management (Woldemeskel, 2000). Higher prevalence was also observed in association with increased age (Woldemsekel and Mersha, 2010). Thus the disease is reported to be endemic and is listed among the major causes of hides and skin rejection in Ethiopia (Woldemeskel, 2000; Woldemeskel and Ashenafi, 2002).

In conclusions, the information on specific diseases transmitted by vectors among small ruminants is very limited. This fact is true for all vector-borne diseases including trypanosomosis which is the major problem to livestock production in Ethiopia. Therefore, there is a need to conduct comprehensive studies on vector-borne diseases of small ruminants, as small ruminants are the stocks of the future in face of diminishing grazing land for larger ones.

6. Diseases due to internal parasites of major importance

6.1. Helminthosis

Helminthosis is considered to be a major cause of mortality and sub-optimal productivity in sheep and goats in traditional farming systems in sub-Saharan countries (Rege *et al*., 2002). Helminths cause direct losses due to deaths and indirect losses due to reduced productivity through reduced feed intake and live weight gains and, decreased quality of skins, wool or mohair (Kusiluka and Kambarage, 1996). Three major classes of parasitic helminthes (nematodes, trematodes and cestodes) cause widespread infections in sheep and goats causing helminthosis with economic and zoonotic importance (Soulsby, 1982; Taylor *et al*., 2016).

6.1.1. Nematodes

Gastrointestinal nematode (GIN) infections are a common constraint in pasture-based herds and can cause a decrease in animal health, productivity and farm profitability (Vande Velde *et al*., 2018). Small ruminants (sheep and goats) are prone to GIN infections, because the areas they graze (pastures and other grass lands) are contaminated with infective stages (eggs and larvae) of GINs and result in continuous infection and reinfection of these animals (Tariq, 2014).

The epidemiology of these parasites depends on the climatic factors (e.g. rainfall, temperature), management systems, hosts and parasite factors. Rainfall (moisture) is most important for survival, development, dissemination and availability of free living stages. GI nematodes can survive harsh conditions by hypobiosis or arrested development of larvae within the host. In the absence of hypobiosis nematodes survive in hosts during the hot and dry season as adults (Taylor *et al*., 2016; Bowman, 2021). High stocking density increases the contamination of the environment with nematode eggs or larvae and thus makes the infective stages to be more accessible to susceptible animals. Host factors (age, breed, nutrition, physiological status) can also determine the severity and incidences of infections. Factors like the fecundity of the adult worms, the prepatent period and the survival and development rate of the parasite in the environment determines the rate of establishment and size of nematode burden in the host (Taylor *et al*., 2016).

Likewise, lungworms require a damp and cool environment suitable for their development and the larval stages (L_3) of *Dictyocaulus filaria* can survive cold. *Muellerius capillaris* and *Protostrongylus rufescen* have indirect life cycles, with land snails and slugs acting as the intermediate hosts. Therefore, factors which influence the epidemiology of the intermediate hosts will determine the epidemiology of the parasite as well (Bowman, 2021; Taylor *et al*., 2016).

The clinical disease development or pathologies causing death or sickness in animals are effected through their feeding activities or physical presence, migration and associated host immune response. Abomasal hypertrophy, blood and protein loss, structural damage involves lung, intestine and other related tissues are some of the mechanisms by which the host suffer the insult (Taylor *et al*., 2016). The common clinical signs of an infection with gastrointestinal nematodes are anorexia, diarrhea, emaciation and anemia (Bowman, 2021; Soulsby, 1982). On the other hand the pathogenic effects of lungworms are blockage of bronchioles that result in obstruction and collapse of alveoli, bronchitis, bronchiolitis and development of granulomatous pneumonia (Taylor *et al*., 2016). Hence, the animal is seen with respiratory distress, cough and nasal discharges (Berrag and Cabaret, 1996; Berrag *et al*., 1997).

Owing to the differences in their predilection sites and pathogenesis mechanisms, GI nematodes present with differing clinical and pathological features where high level infections may lead to the death of the infected animals. Moreover, the impact of nematode infections on the animal is dependent on the intensity of infection as well as the physiological and immunological status of the host. Growing lambs and periparturient ewes are most susceptible to the infection by nematodes. However, the clinical and pathological features of parasitic gastro-enteritis for most infections encountered under field conditions are due to the additive pathogenic effects of several nematodes (Taylor *et al*., 2016).

Detection of parasitism in individual flocks is based on examination of feces, postmortem examination, packed cell volume and FAMACHA score assessment. Routine fecal examination is commonly employed in small ruminant medicine (Tembely *et al*., 1997; Bekele *et al*., 1992a). Overt parasitism is often noted with post mortem examinations (Taylor *et al*., 2016). Finally, packed cell volume and or FAMACHA scoring system can be a sensitive indicator of anemia causing nematodes especially *Haemonchus contortus*. FAMACHA scoring system compares the FAMACHA card with the inferior palpebral conjunctiva. This is a semi quantitative method of identifying animals showing various stages of anemia. The scoring system is from "1" (very anemic) to "5" (normal) (van Wyk and Bath, 2002; Kaplan *et al*., 2004; Reynecke *et al*., 2011). Faecal cultures, postmortem worm counting and pasture larval recovery are also helpful techniques of diagnosis (Taylor *et al*., 2016; Tembely *et al*., 1997).

In Ethiopia, where ruminant livestock are kept on pasture throughout the year and climatic conditions favor the development and survival of free-living stages, helminth parasites are a major cause of economic loss (Mulugeta *et al*., 1989). According to a review (Asmare *et al*., 2015), the prevalence of small ruminant GI nematode infections based on coprological and postmortem findings range from 15.7% to 100% in the country. Such infections were the result of diverse nematode genera and species in both sheep and goats which include *Longistrongylus (Pseudomarshallagia) elongata*, *Trichostrongylus colubriformis*, *Trichostrongylus axei*, *Haernonchus contortus*, *Trichuris ovis*, *Trichuris skrjabini Oesophagostomum columbianum, Bunostomum trigonocephalum*, *Chabertia ovina, Dictyocaulus filaria* and *Muellerius capillaris* (Mamo *et al*., 1981; Mamo *et al*., 1982; Tembely *et al*., 1997; Bekele *et al*., 1992a; Assefa, 1997; Ayalew, 1995). According to a review on earlier studies in Ethiopia (Biffa *et al*., 2007), *Trichostrongylus* and *Haemonchus* are the dominant over other genera of nematode parasites infecting small ruminants contributing to huge productivity losses while *Haemonchus* is considered to be one of the most pathogenic nematodes leading to widespread morbidity and mortality of sheep and goats (Taylor *et al*., 2016). Likewise, three important lungworm species namely *Dictyocaulus filaria*, *Muellerius capillaris* and *Protostrongylus rufescens* are reported to be prevalent in both sheep and goats in the Ethiopia (Asmare, 2015).

Generally, the widespread and high prevalence of GIN and lungworm infections in sheep and goats has been noted in all agro-ecological zones (except lungworms in lowlands). The presence of highly pathogenic parasites like *Haemonchus* along with common occurrence of other nematodes is strong indication for the devastating effect due to additive outcomes of these nematodes in Ethiopia. The problem seems more compounded as the feed resources are far from sufficient especially in the dry seasons. Therefore, this necessitates a strategic approach to control nematodes after indepth epidemiologic investigation of parasitic dynamics both in the environment and the host (Asmare, 2015).

Information on economic losses caused by gastrointestinal nematode parasites in Ethiopia is scarce (Asmare, 2015). A proportional mortality record of up to 11% in lambs attributable to gastrointestinal parasites was reported in a study in the central highlands of Ethiopia (Bekele *et al*., 1992b). A study suggestive of the better performance of anthelmintic treated sheep compared to untreated group under natural subclinical helminthosis challenge in central highlands of Ethiopia was reported (Tibbo, 2006). In a similar study Aragaw *et al*. (2011) recorded a shortened lambing interval in ewes treated with anthelmintics compared to their untreated counterparts. Such results suggest the indirect effects of gastrointestinal nematodes on small ruminants and how important these parasites are in affecting the small ruminant health and productivity.

6.1.2. Trematodes

Trematodes (including *Fasciola* spp, *Paramphistomum* spp and *Schistosoma* spp) are the main constraints infecting ruminants that also limit the production and productivity of animals (Taylor *et al*., 2016). *Fasciola gigantica* is the commonest species associated withfasciolosis in most sub-Saharan countries. *Fasciola hepatica* has also been shown to be a significant cause of fasciolosis in highland areas of East and South Africa. The epidemiology of trematode infections in goats and sheep is also determined by climate, management systems, hosts and parasite factors (Kusiluka and Kambarage, 1996). The distribution of fasciolosis is also dependent on the ecology of aquatic snail intermediate hosts that inhabit both tropical and temperate climatic zones. *F. hepatica*, whose intermediate host is *Lymnaea truncatula,* has cosmopolitan distribution in high-altitude, temperate, and cooler areas in tropical and subtropical areas; while *F. gigantica*, whose intermediate host is the *Lymnaea natalensis,* is distributed widely in tropical regions (Taylor *et al*., 2016).

In Ethiopia, the distribution of fasciolosis is directly influenced by climatic features, terrain and vegetation. In particular, thermal and soil moisture regimes are important in determining the seasonal patterns of infection due to their effects on the larval development in the lymneaid intermediate hosts, the environment phases and activity of the snail vectors. *F. hepatica* is the most important species covering over three-quarters of the country with its high prevalence in the highland areas attributed to poor drainage and the acidic nature of the soil favoring the survival and development of the snails. *F. gigantica*, is distributed mainly in the western humid zone that encompasses approximately one-fourth of the country (Yilma and Malone, 1998).

According to a review (Asmare *et al*., 2015), the apparent prevalence of *Fasciola* ranges from 5.6% to 56.3% in sheep and 0.8% to 17.2 % in goats. Both *F. hepatica* and *F. gigantica* were the two species most commonly implicated as the etiological agents of fasciolosis in Ethiopia and mixed infection with both species of *Fasciolla* is reported to be common in both sheep and goats. This report was consistent to the observation made by Yilma and Malone (1998) using GIS based prediction that stated the occurrence of mixed infection at intermediate (1200-1800 m.a.s.l) altitude zone. Irrespective of the parasitic species involved, the infection has been noted as an important cause of morbidity and mortality in small ruminants. The finding of a longitudinal study that lasted for 4 years in Debre Berhan area, the central highlands of Ethiopia, underscored fasciolosis as the primary cause of mortality in sheep with a proportional mortality rate of 45.7% (Njau *et al*, 1988). Similarly, fasciolosis that occurred at an outbreak scale in Sheno Agricultural Research Center was responsible for 73.1% of research sheep deaths at the end of the rainy season/early dry season in 1999 (October to November) (Tibbo, 2000).

Consequently, the direct impacts of fasciolosis are attributable to liver lesions, reduction in feed utilization efficiency, deprivation of the animal of digested nutrients, and reduced feed intake through loss of appetite and discomfort leading to reduced feeding time. As a result, the effects include reduced growth rates, reduced production (meat, milk and wool), reduced reproductive efficiency and mortality. Reduced reproductive efficiency manifests itself through reduced pubertal development, extended lambing interval, reduced weight and number of weaned offspring per ewe and subsequent effect on the age and sex structure, and genetic improvement of the flock (Ngategize *et al*., 1993).

Besides morbidity and mortality fasciolosis causes to small ruminants (Njau *et al*., 1988), liver condemnation due of fasciolosis is very common at slaughter resulting in substantial financial loss to export abattoirs and owners of butcheries (Jibat *et al*., 2008; Kumsa and Mohammedzein, 2012). The financial loss from mortality, morbidity and liver condemnation associated with ovine fasciolosis alone were estimated at 46.5, 48.8 and 5.7% respectively of the total 48.4 million birr annual loss (Ngategize *et al*., 1993). Sheep are more commonly affected by fasciolosis than goats in Ethiopia (Jibat *et al*., 2008; Dagnachew *et al*., 2011). According to a review by Mehmood *et al* (2017), the maximum average prevalence of fasciolosis reported in sheep in Ethiopia was 40.2% while it was 9.6% in goats. Indeed, the available studies reported the prevalence to be high and widely distributed. Considering such a high prevalence of fasciolosis in small ruminants with sheep more significantly affected than goats and adult animals more affected than young, there is a need for strategic use of chemotherapy and control of snail intermediate host especially in high risk areas (Asmare, 2015).

6.1.3. Cestodes

The common parasitic cestodes encountered in goats in the sub-Saharan region include *Stilesia hepatica* and *Moniezia expansa*. *M. expansa* infection is very common in kids and heavy infection with the parasite causes unthriftiness. Presence of the metacestodes of *Echinococcus granulosus* (hydatid cyst)*, Taenia ovis* (*Cysticercus ovis), Taenia multiceps* (*Coenurus cerebralis)* and *Taenia hydatigena* (*Cysticercus tenuicollis)* in tissues or organs lead to condemnation of the affected tissues/organs. The cestodes, *M. expansa, S. hepatica, S. globipunctata* and *A. centripunctata* have indirect life cycles and the intermediate hosts are the soil-inhabiting oribatid mites. Birds may be involved in the dissemination of tapeworm eggs (Kusiluka and Kambarage, 1996). Cestodes can be diagnosed by demonstration of eggs or proglottids in host feces, finding of the adult worms in the small intestine or bile ducts or detection of metacestodes in liver, lung, brain or other organs at postmortem examination (Bowman, 2021; Taylor *et al*., 2016).

Information on epidemiology and ecology of adult cestodes in small ruminants in Ethiopia seems to be limited as a result of their little pathogenic and clinical significance. This also makes explanation difficult for the variation among the reported cases (Biffa *et al*., 2007). A study based on routine postmortem examinations of sheep from central Ethiopia revealed the prevalence of *Stilesia hepatica* and *Monezia* species (Assefa, 1997). Heavy infections due to *Monezia* species in young animals may cause anorexia, weight loss, moderate anemia, enteritis and sometimes obstruction of the intestines. *S. hepatica* occurs in the bile ducts of small ruminants and its economic importance is associated with condemnation of the affected livers. Migration of *Coenurus cerebralis* in the brain may cause meningo-encephalitis while massive numbers of hydatid cysts in the lungs may cause respiratory problems. Other cestodes have limited clinical significance in small ruminants (Kusiluka and Kambarage, 1996). According to a review (Asmare, 2015), the overall prevalence of metacestodes of canid cestode parasites in small ruminants in Ethiopia was 11.8%. *Cysticercus tenuicollis* was the commonest metacestode reported (31.2%) while the other metacestodes were observed in much smaller proportions of 8.8% for hydatid cysts, 4.9% for *C. ovis* and 4.6% for *C. cerebralis* (Asmare, 2015).

The economic losses induced by larval stages of most cestodes (metacestodes) may be high due to the condemnation of heavily infected carcasses and organs and the necessity to freeze or boil infected meat. Losses may also occur from restriction of exports of meats and meat products. The significance of its impact in the meat trade industry is increasingly becoming important in view of the drastic measures and very strict regulations of importing countries. Compared to the larval stages of other parasitic cestodes, the occurrence of metacestodes of *Taenia* species and *Echinococcus granulosus* are higher in the Ethiopian sheep population (Biffa *et al*., 2007).

Metacestodes cause condemnations of edible visceral organs and as a result financial losses associated with organ condemnation were reported to be substantial. Annual loss from liver and lung condemnation due to hydatid cyst alone was estimated at 2,493,524 ETB (USD 149,312.8) in a study conducted in Jimma town (Kumsa and Muhammadzein, 2012). Another study conducted in Desie municipal abattoir, estimated the annual financial losses to be 3,284,378.29 ETB (USD 178,693.04) due to hydatid cysts and *C. tenuicollis* (Gessese *et al*., 2014). Metacestodes were also found to be the major causes of organ condemnation in other similar studies made at export abattoirs located in central Ethiopia (Jibat *et al*., 2008; Regassa *et al*., 2013). Considering the existence of these metacestodes at an overall prevalence of 11.8% (Asmare, 2015) in small ruminant population currently consisting of 42.9 million sheep and 52.5 million goats (CSA, 2021) the economic significance to the country will be enormous due to direct and indirect losses.

This shows that the importance of these parasitic stages as a cause of mortality, morbidity and economic losses associated with organ condemnation to small ruminant productivity in Ethiopia is significant. Moreover, the widespread nature of the infections shows the potential environmental contamination with cestode eggs and chances for the exposure of small ruminants. Therefore, there is a need for a holistic approach for control of metacestode infection; including cultural transformation in waste offal management, regulatory imposition on control of stray dogs, backyard slaughter practice and pet animal management (Asmare, 2015).

6.2. Protozoa

6.2.1. Coccidiosis

Coccidiosis of small ruminants is a protozoan infection caused by several species of the genus *Eimeria* which develop in the small and the large intestine, affect young animals in particular and are specific for each host. *Eimeria ovinoidalis* in sheep and *Eimeria ninakohlyakimovae* in goats are the most pathogenic species. Coccidiosis is of great economic importance because of the losses due to clinical disease (diarrhea) but also because of subclinical infections leading to poor weight gain (Chartier and Paraud, 2012; Foreyt, 1990). The disease is widespread among small ruminants and has been reported in all sub-Saharan countries (Kusiluka and Kambarage, 1996). Sub-clinically infected animals continuously shed the oocysts and contaminate the environment. Oocyst excretion is at the maximum around the weaning period and shows a steady decline afterwards due to a strong immunity (Chartier and Paraud, 2012). Overstocking and poor hygiene favor rapid transmission and built-up of coccidial infections in animals whereas, stress factors such as weaning, inclement weather, confinement and intercurrent diseases precipitate the occurrence of a clinical disease. Temperature, moisture and oxygen tension are the main factors which determine the survival and development of coccidial oocysts to the infective stage (Chartier and Paraud, 2012; Taylor *et al*., 2016).

At optimum conditions, unsporulated oocysts in feces of infected hosts sporulate and become infective in 2-5 days (Foreyt, 1990). Sporulated oocysts are ingested by hosts followed by release of sporozoites in the intestine. Sporozoites penetrate the intestinal wall and become trophozoites which divide asexually to form schizonts (meronts). The schizonts rupture and release merozoites which infect new intestinal cells. Asexual (schizogony) development is followed by sexual development (gametogony). During gametogony microgametocytes and macrogametocytes develop into microgametes and macrogametes respectively. Microgametes fertilize intracellular macrogametes and oocysts (zygotes) are produced. When the host cell ruptures, the oocysts are released into the intestinal lumen and are passed out in feces (Foreyt, 1990; Soulsby, 1982; Taylor *et al*., 2016).

Pathogenesis depends on the effect of the developmental stages of the parasite in various regions of the intestine. The number of oocysts ingested, species of *Eimeria* involved, age and immune status of the host, location of the parasite in tissues and number of host cells destroyed determine the severity of the disease. Destruction of capillaries in the intestinal mucosa may lead to hypoproteinaemia and anemia. The changes in the intestinal mucosa cause increased rate of peristalsis, malabsorption and diarrhea. Diarrhea is followed by dehydration, acidosis, anemia and terminal shock (Soulsby, 1982; Taylor *et al*., 2016).

Mucoid or bloody diarrhea, abdominal pain, tenesmus, inappetence, debility, loss of weight and dehydration are common features. In acute disease, fever, ocular and nasal discharges may occur. Subclinicall coccidiosis is associated with reduced feed intake, poor weight gains and poor food utilization. Coccidiosis is self-limiting; however, other enteropathogens can complicate the clinical picture. The gross pathological picture includes a thickened, edematous and sometimes hemorrhagic intestinal wall. Necrosis, greyish-white nodular lesions and polyp-like growths may be seen on the mucosa. The intestinal contents become fluid, dark brown or hemorrhagic (Chartier and Paraud, 2012).

In Ethiopia, high prevalence of small ruminant coccidiosis has been recorded from different parts of the country. According to Kiltu *et al*. (2016), the prevalence of coccidiosis was 62.7% in sheep and 66.9% in goats in eastern Ethiopia while Ayana *et al*. (2022) reported 58% in sheep around Adama and Bishoftu Towns. Likewise, Ayana *et al*. (2009) recorded 59.6% of *Eimeria* infections in sheep and goats brought to ELFORA export abattoir at Debre-zeit. Senbeto and Chekol (2022) also reported about 37.5% and 50.5% coccidiosis respectively in sheep and goats in Pawe district, Metekel zone of Benishangul Gumuz Regional State. Moreover, very high prevalence of coccidiosis was detected in small ruminants with 87.31% infections in sheep and 85.03% in goats in Tigray regional state of Northern Ethiopia (Etsay *et al*., 2020).

7. Diseases due to external parasites (Arthropods)

7.1. Mange mite infestation

Mites are in the subclass Acari within the class Arachnida and most of those of veterinary importance are in the orders Trombidiformes (*Demodex bovis*) or Sarcoptiformes (*Chorioptes bovis*, *Sarcoptes scabiei* and *Psoroptes ovis*). The Sarcoptiformes are astigmatid mites that are thought to have evolved from free-living oribatid mites (Andrew and Forbes, 2021), which are intermediate hosts for several species of tapeworms including *Anoplocephala*, *Moniezia* and *Stilesia*. Infestation by mites is called acariasis and can result in severe dermatitis, known as mange, which may cause significant welfare problems and economic losses. Parasitic mites are small, most being less than 0.5 mm long, though a few blood□sucking species may attain several millimeters when fully engorged (Taylor *et al*., 2016).

Sarcoptic mange causes intense pruritis in sheep and goats and makes animals scratch and rub the body against hard objects. The continued itch and resulting restlessness prevents the animals from grazing. On the other hand Psoroptic mange are non-burrowing mites that feed on lipid emulsion of skin cells and exudates superficially and induce hypersensitivity reaction to the presence of antigenic mite fecal material. This leads to severe pruritis, wool loss, and restlessness, biting and scratching of infested areas, weight loss, and reduced weight gain and in some cases, death. On the other hand Demodectic mites reside much deeper in the skin and lesions may be papular, nodular and, rarely, pustular (Taylor *et al*., 2016).

Mange mites are common causes of clinical and subclinical skin diseases among small ruminants in different agro-ecologies in Ethiopia (Asmare, 2015). Available reports show that mange mites infesting small ruminants in Ethiopia belong to three important genera; namely, *Sarcoptes*, *Psoroptes* and *Demodex* (Tolossa, 2014). Accordingly, the highest mange mite infestation prevalence reported was 31.8% in goats and 21.1% in sheep in and around Kombolcha area of Amhara region (Tadesse *et al*., 2011). Moreover, Tolossa (2014) in his review emphasized the infestation to be very common in Oromia and Amhara Regional States as well.

Asmare (2015) in a systematic review on available data showed the pooled group estimate for sheep as 2.6% and 7.7% for goats with a statistically significant difference. Age wise the pooled estimate for young was 4.8%, while that of adult was 6.2%. Significant difference in the prevalence was also noted between the high land and lowland agro-ecologies. *Sarcoptes* and *Demodex* were the predominant mange mites reported, and they were observed more frequently in goats than in sheep (Asmare, 2015)). It is well documented that sarcoptic and demodectic Mange mites are very rare in sheep and when they occur, they are confined to the non-wooly parts of the body and cause only mild lesions. Consequently, an infested animal may be missed during observation as all of the studies were based on a crosssectional design. In contrast, sarcoptic and demodectic manges in goats often takes a chronic course in infested animals with a generalized skin condition characterized by marked hyperkeratosis (Soulsby, 1982; Constable *et al*., 2017; Taylor *et al*., 2016). Perhaps, this might have increased the clinical visibility and the chance of detecting mites in cross-sectional studies in goats compared to sheep.

The other possible reason could be the differences in the agro-ecology where sheep and goats are kept in Ethiopia. Sheep are the dominant species in highland crop–livestock farming systems while goats are mainly kept in lowland mixed crop–livestock production systems (Legese *et al*., 2014) due to their better adaptation to the climatic conditions and feed scarcity in this agro-ecology. This might have made goats more prone and victim of the mite infestation due to sharing common agro-ecology with parasites by large. A third possible factor could be related to the common management practices of the animals. In most places of Ethiopia, sheep are kept tethered on small plots during the day while goats obtain their feed usually by free ranging along road sides, at market places and around flour mills which increases the chance of prolonged contact between animals and thereby enhancing spread of mites amongst the animals. The finding of higher prevalence in goats than sheep is also in line with previous studies (Aatish *et al*., 2007; Ogundiyi *et al*., 2012). Moreover, the observation of the three genera (*Sarcoptes*, *Demodex* and *Psoroptes*) of mange mites in Ethiopia has great implications for small ruminant production as these mites are known to be notorious ectoparasites and are responsible for great economic losses due to damaged skin and wool. They cause anemia, poor physical condition, decreased milk and meat production as well as suboptimal lambing and growth rates (Soulsby 1982; Fthenakis *et al*. 2000).

In conclusion, mange-mite infestation is an important parasitic infestation of small ruminants that needs attention as a part of animal health service delivery and particular focus should be given to mites of the genus *Sarcoptes* and *Demodex* and also Psoroptes when possible.

7.2. Tick infestation

The ticks are obligate blood feeding ectoparasites of vertebrates, particularly mammals and birds. They are relatively large and long lived, feeding periodically on large blood meals, often with long intervals between meals. Tick bites may be directly damaging to animals, causing irritation, inflammation or hypersensitivity and, when present in large numbers, anaemia and production losses. The salivary secretions of some ticks may cause toxicosis and paralysis; however, more importantly, when they attach and feed they are capable of transmitting a number of pathogenic viral, bacterial, rickettsial and protozoal diseases (Taylor *et al*., 2016).

Ticks belong to two main families, the Ixodidae and Argasidae of which the most important is the Ixodidae, often called the hard ticks, because of the presence of a rigid chitinous scutum, which covers the entire dorsal surface of the adult male. In the adult female and in the larva and nymph it extends for only a small area, which permits the abdomen to swell after feeding (Taylor *et al*., 2016). Thus ticks are among the most important ectoparasites that affect sheep and goat production and productivity (Jongejan and Uilenberg, 2004). Hence, ticks are among the major hindrances to the productivity of small ruminant in Ethiopia. Besides the role they play as vector of disease, ticks can be harmful to livestock and of great economic importance due to their direct effects. These effects are attributed to the deep and painful bite wound created which is more severe in long mouthpart ticks, *Amblyomma* and *Hyalomma*. Deep bites often lead to abscess formation due to secondary invasion with pyogenic bacteria, and damages to udder (Jubb *et al*., 1993). The damage caused by ticks diminishes the value of skin in leather industry (Hailu, 2013; Kassa, 2005; Jongejan and Uilenberg, 2004). According to the available studies in Ethiopia, ticks infesting small ruminants belong to four important genera; namely, *Amblyomma*, *Rhipicephalus*, *Boophilus* and *Hyalomma* (Hailu, 2014).

According to a review made by Asmare (2015) on articles published during 2008 to 2015 in the country with a reasonable coverage of all major agro-ecologies revealed a pooled prevalence of 27.5% (95% CI: 21.8-34.1) tick infestation in small ruminants. The studies showed that ixodid ticks infesting sheep and goats in Ethiopia belong to four important genera, namely: *Boophilus*, *Rhipicephalus*, *Amblyomma* and *Hyalomma*. And the tick species reported to infest sheep and goats included: *Boophilus decoloratus*, *Rhipicephalus evertsi evertsi*, *Rhipicephalus praetextatus*, *Rhipicephalus pravus*, *Rhipicephalus pulchellus*, *Rhipicephalus sanguines*, *Amblyomma variegatum*, *Amblyomma gemma*, *Amblyomma lepidum*, *Amblyomma cohaerens*, *Hyalomma marginatum marginatum*, *Hyalomma marginatum rufipes*, *Hyalomma impelatum* and *Hyalomma truncatum*. Of these ticks, three genera especially *Amblyomma*, *Rhipicephalus* and *Boophilus*, are widespread throughout the country (Asmare, 2015).

However, information about such ticks infesting sheep and goat population in the regions of Afar, Benshianguel and Gambella is still lacking. Likewise, there was no study addressing seasonal pattern of tick distribution in sheep and goats overall. Therefore, it is recommended to perform an epidemiological study that covers all seasons of the year in order to develop effective tick control strategies. Therefore, it can be concluded that four major genera of ticks comprising of many species infesting sheep and goats occur in Ethiopia based on different agro-ecologies and hence these ticks are of great economic significance in the country as they damage the skin and transmit diseases (Asmare, 2015).

7.3. Sheep ked (*Melophagus ovinus*) infestation

Sheep ked is one of the most widely distributed and important external parasites of sheep. The female gives birth to a single, fully developed larva, which is cemented to the wool and pupates within 12 hours. A young ked emerges after ~22 days. The entire life cycle is spent on the host (Taylor *et al*., 2016).

Sheep keds pierce the skin with their mouthparts and suck blood. They usually feed on the neck, breast, shoulder, flanks, and rump. Ked bites cause pruritus over much of the host's body; sheep often bite, scratch, and rub themselves, thus damaging the wool. The fleece becomes thin, ragged, and dirty. Infested sheep particularly lambs and pregnant ewes may lose vitality and become unthrifty (Taylor *et al*., 2016). Sheep ked is among the major factors that affect sheep productivity due to the intense irritation induced by the keds making sheep restless and do not feed well, resulting in loss of body condition (Wall and Shearer, 2001). Heavy infestations can considerably decrease the condition of the host and even cause anemia. Close inspection of the damaged, dirty wool and underlying skin reveals infestation by the unique appearance of these wingless, hairy flies (Mullen and Durden, 2019; Taylor *et al*., 2016). Moreover, Sheep ked is the most important ectoparasite that causes skin downgrading as a result of inflammation that leads to pruritis, biting, rubbing and a vertical ridging of the skin known as "Cockle" (Taylor et al., 2016; Wall and Shearer, 2001). Moreover, staining of the wool by the feces of the ked reduces its value and gives it a peculiar musty odor (Wall and Shearer, 2001).

In Ethiopia Sheep ked is an important ectoparasite in some parts of the country with variable prevalence estimates. Based on the available evidences the pooled prevalence of Sheep ked infestation in Ethiopia was estimated to be 7.9% (95 % CI: 4.6 -13.2) with an observed records of over 80% from highland agro ecology

(Asmare, 2015). This is due to the fact that cooler highland agro-ecology is very conducive for Sheep ked reproduction and growth (Constable *et al*., 2017) as heavy infestations usually occur in winter months and decline during summer. Sheep keds are sensitive to hot, dry weather and numbers decrease markedly over the summer (Taylor *et al*., 2016).

Hence, Sheep keds are a potential threat and serious economic problem for sheep production in the highland areas of Ethiopia and therefore the external parasite control program should consider the fact that Sheep ked is among the target parasite in the highland areas (Asmare, 2015).

8. Reproductive health

Sheep and goats are very fertile animals, with reproductive potential far superior to that of most other domestic animals. Specific assessment of the reproductive system should always be preceded by a complete physical examination to determine general health status and to detect problems that warrant therapeutic or management intervention (Edmondson and Shipley, 2021; Edmondson *et al*., 2012).

9. Flock and herd health management

The main goal of a flock/herd health program is to improve overall health and welfare, thereby decreasing production losses from diseases, increasing productivity, and maximizing profitability. Flock/herd health can be improved through general husbandry, nutrition, parasite control, vaccination, and environmental management. To accomplish this goal, those common diseases seen on the farm and the various management practices should be understood. Since each flock/herd is different, an individual herd health plan which depends on the herd/flock size, purpose, and the farm's production goals should be developed (Dawson *et al*., 2021).

9.1. General Herd Health considerations

An obvious key to a successful small ruminant operation is having a healthy, productive herd. The health of small ruminants is affected by a number of factors, including genetics, disease prevalence, environment, nutrition, and management, among others. The greatest disease threat is an animal introduced from another source. Selection of healthy animals and integrating them into the herds should begin at the time of purchase which should be made only from reputable sources to minimize the chance of buying diseased animals or animals carrying unapparent disease. Prior to purchase, information about the animal must be obtained regarding to the disease history, current disease status, and vaccination protocols. Animals can undergo disease testing prior to final purchase and the exact diseases tested will vary depending on the operation (Dawson *et al*., 2021; Smith and Sherman, 2009).

Once animals are on the farm, providing a healthy environment, proper nutrition, and preventive health care is essential in maintaining herd health. However, animals are affected by a variety of conditions and diseases under different management conditions and no matter how well animals are cared for, diseases will occur. Early detection of sick animals or animals undergoing nutritional or other stress falls on the owner and is accomplished by daily observation. Small ruminants show mild to moderate behavioral changes before showing obvious signs of a condition or disease. When changes in behavior do occur, consider that it may be a herd/flock health problem rather than an individual animal problem. This is because small ruminants tend to stay close to one another, which can promote the spread of any infectious conditions. The following steps should be undertaken when dealing with a potential disease outbreak (Dawson *et al*., 2021).

1. Isolate any affected animals.
2. Determine if the condition is a single occurrence or the start of a bigger problem.
3. Check all animals carefully to identify sick ones.
4. Submit any mortality for a postmortem examination as soon as possible or take appropriate tissues from the animal for diagnosis at a state or other diagnostic laboratory facility.

9.2. Flock monitoring and surveillance

Small ruminants have different health needs according to their stage of production. Providing for these health needs will increase your chances of having a healthy and productive farm. Dawson *et al*. (2021) gave the following recommendations as most important components to apply for all small ruminants.

9.2.1. Pre-breeding

To achieve a healthy gestation and parturition, a producer must attend to breeding animal condition prior to mating. An easy and practical way to assess the nutritional, and indirectly the health, status of the herd is through the body condition score (BCS). It is the best simple indicator of available fat reserves that can be used by the animal in periods of high energy demand, stress, or suboptimal nutrition. A BCS of 1.0 is an extremely thin animal with no fat reserves, and a BCS of 5.0 is a very over conditioned (obese) animal. In most cases, healthy small ruminants should have a BCS of 2.5 to 4.0. A BCS of 2.0 or lower indicates a management or health problem.

When overall herd body condition starts to decrease, managerial intervention such as supplemental feeding, deworming, pasture rotation, etc., needs to be taken. Conversely, when overall body condition starts to increase in the herd to above recommended levels, the owner should reduce supplemental feeding. Ignoring an animal’s body condition and waiting to intervene until they become either too thin or too fat may result in production and animal losses or decreased profits from overfeeding. Ideally, does and ewes at pre-breeding should have a BCS of 2.5 to 3.5. Females having a BCS less than 2.0 should be supplemented (flushed) with grain 2 to 4 weeks before breeding, which may improve their pregnancy rates. Abrupt fence line exposure to males in the late fall transition period can help bring about cycling.

9.2.2. Breeding Does and Ewes

Thirty to 60 days before the breeding season, examine animals for udder and teat conformation, dentition (teeth), musculoskeletal problems, feet, and body condition. Cull does and ewes that have severe problems or do not meet herd conformation goals. Some common conditions seen in breeding females include lameness, chronic mastitis, bad teats, and poor body condition due to chronic diseases, parasitism, old age, or other causes. Doelings /ewe lambs should be at least 65 to 70% of their estimated mature weight before their first breeding. Does/ewes should have fair to good body condition at the time of breeding (BCS of 3 to 3.5). They need to be vaccinated for common diseases and conditions seen at the farm, FAMACHA scored and dewormed if necessary, and have their feet trimmed.

9.2.3. Breeding Bucks and Rams.

Bucks and rams are often neglected or not examined during routine herd health procedures. Some common conditions seen are urinary calculi (stones), lameness, urine scalding around the prepuce, damage to horns/ antlers due to fighting, and injury due to a dominant buck/ram in the pen. In the case of urinary scald, wash the affected area and apply petroleum jelly to help protect that area. To prevent urinary calculi, maintain a 2:1 to 2.5:1 ratio of dietary calcium to phosphorous and provide a high level of salt (up to 4%) to encourage water consumption. Adding 1 to 2% ammonium chloride in the diet to acidify urine can also help prevent urinary calculi. At least 4 weeks before the breeding season, evaluate bucks'/rams' body condition and adjust feeding program as needed.

Conduct a breeding soundness examination, assess the buck's/ram's overall condition and capacity to serve does/ewes by evaluating the health history, checking physical soundness of feet and legs, and inspecting the external genitalia for abnormalities. Palpate the scrotum to ensure that it is firm, testes are similar in size and freely movable in the scrotum and the epididymis is normal. Rams should have minimum scrotal measurements for their age. There are no standards for buck scrotal circumference, but a scrotal circumference of 23 to 25 cm minimum measurement is desirable. Bucks/rams should be vaccinated at the same time as the females and for the same diseases. As breeding season approaches, extremely aggressive and dominant bucks/rams may need to be penned separately to prevent injury. Monitor fecal egg counts or FAMACHA score and deworm as needed.

9.2.4. Breeding Season

Watch does/ewes and bucks/rams carefully during the breeding season. This is a particularly strenuous and active time for bucks/rams, and lame or sick sires will not be able to breed adequate numbers of does/ewes. Fertility drastically decreases in hot weather. Do everything you can to cool the buck/ram. This may include shade and fans during the day in very hot climates. To prevent overexertion, maintain a proper male-to-female ratio. In pasture conditions, a mature goat buck or ram be expected to breed 30 to 50 does/ewes during the breeding season. Definitive numbers for a buck-to-doe ratio range from 10 to 25 depending on pen size and the age of the buck. Have some means of monitoring breeding activity, such as a marking harness for goats and sheep. A breeding season of 45 to 55 days is common.

9.2.5. Gestation (Pre-parturition)

Fulfilling the health and nutritional needs of the doe/ewe during gestation promotes a normal parturition, healthy kid/lamb and sufficient colostrum and milk production after parturition. Provide an adequate diet and have clean, cool water and free-choice trace-mineralized salt available. Pregnant does/ewes should be body condition scored in early pregnancy and again 6 weeks prior to kidding/lambing and should have a BCS of 3.0 to 3.5 just prior to parturition. Monitor feed quantity and quality in the last one-third of gestation, as most fetal growth occurs during this time. Very thin or fat older sheep/goats carrying triplets or quadruplets may experience a decline in feed intake during this time, making them highly at risk for developing pregnancy toxemia. Booster vaccinations for *Clostridium perfringens* type C and D and tetanus toxoid should be administered no later than 3 to 4 weeks prior to kidding/lambing. Other vaccinations or boosters should also be provided for diseases causing abortion. Monitor fecal egg counts or FAMACHA score and deworm as needed.

The majority of does/ewes experience no severe problems during gestation. However, vaginal prolapses, hernia, ruptured prepubic tendon, acute mastitis, and pseudo-pregnancy can occur. Vaginal prolapses are more common in ewes but not in goats. Factors that contribute to vaginal prolapses in ewes are genetics, body condition of the ewe, quality of roughage fed, location of tail docking, etc. Abdominal hernia is seen usually in late gestation or due to trauma or postsurgical complications. Ruptured prepubic tendon is seen in older does/ewes in late gestation.

Vaccinations for chlamydia, campylobacter, and leptospirosis are included, if they are diagnosed as a problem of reproductive failure and abortions on the farm. Pre-breeding booster vaccinations are usually done at least 3 to 4 weeks prior to breeding. Abortions can occur anytime during gestation for a variety of reasons. Early-term abortions may go unnoticed and the doe/ewe is categorized as having failed to conceive rather than aborted. Late-term abortion storms are mainly infectious in nature. Sporadic abortions in does may be due to stress-related causes like weather changes, transportation, shearing etc.

9.2.6. Parturition (Kidding/Lambing)

The doe/ewe should kid/lamb in a clean environment, either a well-drained clean pasture or a stall bedded with straw or other absorbent material. Prior to birth, the kid/lamb has existed in a germ-free environment, and parturition exposes them to common disease organisms to which a mature animal has developed resistance. The kidding/lambing stall or pasture should be located near a well-traveled area so that the does/ewes are observed at frequent intervals for dystocia. Few adult sheep or goats require assistance at the time of parturition, although problems are always a possibility. First-freshening does or ewe lambs should be closely watched, especially if bred to bucks/rams known to sire large kids/lambs.

Signs of impending parturition include udder engorgement, swelling of the vulva, restlessness, and vulva mucus discharge. The ligaments in the pelvic area will relax and the udder secretions change from clear honey-like form to thick white/yellow milk (colostrum). The doe/ewe may also lose appetite. *Stage one* of parturition consists of uterine contraction and cervical dilation, may last from 3 to 6 hours or more, and ends with the rupture of the amnion. *Stage two* is the active stage of labor exhibited by abdominal contractions and birth, lasting 30 minutes to 1 hour. If the doe or ewe is straining or birth is delayed for more than 30 minutes in an adult doe/ewe, or greater than 1 hour in first time kidding does or ewe lambs, assistance maybe needed. *Stage three* consists of expulsion of the placenta and usually occurs within a few hours after the last fetus is born.

9.2.7. Problems in Parturition

Most does/ewes will kid/lamb with little to no assistance required; however, problems can occur. The most common problems encountered are an oversized single fetus; abnormal presentation, position, and posture; or two fetuses entering the birth canal at the same time. In a normal birth presentation, the fetus will be in an anterior presentation, dorso-sacral position with their front feet extended into the birth canal. Posterior presentation, dorso-sacral position, with their hind limbs extended, is seen where the rear legs enter the birth canal first.

9.2.8. Kid/Lamb Management at Birth

After birth, two management practices are critical to the future health and survival of the newborn. The navel cord should be dipped in a solution of iodine (1 or 2% is now preferred to 7% tincture of iodine due to tissue damage) or 2% chlorhexidine solution to prevent entry of disease causing organisms, especially for neonates born in confinement or small lots with high populations. Make sure the entire cord is immersed in the iodine or chlorhexidine solution.

The other critical practice is the feeding of colostrum ideally within 2 to 4 hours of birth. If a newborn neonate does not or cannot nurse, the colostrum should be bottle-fed or tube fed to ensure adequate consumption. Neonates should receive 15% of their body weight during the first 24 hours of life. For example, a 2.7 kg kid/lamb should receive 400 mL of colostrum within 24 hours of birth, and the colostrum should be divided into at least three to four feedings, due to the size of the abomasum. As a general rule of thumb, feed a minimum of 2.7 kg – 360 mL or 1 kg – 150 mL or 2.7 kg – 375 mL of body weight within 24 hours. Excess colostrum may be collected and frozen for use to supplement orphaned/abandoned kids/ lambs.

Caprine Arthritis Encephalitis (CAE) virus and *Ovine progressive pneumonia* (*OPP*) are transmitted from the doe/ewe to the kid/lamb mainly through colostrum and milk. Methods to prevent transmission include feeding colostrum frozen from does and ewes tested and shown to be CAE/OPP-free, feeding heat-treated colostrum and pasteurized milk, feeding bovine colostrum and milk, or feeding commercially available artificial colostrum replacer. Colostrum can be heat treated by raising the temperature to 56°C for 60 minutes or 74°C for 15 seconds. Milk should be pasteurized by treating at 63°C for 30 minutes or 72°C for 15 seconds. The temperature is critical for colostrum because a higher temperature will denature colostral proteins that provide disease immunity and a lower temperature will not kill the virus. Heat-treat colostrum or pasteurize milk by using a water bath with an accurate thermometer or by equipment purchased for the task. If a herd is infected with CAE, owners should not feed kids unpasteurized milk even from test-negative does.

Under certain conditions, newborn kids/lambs may benefit from injections of vitamins A and D within 4 days of birth. A vitamin E/selenium injection given within 72 hours may be beneficial in areas of selenium-deficient soils. If supplementation is necessary, feeding dietary supplements in the ration in appropriate levels will usually prevent deficiencies. Fat-soluble vitamins and minerals are toxic if given in excess. Examine neonates carefully at birth for any physical deformities or congenital abnormalities. The most common congenital defects include cleft palate, umbilical hernia, parrot mouth (under shot jaw), and atresia ani (no anal sphincter). Diarrhea and pneumonia can cause high mortality rates in neonates. A clean, dry, draft-free environment is an excellent preventive measure.

9.2.9. Artificial Rearing of Neonates

Milk is the principal dietary component for neonates. The majority of meat goat kids and lambs nurse their dam until weaning. However, commercial milk replacer is used in orphans, kids/lambs from young does and ewes that have lactation problems, does/ewes with more than two offspring, and does/ewes who have abandoned their young. Dairy kids are taken away from their dam as soon as they are born. Typically, milk replacers contain 22 to 30% protein and 28 to 30% fat (on a dry matter basis). A species-specific milk replacer needs to be used if possible. If no other milk replacer is available, calf milk replacers may be used as a last resort. Maintaining milk replacer quality after mixing is very important when neonates are fed ad libitum.

Milk is fed using bottles, buckets, or self-feeder units depending upon size of the farm, available labor, and personal preference. With any system of feeding, the health of the neonate, sanitation, and available labor are the major factors to consider. Under natural suckling, neonates consume small amounts of milk at very frequent intervals. Ideally, artificial rearing should mimic natural suckling, but labor constraints often preclude frequent feeding. Nevertheless, neonates are ideally fed three to five times daily for the first 1 to 2 weeks and two to three times daily thereafter. Bottle-feeding is labor intensive, but neonates receive more individual attention and are easier to handle post-weaning than kids and lambs suckling does/ewes.

For larger herds, self-feeder units may successfully reduce labor. The key factor in this system is maintaining a low milk temperature (40°F, < 5°C) to limit excessive intake by a kid/ lamb at any one time. Small, frequent feedings increase digestibility and decrease digestive disturbances. Rapid consumption of large quantities of milk may lead to fatal bloat due to milk entering the reticulo-rumen space. Rapid passage of milk through the abomasum and small intestines can result in diarrhea or nutritional scours.

A strict feeding schedule should be followed when using a milk replacer to bottle feed kids/ lambs. Frequently, neonates become "pets," and there is a tendency to feed them as much milk as they will consume each feeding. By leaving them on a milk replacer too long, these neonates extend the time they take to start eating solid feeds and may result in bloat and sudden death due to enterotoxaemia or diarrhea. Early vaccination for *C. perfringens* is necessary for bottle-fed or artificially reared neonates.

9.2.10. Dam-Raised Neonates

Most neonates are raised with their dams on pasture. While this removes the need for feeding milk replacer, these kids/lambs should not be neglected in terms of nutritional and health needs. Owners must remember that since these animals are raised in the same environment as their dams, they are also exposed to the same health, disease, management, and grazing conditions. If internal parasites are a problem in the dams, expect the same in the neonates and take management steps to reduce exposure to internal parasites through pasture rotation or other means. If housed at any time, avoid crowding and have clean bedding and adequate ventilation. Neonates are naturally curious and will begin to explore and nibble on various items in their pens and surroundings early in their life. If there are toxic substances or plants, plastic, or other harmful materials lying around, chances are some neonates will eat them. If pasture is of very poor quality, neonates that are beginning to nibble on grass or hay will not receive much nutritional benefit. This can slow down early growth.

Early access to a creep feed or pasture containing lush, nutritious forage will benefit neonates and get them accustomed to eating solid food and enhance the development of their gastrointestinal tract, promoting early growth. Entry into the area containing creep feed or pasture should be restricted to neonates by fencing or gates that prevent access by adult animals. Coccidiostats can be mixed in the creep feed and in grower rations for lambs and kids.

9.2.11. Weaning

In raising kids and lambs, increases in size and weight are not the only measure of success. A well-formed skeleton and proper development of internal organs are often neglected or overlooked. Dry-feed consumption is important in developing body capacity that leads to increased feed intake and digestion. Begin offering a creep feed no later than 3 to 4 weeks of age. As creep feed consumption increases, gradually reduce the amount of milk fed. Research has shown that at 2 months of age, a weaned kid has a reticulo-ruminal capacity five times as large as suckling kids/lambs of the same age do.

Kids/lambs on pasture should be consuming forages such as pasture or hay by 2 weeks of age and grain within 4 weeks. Give careful attention to the formulation of a concentrate supplement for pre-weaning animals. Palatability is of primary concern. Molasses at the rate of 10% of total dry matter, corn (preferably ground or rolled), and whole or rolled oats make up the energy "core" of a good pre-weaning diet. Balance the crude protein needs by adding cottonseed or soybean meal or another high quality protein source. Crude protein in the pre-weaning ration should range from 14 to 18%. Ground alfalfa may be added up to 5% or less to provide additional stimulation for reticulo-ruminal development.

Several factors should be considered when deciding to wean. The most important consideration is whether the average daily consumption of concentrate and forage is adequate for growth and development to continue in the absence of milk. Fixed weaning ages are less desirable than weight goals such as 2.0 to 2.5 times birth weight. When a kid/lamb is eating 0.25 lb of grain per day, plus some hay, and is drinking water from a bucket, it is time to wean. Adding coccidiostats in the creep feed and in the grower ration will help control coccidiosis in lambs and kids.

9.2.12. Post-weaning

The post weaning period is a critical time due to the stress of removing offspring from their dams. Hand-reared neonates seem to be less stressed when weaned from a milk source as compared to neonates that have been nursing their dams. Neonates that have started consuming creep feed and hay prior to weaning tolerate weaning stress better than those that do not consume appreciable amounts of solid feed. Common diseases encountered during the weaning period include pneumonia, coccidiosis, gastrointestinal parasitism, polioencephalomalacia, and enterotoxaemia.

To reduce the incidence of respiratory diseases at weaning, avoid overcrowding, maintain proper barn ventilation, and observe animals daily to ensure adequate feed and water intake as well as early detection of disease signs. To control coccidiosis, reduce the number of oocytes in the environment by reducing stocking densities and removing soiled bedding. Keep hay and feed racks above the ground and incorporate a coccidiostat in the feed (sheep/goats). Regular pen and pasture rotation can decrease exposure to coccidia. On initial exposure to fresh pasture in late spring or summer, weanlings may incur heavy internal parasite exposure. To avoid exposing them to an infested pasture, place weanlings in a clean pasture that has had no small ruminant presence for at least 2 months.

Depending on the history of anthelmintic used, kids and lambs with a FAMACHA score greater than 3 should be dewormed with an appropriate dewormer or a combination of different classes of wormer. In meat goat/lamb finishing programs or feedlots, be aware of the potential for bloat, enterotoxemia, and urinary calculi. Prevent bloat by gradually increasing grain over a 10- to 14-day period. Follow proper vaccination program to prevent enterotoxemia. Polioencephalomalacia incidences can be reduced by gradually increasing grain in the diet, decreasing sulfur/sulfate content in the ration, providing clean water, early detection and treatment with amprolium and sulfa drugs, and monitoring animals after deworming. Castrated and intact males are prone to urinary calculi as young as 3 months of age. Prevent by providing a continuous supply of clean fresh water, including 4% salt in the diet, or giving a salt block. Continuous or pulse dose feeding of urinary acidifiers like ammonium chloride helps to acidify the urine and prevent stone formation.

9.3. Record Keeping

Record keeping is an essential part of good livestock and farm business management. Recording can be done most easily if animals have some form of identification. Thus, animal recording and identification are inseparable. There are two main objectives of animal identification and recording:

- ❖ To identify animals belonging to a particular owner; proof of ownership.
- ❖ To use as a management tool to:
    - ✓ undertake performance evaluation,
    - ✓ perform genetic selection,
    - ✓ keep proper health records,
    - ✓ accurately measure production and reproduction, and
    - ✓ Perform other important management functions required to run an effective and efficient farm enterprise (Solomon *et al*., 2008).

Establishment of a national livestock data-recording system is important for a uniform development of recording and analysis procedures.

The national recording system should:

- o Be uniformly used throughout the country.
- o Be simple to implement and use.
- o Allow identification of the best and poorest management procedures.
- o Provide information necessary to make management decisions.
- o Provide data for research, policy development and extension.
- o Help in implementing genetic improvement programs.

Such national schemes can become successful if there is clear benefit to participating farmers. However, the need for record keeping could arise from its importance on a scale broader than a single farm. Effective, reliable and traceable identification and recording systems for live animals and animal products could enable national or international bodies to rapidly respond to disease outbreaks and biosafety concerns. This will help to identify the source or sources of the problem, understand its implications and take appropriate measures (Solomon *et al*., 2008).

9.3.1. Types of Records

Sheep and goat production records should give details of individual ewe or doe performance over successive years on fertility, prolificacy, rearing or mothering ability and milk production directly or indirectly estimated through lamb/kid growth rate to a given age. If records are used for selection purposes, comparisons should be made between animals in the same flock to avoid confusion arising from differences in farm conditions or other environmental effects. Another option is to mathematically correct for known factors causing differences. As the number of animal records increases, their reliability to be used as a guide for breeding value of individual animals is increased.

On-farm records are essential in evaluating and improving the performance of sheep and goats within a farming system. Farmers should have a record book in which all records are kept. This should be stored in a place where it will not become soiled or wet, making the records useless. The format should be simple and readily understood by the farmer. This record book should be written in a language understood by farmers in the area and must contain any type of regional-specific records or information that needs to be kept (Solomon *et al*., 2008).

Below is a list of records that may need to be kept under Ethiopian conditions. The value and relevance of the different types of records will vary with differing sheep and goat production systems.

- Lambing records, which include identity, dam ID, weight, date of birth, type of birth and sex.
- Growth or weight records kept periodically by recording the body weight of animals.
- Health records including morbidity, mortality, signs and symptoms, diagnosis, treatments and vaccinations, etc.
- Feed consumption: This is difficult to estimate on farms where animals graze, but for capital-intensive farm businesses, such as finishing or fattening operations, the amount of concentrate fed should be recorded to calculate profitability.
- Milk production records: recording once weekly may suffice as this is highly correlated with total milk production. Therefore, in dual-purpose sheep and goats, or even in meat types, a random sample of lactating females may be selected for recording their once-a-week milk production.
- Mating records: Sire, dam and progeny identification is important in breeding, sale, and culling decisions.
- Testes size: Recording testes size at one year of age can assist in sire selection. Testes size in males is related to ovarian activity (multiple ovulations) in females.
- Carcass yield or dressing percentage is a factor that has tremendous economic value, particularly in a community-based breeding program involving meat breeds. This information could be obtained from slaughterhouses/abattoirs.
- Hides and skins: For a crossbreeding program there may be a need to record skin quality aspects such as area of hide, skin thickness, elasticity, pigmentation and density of hair.

9.4. Biosecurity

Biosecurity refers to the combination of all the different measures implemented to reduce the risk of introduction and spread of disease agents (Barceló and Marco, 1998; Amass and Clark, 1999). Biosecurity measures can be implemented at different levels such as country, region, herd or flock, and even individual animals. Implementing biosecurity involves adopting a set of attitudes and behavior to reduce risk in all activities involving animal production or animal care. It is based on the prevention of and protection against infectious agents. The measures to be established should be seen as part of a process aimed at improving the health of animals, people and the environment. Biosecurity can be subdivided in two main components: external biosecurity (also called bio-exclusion) which is aimed at keeping pathogens out of the herd; and internal biosecurity (bio-management) which focuses on preventing the spread of pathogens within the herd. Bio-containment (avoiding the spread of pathogens from herd to herd) is mainly associated with external biosecurity (Dewulf and Van Immerseel, 2019).

The aim of combining all biosecurity measures is to prevent both the introduction as well as the spread of infectious agents in a group of animals. As such it targets reducing the infection pressure exerted upon the animals. Effective biosecurity is the foundation of disease prevention, which can be complemented by additional preventive measures such as vaccination or use of feed additives. Biosecurity is important both in controlling exotic as well as endemic diseases. If biosecurity and disease prevention measures are well implemented it is possible to reduce curative treatment of diseased animals to an absolute minimum. If biosecurity is well established then additional preventive measures will have a greater impact and the need for curative treatment can be kept to a minimum. Improving biosecurity, and by consequence reducing infection pressure may also result in substantial improvements in production results as well as reduced antimicrobial use (Dewulf and Van Immerseel, 2019; Edmondson *et al*., 2012).

The process begins with a risk assessment listing already present diseases and then diseases that have potential for entry to the farm. Hence, procedures and protocols to prevent disease entry through management, disease testing, quarantine procedures, etc., need to be established. In addition to preventing entry of diseases, producers must also have a plan to deal with animals that contract a disease to prevent further spread within the farm. New animals moving onto a unit should be kept in quarantine for a minimum of 14 days, but ideally longer if possible. A building with a separate airspace to the main accommodation is ideal, as is a separate paddock outdoors, providing sheep and goats do not have contact with others in adjoining fields. During this quarantine period, they should be examined or tested for any clinical evidence of infectious diseases. Any vaccinations relevant to the holding onto which they have been moved should be administered, together with any other prophylactic or therapeutic regime deemed necessary, based on history and clinical and laboratory test results (Edmondson *et al*., 2012).

9.4.1. Biosecurity practices

Not all biosecurity practices are feasible or necessary for every operation. Producers must assess their risks when deciding which practices to adopt. The following practices (Dement *et al*., 2008) can generally be used by sheep and goat producers:

- ✓ Consult a veterinarian when implementing vaccination and other herd or flock health management strategies.
- ✓ Limit the number of people who enter the premises, and know all people who come and go, including consultants, salesmen, deliverymen, maintenance workers and veterinarians.
- ✓ Keep gates locked at all times and maintain good perimeter fences.
- ✓ Inventory ranch vehicles and equipment regularly and lock all vehicles left outside.
- ✓ Use a disinfectant, such as bleach, to kill viruses and bacteria. A mixture of 1/2 cup bleach to 1 gallon of water is sufficient. A pump-up sprayer is ideal for applying disinfectant in most situations.
- ✓ Sweep out trailers to remove loose dirt, hay and grain, cobwebs, trash or debris.
- ✓ Remove mud and manure by scraping or scrubbing both the interior and exterior of the trailer, truck and equipment.
- ✓ Soak and wash vehicles and equipment using water and detergent or disinfectant. Use a brush or pressure washer if necessary.
- ✓ When washing the outside of vehicles and trailers, start at the top and front and work from top to bottom and front to back.
- ✓ When washing the inside of vehicles and trailers start with the ceiling and work down the wall to the floor. Begin at the front of the trailer and work toward the back.
- ✓ Control pests such as rodents, arthropods and birds, and limit their access to feedstuffs.
- ✓ Train employees to report sick animals, suspicious activity or people, and unusual events.
- ✓ Know your neighbors and set up a crime watch program.
- ✓ Request that local law enforcement agencies randomly drive by your premises and look for unusual behavior.
- ✓ Create an emergency contact list of resource people in the community.
- ✓ Make sure critical information is readily accessible to any first responders who might be called to the scene. Include maps of the premises, types and locations of chemicals, and an inventory of animals.

9.4.2. Vaccinations

Vaccinations provide the body with a way to make antibodies to combat disease without contracting the disease, so that if the animal is exposed to the disease later, its body can produce more of these antibodies to combat the disease. Vaccines are made from killed pathogens or modified living organisms that have been altered to stimulate immunity without causing disease. Vaccines are effective in preventing certain diseases in sheep and goats; however, vaccines are not 100 percent effective. By law, all vaccines must come with instructions on proper usage. Some vaccines require only a onetime injection; most require two injections 3 to 6 weeks apart plus annual boosters to maintain immunity. For best protection, vaccinate animals before, not after, they are exposed to a particular disease. Hence, owners must consult a veterinarian about the proper timing of vaccinations as part of an overall herd/flock health management plan (Dement *et al*., 2008).

Properly conducted and managed vaccination programs are critical to enhancing the immune status of the herd. Proper timing of vaccinations and booster immunizations will assist in combating disease and minimize the severity of any disease outbreak. Disease prevention using vaccination programs can be developed by the veterinary staff and the stakeholders considering local information on disease occurrence together with epidemiological knowledge. Under Ethiopian context vaccination program for sheep and goats will include the following elements:

- Routine vaccination using some of the following vaccines: i.e., Pasteurellosis, Sheep and goat pox, anthrax, Pest des petits ruminants (PPR) and;
- Ring vaccination carried out during outbreaks of Contagious Caprine Pleuropneumonia (CCPP) in which case goats that are found around the outbreak areas will be vaccinated. This will serve as a barrier to halt the spread of infection (Sileshi and Desalegn, 2008).

Vaccines are fragile and must be handled according to the manufacturer's label directions to remain effective and in therefore the following guidelines must be followed (Dement *et al*., 2008).

- ✓ Before vaccinating animals, owners must consult a veterinarian and read the label and/or packet insert.
- ✓ Note the expiration date and the instructions for storing the vaccine properly.
- ✓ Most vaccines must be refrigerated during storage and use. Vaccines need to be kept in a cold chain (i.e., kept cold at all times from production through transport and storage, and before injecting into an animal). Hence, vaccines must be kept: in an ice box with sufficient amount of ice during transport and at 4°C or -20°C while in the clinic.
- ✓ If vaccines or other medications do not require refrigeration, store them out of direct sunlight in a controlled environment.
- ✓ Give the right vaccine to the right species of animal. If the label indicates use in swine, do not use it in sheep and goats. This off-label use is illegal.
- ✓ Give the proper dosage, in the recommended area on the animal, using the recommended technique.
- ✓ Once a vial is open, do not insert a used needle back into the bottle. Always use a clean needle or a transfer needle.
- ✓ Use a clean needle for each animal to prevent disease transmission in a herd.
- ✓ When finished vaccinating for the day, properly dispose of the remaining vaccine, which does not keep well once the vial seal has been punctured. Once a vaccine vial is opened, the expiration date is void.
- ✓ Do not use chemical sterilants to disinfect syringes for modified-live vaccines.
- ✓ Properly dispose of used needles in a puncture-proof container.
- ✓ Give boosters when a label requires it.

9.5. Deworming and external parasite control

9.5.1. Prevention and control of internal parasites

Currently, internal parasites are mainly controlled by use of anthelmintic drugs. Unfortunately, drug resistance has become a problem to sheep and goat production areas throughout the world. It is inevitable that it will also occur in Ethiopia. Meat and live animal importing countries now require livestock products to be free from drug residues. Therefore, there is a need to follow an integrated worm management program for sheep and goats as described below (Taylor *et al*., 2016; Sileshi and Desalegn, 2008).

9.5.1.1. Curative deworming

As with other infections, the treatment of gastrointestinal parasites should be preceded by removal of the source of infection. However, in a communal grazing system, keeping animals away from sources of infection is difficult. You can use anthelmintic treatment to remove the parasites. There are several options from which to choose in deciding which animals to treat.

The first option is treating targeted groups of animals exhibiting the signs of lagging behind the flock, showing weakness, ill-thrift, anorexia, and diarrhea. It also aims at young animals (lambs, kids/weaners) which are susceptible to infection as well as pregnant/lactating ewes and does because of weakened immune response during this physiological state. The second option is to treat anemic animals by using FAMACHA scoring to check highly anemic animals. FAMACHA is a method developed in South Africa for testing for anemia caused by parasites, particularly for *Haemonchus contortus*. There is a 5-number scale on a FAMACHA card. Categories 1 and 2 need no treatment; an animal registering a 3 needs treatment only if it looks sick while categories 4 and 5 need treatment. Always treat sheep and goats with a score of 4 and 5 where the FAMACHA test should be repeated every 4 weeks and treated as necessary. The third option to treat animals based on parasitological parameters using egg counts to monitor infection and proceed with the curative treatment by selecting appropriate drugs. Goats require twice the cow dosage of all dewormers, except for Levamisole that should be given at 1.5 times the cow or sheep dose (Sileshi and Desalegn, 2008; Taylor *et al*., 2016; Constable *et al*., 2017).

9.5.1.2. Preventive deworming

Preventive deworming (drug prophylaxis) consists of eliminating worm infections by regular treatment of herds/flocks. The treatment program should eliminate worms at peak infection and prevent reinfection of pasture during high-risk periods. Several treatment programs are proposed for different times of the year. In practice, a number of regular treatments for diseases such as fasciolosis should be given. For sheep and goat production areas of Ethiopia, the following approaches may be considered. First, treatment may be given at the end of the rainy season (September/October) according to the altitude. At this time, animals are well nourished and may have large numbers of parasites without seemingly being affected by the worms. Killing these parasites with anthelmintic drugs will improve performance during the upcoming harsh, dry season conditions. Second, treatment may be given at the end of the dry season (April/May) where the entire herd/flock should be treated. This treatment reduces infection of pastures by residual parasites and parasites which occur throughout the year. Two treatments per year, with improved management, seem to be an optimum (Sileshi and Desalegn, 2008).

9.5.1.3. Strategic deworming

Strategic deworming of animals with approved drugs is an important strategy in controlling internal parasites. Annual rotations of anthelmintic drugs are not currently recommended as this can increase rate of resistance to all drugs. Using one class of a broad spectrum drug until it is no longer effective and then switching to another class of a broad spectrum drug is considered a better strategy. The new strategy is thus recommended for use (Taylor *et al*., 2016). Moreover, it is necessary to consider the following points seriously:

- Use a full dose of anthelmintics whenever treatment is carried out. This is recommended to help prevent the development of resistance.
- Treat all newly introduced animals before allowing them to mix with the remaining flock.

Two treatments are recommended at the beginning of the dry season and two treatments at the beginning of the rainy season. The interval between the first and second treatments should be 2-3 weeks. The treatment at the beginning of the dry season is done to eliminate the current parasite burden, enabling animals to better cope with the nutritional stress during the dry season. A treatment before the rainy season will prevent contamination of pastures at a time when conditions are becoming favorable for egg and larval development (Sileshi and Desalegn, 2008).

9.5.1.4. Pasture management

Pasture management is designed through long-term planning with such factors as the age groups of animals and the time and intensity of grazing. This can be practiced by considering the following issues into consideration.

- Pasture rotation: dividing a pasture into paddocks and moving animals from one paddock to another to optimize use of grass. Use of a “50/50” grazing system, (all the animals on half of the farm).
- Grazing height: some experts recommend that animals be allowed to graze new pastures very close to the ground so that the sun can diminish the chances of survival of the parasites brought in with the animals.
- Grazing time: the drier the grass, the more parasites will stay at the base of the plants. The risk of infection is greatly lowered by waiting until the dew has lifted or until the grass has dried after the rains.
- Graze by age group: the susceptibility of animals varies with age. It is logical to graze younger animals in fields where parasite populations are very low and separately from adult animals. Alternate grazing pastures annually.
- Multi-species grazing: graze cattle after sheep and goats. Cattle clean the pasture after sheep and goats have grazed. The cattle ingest a significant quantity of mature larvae from the lamb stools, but cattle are not affected by most internal parasites of sheep and goats. If the cattle are allowed to graze the grass down to 3–5 cm from the ground, many parasites will be killed off due to exposure to the sun.
- Improvement of drainage: pasture that remains wet for a long period is an ideal environment for survival of internal parasite larvae. Drainage of a field reduces the larvae’s chances of survival.

9.5.1.5. Control options through breed choices

Parasite control is possible through an integrated approach by combining different control strategies. The use of breeds that have increased worm resistance is one strategy. Some breeds of sheep and goats are more resistant to parasites.

- In sheep for example: Florida Native, Louisiana Native, Barbados Black Belly, Red Massai of Kenya, etc., are resistant breeds.
- Resistant breeds can be introduced in an area to replace existing susceptible breed(s) provided that they are productive under the new circumstances.
- A local breed can be crossed with a resistant breed imported from other areas.
- Note that sometimes one breed is economically desirable despite its relative susceptibility to major diseases (e.g., Merino for fine wool production despite its relative susceptibility to diseases from round worms such as *Haemonchus contortus*).
- Resistance of Ethiopian sheep and goat breeds to internal parasites is not known.

9.5.1.6. Anthelmintic drugs and dosages

There are different formula and presentation of anthelmintic drugs. The following are some examples:

- Boluses/pills or tablets- these are practical and easy to use.
- Liquid preparations/drenches - these are locally available ready-to-use preparations.
- Pastes- easy to administer if you have a dispenser. Not commonly available in local markets.
- Medicated blocks- difficult to control the amount of drugs consumed. Not locally available at present.
- Slow-release formulations - drugs placed in the rumen and hence will be delivered continuously. Not locally available.

9.5.2. Prevention and control of external parasites

9.5.2.1. Prevention and control of ticks

When it is planned to carry out prevention and control of ticks, treatment with acaricides is only recommended in places where ticks are present in large numbers. If ticks are not in large numbers, use of acaricides is not needed. In such circumstances, it is advisable to manually remove and kill them by hand using a needle or thorn. It is also a better option to shear the animal's hair and then apply an insecticide (such as Amitraz) as spray, a dip or pour-on solutions. Knapsack spraying is the most practical method if more intensive control measures are needed for a small number of animals. The most efficient method of hand-spraying should target the areas of the body along the entire length of the back, the sides and flanks, the brisket, each leg, belly, udder or scrotum, tail, anal area and finally, the head, face, neck and ears. A very effective method of control can also be achieved by using a small volume of special acaricide applied as a pour-on solution along the back of an animal. Currently, mobile dipping vats for sheep and goats are available and very effective. It is also important to check recently purchased or borrowed animals for presence of ticks especially around the shoulders. When ticks are seen on an animal, it should be treated immediately to prevent transmission to other animals (Taylor *et al*., 2016; Sileshi and Desalegn, 2008).

Ticks can develop resistance to acaricides as a result of frequent dipping and the uses of dip solutions at lower than recommended concentrations. Hence, the manufacturer's recommendations should be strictly followed to avoid such problems. Acaricides are also toxic to people as well as animals and care should be taken to limit contact with the skin and prevent any possibility of dip fluid being drunk, or contaminating ground water. Moreover, acaricides are also very damaging to wildlife and fish, so great care is needed when discarding used dip fluid. It will also be advisable to avoid recommending of unnecessary tick control measures. Other ectoparasites can usually be controlled by improving animal nutrition, ensuring better hygiene of animal houses and by occasional spraying or dipping (Taylor *et al*., 2016; Sileshi and Desalegn, 2008).

9.5.2.2. Treatment and control of lice

Spraying or dipping with insecticides is effective and should always be carried out twice. The first time to kill the lice currently on the body and the second, 14 days later, to kill lice hatching from eggs present at the first treatment as the eggs are not affected by insecticides (Sileshi and Desalegn, 2008).

9.5.2.3. Treatment and control of sheep keds

Shearing of wool sheep is recommended as it greatly reduces the infestation not only because of the removal of the keds with the wool, but also exposing those remaining on the skin to the environment in order to greatly reduce their development. Spraying or dipping with insecticide after shearing is also required to destroy keds (Sileshi and Desalegn, 2008).

9.5.2.4. Treatment and prevention of Psoroptic ovis and Sarcoptic mange

Infested sheep should be dipped (not sprayed) with acaricides (such as Diazinon 60%) or provision of ivermectin injection (200 mg/kg) could also be effective. Since newly introduced animals are the main sources of infestation for a flock, these animals must be checked carefully and possibly treated before being introduced into the new flock. Hence, quarantine of newly introduced animals is also a very useful way of preventing the parasite's spread. Additionally, animal houses and pasture fences must be sprayed with acaricides (Sileshi and Desalegn, 2008).

9.5.2.5. Treatment for Demodectic mange

In this case, repeated dipping and spraying with acaricides (such as Diazinon 60%) is important and Ivermectin injection is also effective. It should also be noted that when the contents of a mobile dip are to be discarded, care must be taken to avoid contamination of the environment. Dip contents can be drained into pits. The pits should be at least 150 m away from water sources and it is also extremely dangerous to reuse an empty acaricide container. Plastic or metal containers should be punctured or crushed. The containers should then be buried in an isolation area at least 50 cm below ground surface (Sileshi and Desalegn, 2008).

10. References/Bibliography

Aatish, H.U., Sindhu, Z., Iqbal, Z., Jabbar, A. and Tasawar, Z. 2007. Prevalence of Sheep Mange in District Dera Ghazi Khan (Pakistan) and Associated Hematological/Biochemical Disturbances. *Int. J. Agri. Biol*. 9(6): 917-920.

Abebe, G., 2005. Trypanosomosis in Ethiopia. *Ethiopian Journal of Biological Science* 4 (1):75-121.

Aiello, S. E. and Moses, M. A. 2016. The Merck Veterinary Manual, 11th edition. Merck & Co., Inc. Kenilworth, NJ, USA.

Alemu, B., Gari, G., Libeau, G., Kwiatek, O., Kidane, M., Belayneh, R., Siraw, B., Wieland, B., Asfaw, W. and Abdi, R.D., 2019. Molecular detection and phylogenetic analysis of Peste des petits ruminants virus circulating in small ruminants in eastern Amhara region, Ethiopia. *BMC Vet Res*. 15(1):84. doi: 10.1186/s12917-019-1828-6.

Amass, S.F. and Clark, L.K., 1999. Biosecurity considerations for pork production units. *Journal of Swine Health and Production* 7: 217-228.

Amenu, K., Thys, E., Regassa, A. and Marcotty, T., 2010. Brucellosis and Tuberculosis in Arsi-Negele District, Ethiopia: Prevalence in Ruminants and People's Behaviour towards Zoonoses. *TROPICULTURA*. 28 (4):205-210.

Andrew, B. and Forbes, 2021. Parasites of Cattle and Sheep: A Practical Guide to their Biology and Control (A.B. Forbes).

Aragaw, K., Teferi, M., Haile, A. and Tibbo, M., 2011. Effects of strategic helminthosis control on age at first lambing and lambing interval of communally grazed Menz ewes in Ethiopia, *Livestock Science*, 135(1):38-43.

Asmare, K., Abayneh, T., Sibhat, B., Shiferaw, D., Szonyi, B., Krontveit, R.I., Skjerve, E. and Wieland, B., 2017. Major vectors and vector-borne diseases in small ruminants in Ethiopia: A systematic review. *Acta Tropica,* 170: 95–104.

Asmare, K., 2015. Major parasitic and infectious diseases of small ruminants in Ethiopia: a systematic review and meta-analysis. The International Livestock Research Institute (ILRI). Addis Ababa, Ethiopia. Pp 259.

Assefa, D., 1997. Sheep health management issues in North Shoa: an overview. 11th Annual Conference. Ethiopian Veterinary Association, Addis Ababa, Ethiopia.

Assefa, G.A. and Kelkay, M.Z., 2018. Goat pasteurellosis: serological analysis of circulating Pasteurella serotypes in Tanqua Aberegelle and Kola Tembien Districts, Northern Ethiopia. *BMC Res Notes*. 11(1):485.

Ayalew, T., 1995. A preliminary survey of sheep helminthosis in Kembebit district, North West Shoa. Proceedings of the 9th Annual Conference. *Ethiopian Veterinary Association*, Addis Ababa, Ethiopia.

Ayana, D., Temesgen, K., Kumsa, B. and Alkadir, G. 2022. Dry Season *Eimeria* Infection in Dairy Cattle and Sheep in and Around Adama and Bishoftu Towns, Oromia, Ethiopia. Veterinary Medicine: Research and Reports 13: 235-245.

Ayana, D., Tilahun, G. and Wossene, A., 2009. Study on *Eimeria* and *Cryptosporidium* infections in sheep and goats at ELFORA export abattoir, Debre-zeit, Ethiopia.

Barceló, J. and Marco, E., 1998. On-farm biosecurity. In: Proceedings of the 15th IPVS Congress, Birmingham, England, 5-9 July, 129-133.

Bekele, T., Kasali, O.B. and Woldeab, T., 1992b. Causes of lamb morbidity and mortality in the Ethiopian highlands. *Vet Res Commun*.; 16(6):415-24.

Bekele, T. and Kasali, O.B., 1989. Toxoplasmosis in sheep, goats and cattle in central Ethiopia. *Veterinary Research Communications*, 13, 371-375.

Bekele, T., Kasali, O.B. and Woldemariam, W., 1992a. Endoparasite prevalence of the highland sheep in Ethiopia. *Preventive Veterinary Medicine* 13 (2): 93-102.

Berhe, K., Weldeselassie, G., Bettridge, J., Christley, R.M. and Abdi, R.D., 2017. Small ruminant pasteurellosis in Tigray region, Ethiopia: marked serotype diversity may affect vaccine efficacy. *Epidemiol Infect*. 145(7):1326-1338.

Berrag, B. and Cabaret, J., 1996. Impaired pulmonary gas exchange in ewes naturally infected by small lungworms. *Int J Parasitol*. 26(12):1397-400.

Berrag, B., Rhalem, A., Sahibi, H., Dorchies, P., Cabaret, J. 1997. Bronchoalveolar cellular responses of goats following infections with *Muellerius capillaris* (Protostrongylidae, Nematoda). *Vet Immunol Immunopathol*. 58(1):77-88.

Biffa, D., Jobre, Y. and Chakka, H. 2007. Ovine helminthosis, a major health constraint to productivity of sheep in Ethiopia. *Anim Health Res Rev*. 7(1-2):107-18.

Bowman, D.D., 2021. Georgis' Parasitology for Veterinarians, 11th Edition. Elsevier Inc.

Buxton, D. and Losson, B., 2007. Toxoplasmosis; General Considerations. In: Ortega-Mora, L.M., Gottstein, B., Conraths, F.J., Buxton, D. (Eds.), Protozoal abortion in farm ruminants, guideline for diagnosis and control. CAB, international, Reading, UK pp. 122-290.

Chanyalew, Y., and Alemu, B., 2014. Comparative Evaluation of Traditional Herb and Conventional Treatment of Ovine Foot Rot in Ethiopia. *International Journal of Livestock Research* 4(2): 42-51.

Chartier, C. and Paraud, C., 2012. Coccidiosis due to *Eimeria* in sheep and goats, a review. *Small Ruminant Research*, 103, 84-92.

Constable, P. D., Hinchcliff, K. W., Done, S. H. and Grunberg, W., 2017. Veterinary Medicine: a textbook of the diseases of cattle, horses, sheep, pigs, and goats. 11th ed. Elsevier Ltd.

CSA (Central Statistical Agency), 2017. Agricultural sample survey, 2016/2017 (2009 EC). Report on livestock and livestock characteristics. Statistical Bulletin 585. Addis Ababa, Ethiopia: CSA.

CSA (Central Statistical Agency), 2021. Agricultural Sample Survey. Volume II. Report on livestock and livestock characteristics (private peasant holdings), Statistical Bulletin, 589. Addis Ababa: Central Statistical Agency.

Dagnachew, S., Anmute, A. and Temesgen, W., 2011 Epidemiology of gastrointestinal helminthiasis of small ruminanats in selected sites of north Gondar Ethiopia. *Vet. J.* 15 (2), 57-68.

Dawson, L. J., Shipley, C. F., Merkel, R., and Pugh, D.G., 2021. Herd and flock health. In: Sheep, Goat, and Cervid Medicine, edited by Pugh, D.G., Baird, A. N., Passler, T., Edmondson, M. A. 3rd edition. Elsevier Inc.

Delil, F., Asfaw, Y., Gebreegziabher, B. and Belihu, K. 2012. Seroprevalence and sero-conversion after vaccination against Peste des Petits Ruminants in sheep and goats from Awash Fentale District, Afar, Ethiopia. *Prev Vet Med*. 103: 157-162.

Dement, A., Antilley, T. J., Hammack, S.P., Cleere, J.J., Jordan, E., Craddock, B.F., Paschal, J.C., Dominguez, B. J., Scott, B. D., Farnell, M. B., Sterle, J. A. and Faries, F.C. Jr. 2008. General Biosecurity for Livestock and Poultry Producers. Texas A&M AgriLife Extension.

Dewulf, J. and Van Immerseel, F. 2019. General principles of biosecurity in Animal production and Veterinary Medicine. In: Biosecurity in animal production and veterinary medicine, edited by Jeroen Dewulf and Filip Van Immerseel, CABI Pp 525.

Dinka, H. and Abebe, G., 2005. Small ruminant trypanosomosis in the southwest of Ethiopia. *Small Ruminant Research*, 57:239–243.

Dubey, J.P., 2010. Toxoplasmosis of Animals and Humans. 2nd edition. Boca Raton, Florida, U.S.A: CRC Press; pp 338.

Edmondson, M.A. and Shipley, C.F., 2021. Theriogenology of sheep, goats, and cervids. Sheep, Goat, and Cervid Medicine, 3rd edition 141-208.

Edmondson, M.A., Roberts, J.F., Baird, A.N., Bychawski, S. and Pugh, D.G., 2012. Theriogenology of Sheep and Goats. Sheep and Goat Medicine, 2nd ed, 150-230.

Etsay, K., Megbey, S. and Yohannes, H. 2020. Prevalence of sheep and goat coccidiosis in different districts of Tigray region, Ethiopia. *Nigerian J. Anim. Sci*. 22 (3): 61-69.

Ferede, Y., Amane, A., Mazengia, H. and Mekuriaw, S., 2014. Prevalence of major sheep diseases and analysis of mortality in selected model sheep villages of south Gondar administrative zone, Ethiopia. *Ethiop. Vet. J*. 18 (2), 83-98.

Fesseha H., 2021. Ovine Footrot and Its Clinical Management. *Vet Med*; 12:95-99. doi: 10.2147/VMRR.S306207.

Foreyt, W.J., 1990. Coccidiosis and cryptosporidiosis in sheep and goats. *Vet. Clin. N. Am*. 6, 655-670.

Fthenakis, G.C., Papadopoulos, E., Himonas, C., Leontides, L., Kritas, S. and Papatsas, J. 2000. Efficacy of moxidectin against sarcoptic mange and effects on milk yield of ewes and growth of lambs. *Vet Parasitol*. 87(2-3):207-16.

Garedew, L., Ayelet, G., Yilma, R., Zeleke, A. and Gelaye, E., 2010. Isolation of diverse bacterial species associated with maedi-visna infection of sheep in Ethiopia. *Afr. J. Microbiol. Res.* 4 (1): 014-021.

Gari, G., Serda, B., Negesa, D., Lemma, F. and Asgedom, H., 2017. Serological Investigation of *Peste Des Petits Ruminants* in East Shewa and Arsi Zones, Oromia Region, Ethiopia. *Vet Med Int*. 2017:9769071. doi: 10.1155/2017/9769071.

Gebrekidan, H., Hailu, A., Kassahun, A., Rohoušová, I., Maia, C., Talmi-Frank, D., Warburg, A. and Baneth G. 2014. Theileria infection in domestic ruminants in northern Ethiopia. *Veterinary Parasitololgy*, 200 (1-2):31-38.

Gebremedhin, B., Woldehanna, M., Flintan, F.B.W. and Poole, J., 2017. Baseline Survey Report for the Regional Pastoral Livelihoods Resilience Project in Ethiopia. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Gebremedhin, E. Z., and Gizaw, D., 2014. Seroprevalence of Toxoplasma gondii Infection in Sheep and Goats in Three Districts of Southern Nations, Nationalities and Peoples‟ Region of Ethiopia. *World Applied Sciences Journal* 31 (11): 1891-1896.

Gebremedhin, E.Z., Abdurahaman, M., Tessema, T.S., Tilahun, G., Eric Cox, E. Goddeeris, B., Dorny, P., Stephane De Craeye, S.D., Marie-Laure Dardé, M.L. and Ajzenberg, D. 2014. Isolation and genotyping of viable Toxoplasma gondii from sheep and goats in Ethiopia destined for human consumption. *Parasites & Vectors* 7, 425.

Gebremedhin, E.Z., Agonafir A., Tessema, T.S., Tilahun,G., Medhin,G., Vitale M., Marco, V.D., 2013. Some risk factors for reproductive failures and contribution of Toxoplasma gondii infection in sheep and goats of Central Ethiopia: A cross-sectional study. *Research in Veterinary Science* 95, 894–900.

Gelagay, A., Teshale, S., Amsalu, W., Esayas, G. (2007). Prevalence of contagious caprine pleuropneumonia in the Borana pastoral areas of Ethiopia. *Small Rumin. Res*. 70: 131-135.

Gelana, M., Gebremedhin, E.Z., Gizaw, D. (2020). Seroepidemiology of Peste des Petits ruminants in sheep and goats in the selected district of Horu Guduru Zone, Western Ethiopia. *Res. Vet. Sci*. 132:527-534.

Gelaye, E., Achenbach, J.E., Jenberie, S., Ayelet, G., Belay, A., Yami, M., Loitsch, A., Grabherr, R., Diallo, A., Lamien, C.E. (2016). Molecular characterization of orf virus from sheep and goats in Ethiopia, 2008-2013. *Virol. J.* 13:34. doi: 10.1186/s12985-016-0489-3.

Gessese, A.T., Mulate, B., Nazir, S. Asmare A. 2014. Major metacestodes in small ruminants slaughtered at Dessie municipal abattoir, Eastern Ethiopia: prevalence, cyst viability, organ distribution and economic implications. *Comp Clin Pathol* 24, 659–668.

Githeko, A. K., Lindsay, S. W., Confalonieri, U. E., and Patz, J. A. 2000. Climate change and vector-borne diseases: A Regional analysis. *Bulletin of World Health Organization*. 78 (9):1136-1147.

Gizaw, D., Gebreegziabher, B., Ayelet, G. and Asmare, K., 2009. Investigation of mycoplasma infection in goats slaughtered at ELFORA export abattoir, *Ethiop. Vet. J.* 13:41-58.

Gulima, D., 2009. Seroepidemiological Study of Bluetongue in Indigenous Sheep in Selected Districts of Amhara National Regional State, north western Ethiopia. *Ethiopian Veterinary Journal*, 13 (1):1-15.

Gumi, B., Firdessa, R., Yamuah, L., Sori, T., Tolosa T., Aseffa, A., Zinssta, J.and Schelling, E., 2013. Seroprevalence of brucellosis and Q-fever in Southeast Ethiopian.Pastoral Livestock. Journal of Veterinary Science and Medicine Diagnosis 2:1. doi:10.4172/2325-9590.1000109.

Hadush, B., Eshetu, L., Mengistu, W. and Hailesilassie, M., 2009. Seroprevalence of contagious caprine pleuropneumonia in Kefta Humera, Alamata (Tigray) and Aba-'ala (Afar), Northern Ethiopia. *Trop Anim Health Prod*. 41:803-6.

Haile A., Gizaw S., Getachew T. and Rischkowsky B.,2018. Challenges in small ruminant breeding programs and resulting investment priorities in Ethiopia. Proceedings of the World Congress on Genetics Applied to Livestock Production, 11: 475.

Harwood, D. and Mueller, K. 2018. Goat medicine and surgery. Boca Raton : CRC Press, Taylor & Francis Group, LLC.

Hill, J., 1996. Goat reproductive management, Proceedings of the Symposium on Health and Diseases of Small Ruminants, American Association of Small Ruminant Practitioners, Nashville, Tenn.

Hirpa A. and Abebe G., 2008. Ethiopian Sheep Goat Productivity Improvement Program (ESGPIP) 2008. Economic significance of Sheep and Goats, in Ethiopian sheep and Goats production hand book. PP 1-4.

ILRI, 2020. Livestock and Fisheries Sector Development project information. Household Level Baseline Survey Report. Baseline Survey Report for the Regional Pastoral Livelihoods Resilience Project in Ethiopia. ILRI Project Report. Nairobi, Kenya.

Jemberu, W.T., Li, Y., Asfaw, W., Mayberry, D., Schrobback, P., Rushton, J. and Knight-Jones, T.J.D., 2022. Population, biomass, and economic value of small ruminants in Ethiopia. *Front. Vet. Sci.* 9:972887.

Jibat, T., Ejeta, G., Asfaw, Y. and Wudie, A., 2008. Causes of abattoir condemnation in apparently healthy slaughtered sheep and goats at HELMEX abattoir, Debre Zeit, Ethiopia. *Revue Méd. Vét*., 159 (5): 305-311.

Kaplan, R.M., Burke, J.M., Terrill, T.H., Miller, J.E., Getz, W.R., Mobini, S., Valencia, E., Williams, M.J., Williamson, L.H., Larsen, M. and Vatta, A.F., 2004. Validation of the FAMACHA eye color chart for detecting clinical anemia in sheep and goats on farms in the southern United States. *Vet Parasitol*. 123(1-2):105-20.

Kiltu, G., Keffale, M. and Muktar, Y., 2016. Study on prevalance of small ruminant coccidiosis in and around Harmaya, eastern Haraghe Ethiopia. *Acta Parasitologica Globalis* 7 (1): 7-11.

Kumsa, B., Signorini, M., Teshale, S., Tessarin, C., Duguma, R., Ayana, D., Martini, M. and Cassini, R., 2014. Molecular detection of piroplasms in ixodid ticks infesting cattle and sheep in western Oromia, Ethiopia. *Trop. Anim. Health Prod*., 46:27–31.

Kumsa, B. and Mohammedzein, A., 2012. Prevalence, organ distribution, risk factors, and financial losses of hydatid cysts in sheep and goats slaughtered in restaurants in Jimma, south western Oromia. *Comparative Clinical Pathology* 23(2), 333–339.

Kusiluka, L. and Kambarage, D., 1996. Diseases of Small Ruminants: A Handbook. Common Diseases of Sheep and Goats in Sub-Saharan Africa, VETAID: Centre for Tropical Veterinary Medicine. Pp. 90-93.

Legese, G., Haile, A., Duncan, A.J., Dessie, T., Gizaw, S. and Rischkowsky, B., 2014. Sheep and goat value chains in Ethiopia: A synthesis of opportunities and constraints. International Livestock Research Institute (ILRI). Pp 70.

Legesse, A., Abayneh, T., Mamo, G., Gelaye, E., Tesfaw, L., Yami, M. and Belay, A., 2018. Molecular characterization of *Mannheimia haemolytica* isolates associated with pneumonic cases of sheep in selected areas of Central Ethiopia. *BMC Microbiol*. 18(1):205. doi: 10.1186/s12866-018-1338-x.

Leta, S. and Mesele, F., 2010. Prevalence of Small Ruminant Trypanosomosis and Tsetse Fly Challenge in Upper Didessa Valley, Ethiopia. *Global Veterinaria* 5 (4): 215-219.

Mamo, B., Gebre-ab, F. and Tedla, S., 1981. Observations on *Dictyocaulus filaria* (Rudolphi, 1809) in Welo and Arsi administrative regions of Ethiopia. *Eth. J. Agric. Sci*., 3: 75-80.

Mamo, B., Tedla, S. and Gebre-ab, F., 1982. Survey of gastrointestinal helminths in sheep slaughtered at the Addis Ababa abattoir, Ethiopia. *Eth. J. Agric. Sci*., 4: 87-94.

Marru, H.D., Anijajo, T.T. and Hassen, A.A., 2013. A study on ovine pneumonic pasteurellosis: isolation and identification of Pasteurellae and their antibiogram susceptibility pattern in Haramaya District, Eastern Hararghe, Ethiopia. *BMC Vet Res*. 9:239. doi: 10.1186/1746-6148-9-239.

McVey, D.S., Kennedy, M., Chengappa, M.M. and Wilkes, R. 2022. Veterinary Microbiology, 4th Edition. Wiley-Blackwell, 864 pages.

Megersa, B., Biffa, D., Belina, T., Debela, E., Regassa, A., Abunna, F., Rufael, T., Stubsjøen, S.M. and Skjerve, E., 2011. Serological investigation of Peste des Petits Ruminants (PPR) in small ruminants managed under pastoral and agro-pastoral systems in Ethiopia. *Small Rumin Res.* 97: 134-138.

Mehmood, K., Zhang, H., Sabir, A.J., Abbas, R.Z., Ijaz, M., Durrani, A.Z., Saleem, M.H., Ur Rehman, M., Iqbal, M.K., Wang, Y., Ahmad, H.I., Abbas, T., Hussain, R., Ghori, M.T., Ali, S., Khan, A.U. and Li, J., 2017. A review on epidemiology, global prevalence and economical losses of fasciolosis in ruminants. *Microb Pathog*. 109:253-262.

Mekibib, B., Mikir, T., Fekadu, A. and Abebe, R., 2019. Prevalence of Pneumonia in Sheep and Goats Slaughtered at Elfora Bishoftu Export Abattoir, Ethiopia: A Pathological Investigation. *J Vet Med*. doi.org/10.1155/2019/5169040.

Ministry of Agriculture (MoA), 2012. Ethiopia Animal Health Year Book (EAHYB) 2011. Pp7-72.

MoA, 2010. Data for the OIE PVS Evaluation Team, Ministry of Agriculture, Addis Ababa, Ethiopia (Cited in Veterinary Privatization Road map, MoA, 2014).

MoA, 2011. Ethiopia Animal Health Year Book (EAHYB) 2011. Pp7-72.

Molla, B. and Delil, F., 2015. Mapping of major diseases and devising prevention and control regimen to common diseases in cattle and shoats in Dassenech district of South Omo Zone, South-Western Ethiopia. *Trop Anim Health Prod*. 47(1):45-51.

Mulugeta, H.S., Tafesse, M., Getachew, W., Kinfe, G., Getachew, T. and Teshome, Y., 1989. The significance of helminth parasites in livestock improvement production. Institute of Agricultural Research (IAR) Proceedings of the 3rd National Livestock Conference, 24-26 May 1989, Addis Ababa, Ethiopia, pp. 49-53.

Negash, T., Tilahun, G., Paton, S., Prevot, F. and Dorchies, P., 2004. Serological survey on Toxoplasmosis in sheep and goats in Nazareth, Ethiopia. *Revue de Médecine Vétérinaire*, 155 (10): 486-487.

Ngategize, P. K., Bekele, T. and Tilahun, G., 1993. Financial losses caused by ovine fasciolosis in the Ethiopian highlands. *Tropical Animal Health and Production,* 25(3):155-161.

Njau, B.C., Kasali, O. B., Scholtens, R. G, and Degefa, M., 1988. Review of sheep mortality in the Ethiopian highlands, 1982–86. ILCA Bulletin No. 31.

Ogundiyi, A.I., Bemji, M.N., Adebambo, O.A., Dipeolu, M.A., Onagbesan, O.M., James, I.J. and Osinowo, O.A., 2012. Prevalence of mange among West African Dwarf sheep and goats and associated haematological and biochemical parameters. *Trop Anim Health Prod*. 44(6):1263-9.

OIE, 2008. Dermatophilosis. Manual of standard for diagnostic test and vaccine, Pp. 725-728.

Purse, B.V., Mellor, P.S., Rogers, D.J., Samuel, A.R., Mertens, P.P.C. and Baylis, M., 2005. Climate change and the recent emergence of bluetongue in Europe. *Nat. Rev. Microbiol*. 3:171-181.

Regassa, A., Moje, N., Megersa, B., Beyene, D., Sheferaw, D., Debela, E., Abunna, F. and Skjerve, E., 2013. Major causes of organs and carcass condemnation in small ruminants slaughtered at Luna Export Abattoir, Oromia Regional State, Ethiopia. *Preventive Veterinary Medicine* 110 (2): 139-148.

Rege, J.E.O., Tembely, S. Mukasa-Mugerwa, E. Sovani, S. Anindo, D. Lahlou-Kassi, A. Nagda, S. and Baker, R.L., 2002. Effect of breed and season on production and response to infections with gastro -intestinal nematode parasites in sheep in the highlands of Ethiopia, *Livestock Production Science* 78 (2): 159-174.

Reynecke, D.P., van Wyk, J.A., Gummow, B., Dorny, P. and Boomker, J., 2011. Validation of the FAMACHA© eye colour chart using sensitivity/specificity analysis on two South African sheep farms. *Vet Parasitol*. 177(3-4):203-11.

Seifert, S.H., 1996. Tropical Animal Health. 2nd edition. Dordrechet: Kluwer Academic Publishers P. 358.

Senbeto, Y.A. and Chekol, A.B., 2022. Prevalence of small ruminant coccidiosis in Pawe District,Metekel Zone, Benishangul Gumuz Regional State, Ethiopia. *Int. J. Adv. Res. Biol. Sci*. 9(7): 262-272.

Sherif, M., Addis, M., and Tefera, M., 2012. Contagious caprine pleuropneumonia: Serological survey in selected districts of Jigjiga Zone, Ethiopia. *Asian J Anim Sci.* 6: 309-315.

Sileshi Z. and Desalegn L., 2008. Sheep and goat flock health. In: Sheep and goat production handbook for Ethiopia, edited by Alemu Yami and R. Alemu Yami and R.C. Merkel. Ethiopia Sheep and Goat Productivity Improvement ProgramPp. 349.

Sitotaw, T., Regassa, F., Zeru, F. and Kahsay A.G., 2014. Epidemiological significance of major hemoparasites of ruminants in and around Debre-Zeit, Central Ethiopia. *Journal of Parasitology Vector Biolology* 6(2):16-22.

Smith, M.C. and Sherman, D.M., 2009. Herd Health Management and Preventive Medicine. In: Goat Medicine, 2nd Edition Wiley-Blackwell.

Solomon, A., Kassahun, A., Alemu, Y., Girma, A., Sileshi, Z. and Adane, H., 2008. Records and record keeping. In: Sheep and goat production handbook for Ethiopia, edited by Alemu Yami and R. Alemu Yami and R.C. Merkel. Ethiopia Sheep and Goat Productivity Improvement ProgramPp. 349.

Soulsby, E.J.L., 1982. Helminths, arthropods and protozoa of domesticated animals, 7th edition. London: Baillière Tindall, 809 pp.

Swallow, B.M., 2000. Impacts of trypanosomosis in African agriculture.In PAAT technical and scientific series No. 2, FAO, Rome.

Tariq, K.A., 2014. A Review of the Epidemiology and Control of Gastrointestinal Nematode Infections of Small Ruminants. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.* 85, 693-703.

Taylor, M.A., Coop, R.L and Wall, R.L., 2016. Veterinary Parasitology. 4thed. Wiley Blackwell Publishing. Pp. 1006.

Tedla, M., Berhan, N., Molla, W., Temesgen, W. and Alemu, S., 2018. Molecular identification and investigations of contagious ecthyma (Orf virus) in small ruminants, North West Ethiopia. *BMC Vet Res*. 14(1):13. doi: 10.1186/s12917-018-1339-x.

Tegegn, A.H., Feleke, A., Adugna, W. and Melaku, S.K., 2016. Ruminant Brucellosis and Public Health Awareness in Two Districts of Afar Region, Ethiopia. *J Vet Sci Technol*. 7: 335. doi:10.4172/2157-7579.1000335.

Tembely, S., Lahlou-kassi, A., Rege, J.E., Sovani, S., Diedhiou, M.L. and Baker, R.L. 1997. The epidemiology of nematode infections in sheep in a cool tropical environment. *Vet Parasitol*. 70(1-3): 129-41.

Teshale, S., Dumetre, A., Dardé, M. L., Merga B., and Dorchies, P., 2007. Serological survey of caprine, toxoplasmosis in Ethiopia: Prevalence and risk factors. *Parasite*, 14: 155-159.

Teshale, S., Geysen, D., Ameni, G., Asfaw, Y. And Berkvens, D., 2015. Improved molecular detection of Ehrlichia and Anaplasma species applied to Amblyomma ticks collected from cattle and sheep in Ethiopia. Ticks Borne Disease, 6(1):1-7.

Teshome, D., Sori, T., Sacchini, F. and Wieland, B., 2019. Epidemiological investigations of contagious caprine pleuropneumonia in selected districts of Borana zone, Southern Oromia, Ethiopia. *Trop Anim Health Prod*. 51:703-711.

Tibbo, M., 2000. Effect of Triclabendazole (Fasinex®) on acute fasciolosis in sheep in central highland of Ethiopia. *Bulletin of Animal Health Production in Africa* 48(2), 87–92.

Tibbo, M., 2006. Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Doctoral dissertation. Swedish University of Agricultural Sciences Uppsala, Sweden, 76 Pp.

Tibbo, M., Woldemeskel, M. and Gopilo, A., 2001. An outbreak of respiratory disease complex in sheep in central Ethiopia. *Trop Anim Health Prod*. 33: 355-365.

Tolossa, Y.H., 2014. Ectoparasitism: Threat to Ethiopian small ruminant population and tanning industry (Review). *J. Vet. Med. Anim. Health* 6(1): 25-33.

Tomassone, L., Grego, E., Callà, G., Rodighiero, P., Pressi, G., Gebre, S., Zeleke, B. and De Meneghi, D., 2012. Ticks and tick-borne pathogens in livestock from nomadic herds in the Somali Region, Ethiopia. *Experimental Applied Acarology* 56(4):391-401.

van Wyk, J.A. and Bath, G.F., 2002. The FAMACHA system for managing haemonchosis in sheep and goats by clinically identifying individual animals for treatment. *Vet Res*. 33(5):509-29.

Vande Velde, F., Charlier, J. and Claerebout, E., 2018. Farmer Behavior and Gastrointestinal Nematodes in Ruminant Livestock-Uptake of Sustainable Control Approaches. *Front. Vet. Sci.* 5:255.

Woldehiwet, Z., 2007. Tick-borne diseases. In: Aitken, I.D. (ed.) Diseases of Sheep, 4th edn. Blackwell Publishing, Oxford, UK, pp. 347-355.

Woldemeskel, M., 2000. Dermatophilosis: a threat to livestock production in Ethiopia. *Dtsch. Tierarztl.Wochenschr*.107:144–146.

Woldemeskel, M., Tilahun, G., Tibbo, M. and Potgieter, L.N., 2000. Prevalence of bluetongue virus antibodies in sheep in central Ethiopia. *Deutsche tierärztliche Wochenschrift* 11/2000; 107(10):408-10.

Woldemeskel, M. and Ashenafi, H., 2002. Study on skindiseases in sheep from northern Ethiopia. *Dtsch. Tierarztl. Wochenschr*.110:20–22.

Woldemeskel, M. and Mersha, G., 2010.Study on caprine and ovine dermatophilosis in Wollo, Northeast Ethiopia. *Tropical Animal Health and Production* 42:41–44.

Woldemeskel, M. and Tibbo, M., 2010. Pulmonary adenomatosis and maedi-visna in Ethiopian central highland sheep: a microscopic study. *Trop Anim Health Prod*.; 42(5):995-9.

Wondmnew, K., Hussien, M., Temesgen, W. and Endalamaw, D., 2018. Determination of prevalense external parasite on different Species. *MOJ Proteomics Bioinform*. 7(5):263-269.

Yilma, J.M. and Malone, J.B., 1998. A geographic information system forecast model for strategic control of fasciolosis in Ethiopia. *Veterinary Parasitology* 78: 103-127.

Yizengaw, L., Belayneh, N., Zegeye, A., Aklilu, F. and Kefale, A., 2020. Sero-prevalence and associated risk factors of Maedi-visna virus in sheep population of selected Area of eastern Amhara, Ethiopia. *Indian J. Anim. Hlth*. 59(2): 150-158.

Zewdu, E., Agonafir, A., Tessema, T.S., Tilahun, G., Medhin, G., Vitale, M., Di Marco, V., Cox, E., Vercruysse, J. and Dorny, P., 2013. Seroepidemiological study of caprine toxoplasmosis in East and West Shewa Zones, Oromia Regional State, Central Ethiopia. *Research in Veterinary Science,* 94(1), 43–48.