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Common Infectious and Parasitic Diseases in Goats of Tropical Africa and their Impacts on Production Performance: A Review

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ABSTRACT

Available scientific studies on goat diseases in tropical Africa are limited to specific regions or specific diseases. This study aimed to review scientific research findings on goat diseases in tropical Africa, focusing on their prevalence and impacts on production performance. All main diseases, such as parasitic, viral, and bacterial diseases, are included in the present study. Studies conducted in different countries have revealed high prevalence rates of gastrointestinal parasites exceeding 95%. These parasites resulted in growth retardation and reduced carcass weight at slaughter. Management of mites could decrease production and reproductive function. Trypanosomiasis led to decreased hematocrit levels, abortions, low birth weight, and high kid mortality. The prevalence of trypanosomiasis has been different across regions, ranging from 2.95% to 57.1%. Peste des Petits Ruminants has been reported in many African countries, causing significant outbreaks with seroprevalence rates ranging from 30% to 55%. Rift Valley fever was characterized by high mortality in adult goats (20-30%) and numerous abortions 2 weeks after infection, with seroprevalence rates ranging up to 25.8%. Contagious Caprine Pleuropneumonia indicated high morbidity (approximately 100%) and high mortality (80% to 100%), with prevalence ranging from 22% to 39% in abattoirs and from 35% to 52% in farms. Brucellosis did not affect the weight of infected animals but reduced litter size in goats and disrupts vital organs. This review highlights the extent of goat diseases in tropical Africa to determine the most appropriate prevention and control strategies.

Keywords: Control strategy, Goat diseases, Prevalence, Production performance, Tropical Africa

INTRODUCTION

Like other agricultural activities, livestock production in tropical areas faces major sustainability challenges (Dedieu et al., 2011). Despite its numerous potential advantages and multifunctionality in household security, goat farming also confronts these very challenges (Dubeuf, 2011). In many African countries with tropical climates, ruminants, especially goats, play a crucial role in agricultural systems (Nair et al., 2021).

Goats could adapt to difficult climatic conditions and limited resources, especially in arid and semi-arid regions where crop production is uncertain in the context of climate change (Monau et al., 2020). Goats play a vital role in maintaining food security and the economic livelihoods of smallholder farmers in rural areas (Monau et al., 2020). A study by Dubeuf (2011) emphasizes the importance of supporting agricultural research, particularly in areas where goat farming has development potential. However, infectious and parasitic diseases pose a major challenge for small ruminant production, as they are one of the main causes of animal mortality on farms (Missohou et al., 2016; Armson et al., 2020). These diseases, including infectious and parasitic diseases, hurt the economy due to livestock mortality and high treatment costs (Adeyemo et al., 2022). They also pose a risk to public health, as some of these diseases can be transmitted from animals to humans (Lancelot et al., 2011). Several research studies have been conducted on these diseases in several tropical climate countries. These research studies have identified the pathogens responsible for goat diseases, whether bacterial, viral, parasitic, or fungal. Furthermore, the prevalences, clinical manifestations, and effects of these diseases on goat production have been described. However, available studies are often fragmented and limited to specific regions or particular diseases (Misinzo et al., 2015; Arsevska et al., 2016; Baron et al., 2016). Therefore, a comprehensive synthesis of research on this topic is necessary to assess the extent of goat diseases in tropical Africa and determine the most appropriate prevention and control strategies. An in-depth review of goat diseases and control and

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prevention strategies in Africa is crucial. It can help maintain the availability of goat products, thus contributing to both food security and livelihoods. It can also reduce economic losses and ensure the economic viability of breeders. In addition, such a review can identify potential risks to human health, paving the way for implementing appropriate measures to mitigate them. Developing prevention and control strategies specifically adapted to goat diseases in tropical Africa would also be possible. The present study summarizes the diseases encountered in tropical African goat farming by focusing on their prevalence and their effects on goat production performance.

PARASITIC DISEASES

Gastrointestinal parasites of goats in tropical Africa

Impact of gastrointestinal parasites on the production performance of goats

In tropical countries, gastrointestinal parasites are highly involved in helminth infections in small ruminants (Githiori et al., 2004; Mpofu et al., 2022). Economically, gastrointestinal strongylosis, especially haemonchosis, is widely acknowledged as a leading cause of health problems in ruminant animals, resulting in substantial economic losses in the livestock industry due to reduced production (Arsenopoulos et al., 2021). The presence of worms in livestock farms influences both the quantity and quality of production (Devadharshini et al., 2022). Gastrointestinal parasites are responsible for growth retardation in kid goats, resulting in reduced carcass weights at slaughter (Arsenopoulos et al., 2021). In dairy females, infestations by digestive *strongyles* have been consistently associated with decreased milk production (Mpofu et al., 2022). In Benin, a study on helminth infections in sheep and goats showed that a moderate worm burden of *haemonchus contortus* induced detectable anemia during the dry season (Attindehou et al., 2012). Naturally resistant animals show an increased immune response against these parasites, reducing the need for drug treatments. This resistance can result from genetic changes, including factors such as carriers and metabolism. Genetic differences play a significant role in susceptibility to gastrointestinal parasites, both across various breeds and species, as well as within genes that are vital for the immune response (Mpofu et al., 2022).

Methods of diagnosing gastrointestinal parasites in goats

Clinical diagnosis of strongylosis is based on clinical signs, such as weight loss, diarrhea, anemia, and rough hair coat (Zajac and Garza, 2020). These symptoms are generally common and nonspecific (Lotfalizadeh et al., 2022). Therefore, it is necessary to identify the responsible parasites using appropriate parasitological diagnostics to confirm the clinical diagnosis and establish an appropriate prevention plan. There are direct methods focused on coproscopic techniques for diagnosing strongylosis (Alowanou et al., 2021). The classical quantitative technique McMaster is the most popular in the field of veterinary parasitology (Alowanou et al., 2021). In addition, it is advocated by the World Association for the Advancement of Veterinary Parasitology in its guidelines for evaluating the efficacy of anthelmintic drugs in ruminants, based on the work of Cringoli et al. (2010). However, there are newer quantitative methods that are more sensitive, precise, and accurate, such as the flotation technique (FLOTAC) and Mini-FLOTAC, developed in the last decade (Cringoli et al., 2017). The FLOTAC technique utilizes a specific centrifuge and is highly sensitive, while Mini-FLOTAC is a variant that does not require a centrifuge and is based on passive flotation with fewer preparation steps (Cringoli et al., 2017). The Mini-FLOTAC method consists of a passive fluctuation of parasitic structures, which makes it possible to diagnose helminth eggs/larvae as well as protozoan oocysts or cysts at the same time (Cringoli et al., 2017). In their study on the assessment of the Mini-FLOTAC and McMaster methods for the detection of gastrointestinal parasites in West African sheep, dwarf goats, and crossbred rabbits, Alowanou et al. (2021) concluded that the Mini-FLOTAC method showcased enhanced diagnostic performance in terms of prevalence. As a result of this finding, they suggested that the Mini-FLOTAC method held greater reliability and could potentially serve as a more dependable alternative for veterinary clinics. Other research has also confirmed that the Mini-FLOTAC method has higher sensitivity and efficiency than the McMaster technique in identifying parasites in human and other animal samples (Barda et al., 2013; Dias de Castro et al., 2017; Noel et al., 2017). The method frequently employed in laboratory evaluations to ascertain worm types in living animals involves the identification of larvae in freshly expelled feces (mainly lungworm larvae) or those maturing in fecal cultures (gastrointestinal nematodes, Van Wyk and Mayhew, 2013). However, only an individual with expertise can accurately distinguish the larvae (Van Wyk and Mayhew, 2013). For numerous genera of nematodes, discerning features, such as the morphology of the anterior end (head) of the larvae, are nearly identical (Van Wyk and Mayhew, 2013). In order to address this issue, Van Wyk and Mayhew (2013) devised an innovative method that entails determining the portion of the larval sheath tail extension containing a delicate, whip-like filament at the tip.

Prevalence of gastrointestinal parasites in goats across some tropical African countries

It was reported that more than 95% of small ruminants in tropical regions suffer from gastrointestinal parasite infestations (Terefe et al., 2012). In the context of Benin, parasitological surveys indicated that goats primarily indicated infestations of *coccidia* (92.24%) and *strongyles* (83.91%), followed by *Strongyloides* spp. (73.25%, Challaton et al., 2023). Additionally, *Moniezia* spp. infestations were observed at a rate of 21.8%, along with other gastrointestinal parasites, such as *Trichuris* spp. (0.94%) and *Toxocara* spp. (0.28%, Challaton et al., 2023). A gastrointestinal parasitic

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investigation conducted by Faihun et al. (2017) on small ruminants (sheep and goats) and wild ruminant species (harnessed bushbuck) revealed the presence of six different parasites in sheep and goats (including *strongyles*, *Strongyloides*, coccidian, cestodes, *Capillaria*, and trematodes) with prevalence rates ranging from 60% to 100%. In a study conducted by Ipungu et al. (2017) on goats raised in the municipality of Lubumbashi city in Congo, an infestation rate of 89.6% was observed during the dry season and 91.2% during the rainy season, caused by gastrointestinal *strongyles* as well as a lungworm (*Dictyocaulus* spp). The identified parasites included *Dictyocaulus* spp. (88.6%), *Trichuris ovis* (60%), *Capillaria* spp. (29.5%), *Ostertagia* spp (20%), *Trichostrongylus* spp (30.5%), *Charbetia ovina* (8.6%), and *Strongyloides papillosus* (1%, Ipungu et al., 2017). In an epidemiological study on gastrointestinal helminths of goats in Middle Guinea, Barry et al. (2002) observed prevalence rates of 94% for *strongyles*, 25% for *Trichuris*, 20% for *Strongyloides*, and 12% for *Moniezia*. The results of a study conducted in Cameroon by Malla et al. (2021) revealed a high prevalence of 89.0% for gastrointestinal parasites in goats, including *Trichostrongylus* spp. and *Haemonchus* spp., *Strongyloides* spp., and Protozoa. In Ethiopia, a study conducted by Chalchisa et al. (2015) revealed a prevalence of 90.1% for mixed strongyle infestation in goats. The most common genera of *strongyles* in this study were *Haemonchus* (76.1%), *Trichostrongylus* (56.3%), *Oesophagostomum* (33.1%), *Bunostomum* (20.1%), and *Chabertia* (5.2%).

Methods of controlling gastrointestinal parasites in goats

The treatment of digestive parasitoses in small ruminants in tropical Africa is generally carried out using synthetic chemical products, such as benzimidazoles, imidazothiazoles, and avermectins (Arsenopoulos et al., 2021). However, the use of these molecules is limited by several factors, including parasite resistance, low vaccine coverage, inaccessibility to modern veterinary products for rural farmers, high cost of products and treatments, and unapproved products (Sargison and Scott, 2003; Fajimi and Taiwo, 2005). Complementary approaches, such as fodder or bioactive plants/ethnoveterinary products, biological control using fungi, as well as grazing and nutritional management strategies are employed to control these parasites (Mpofu et al., 2022). Many farmers return to medicinal herbs as a natural alternative to synthetic chemical products (Hounzangbe-Adote., 2001). These herbs have been used for a long time to treat digestive parasitoses in small ruminants (Sadr et al., 2022). The study by Tchetan et al. (2021) listed several medicinal plants whose efficacy against gastrointestinal parasites has been confirmed both by farmers and traditional healers, as well as through scientific results. These plants, rich in bioactive molecules, such as flavonoids, tannins, and alkaloids, are easily accessible to farmers (Tchetan et al., 2021).

Acarioses (mite agents of scabies)

Impact of scabies on the production performance of goats

Mites infesting animals have significant economic implications due to factors such as slowed growth, decreased daily weight gain, treatment, skin and leather damage, and labor costs, as well as mortality losses (Arul et al., 2023). In Ethiopia, ectoparasites were responsible for 35% of sheep skin waste and 56% of goat skin waste in the market (Kebede, 2013).

Methods of diagnosing scabies in goats

Methods for diagnosing scabies in goats include careful clinical examination for characteristic signs such as itching, crusting and hair loss, papules, erythema, excoriations, desquamation, and thick wrinkled skin (Chuka et al., 2020). For direct microscopic examination, skin lesion samples are taken and dissolved in a 10% potassium hydroxide solution, centrifuged, and then observed under the microscope for the presence of mites or their structures (Benti et al., 2020; Chuka et al., 2020). These skin lesion samples can be fixed in 10% neutral buffered formalin, followed by processing, staining with hematoxylin and eosin, and finally, microscopic observation to identify specific features of scabies, such as epidermal hyperplasia, hyperkeratosis, as well as the presence of mast cells, eosinophils or lymphocytes in the dermis (Chuka et al., 2020).

Prevalence of scabies in goats across some tropical African countries

A study carried out in southern Benin by Salifou et al. (2013) regarding the prevalence of scabies in small ruminants, along with affected owners suffering from the same disease, identified the species *Sarcoptes scabiei* with a prevalence rate of 28.33% and 9.5% in animals and small-scale farmers (human cases), respectively. Infestations were notably more frequent among goats (39.6%). These findings imply a significant correlation between suspected human cases and these animals (Salifou et al., 2013). The same species (*Sarcoptes scabiei*) had been identified in the northern region of Benin by Tassou (2009). Another research showed the existence of another variety of mites of the genus *Psoroptes* in the northern region of Couffo in Benin (Koudandé, 2006). The species *Psoroptes comunis* and *Sarcoptes scabiei* were encountered in goats with a prevalence of 58.1% in a study conducted by Davou et al. (2017) in north-central Nigeria. In southwestern Nigeria, Ogundiyi et al. (2012) reported a prevalence of 0.53% of scabies in goats caused by *Sarcoptes scabiei aprae*. In Ethiopia, the combined prevalence of *Sarcoptes scabiei* in sheep and goats in a meta-analysis was estimated at 4.4%. The study further revealed that mites of the genus *Sarcoptes*, *Demodex*, and *Psoroptes* were the most prevalent mites infesting small ruminants in the country (Asmare et al., 2016a).

Methods of controlling scabies in goats

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The treatment and prevention of *Sarcoptes scabiei* are carried out using various synthetic chemical products such as ivermectin, diazinon, phoxim, and coumaphos (Benti et al., 2020). Dipping with other insecticides can also be useful in combating parasites and preventing secondary bacterial complications (Benti et al., 2020). Maintaining hygiene in housing and avoiding overcrowding can minimize the accumulation and spread of mites (Benti et al., 2020). Currently, there is no commercial vaccine available to protect animals against scabies caused by mites (Benti et al., 2020). Farmers also use traditional methods, such as plants, for scabies control in Africa (Dassou et al., 2014; Yasine et al., 2015). Prevention and control of scabies in small ruminants remain an important concern for animal and human health, as well as for the livelihoods of farmers (Salifou et al., 2013).

Trypanosomiasis

Impact of trypanosomiasis on the production performance of goats

In a study in Nigeria to investigate the susceptibility of Sahelian goats to experimental *Trypanosoma vivax* infection, Akinwale et al. (2006) observed a reduction in hematocrit levels two weeks following infestation. In Burkina Faso, it was provided evidence of the impact of the *Trypanosoma* spp. on hematocrit levels by comparing the mean hematocrit levels of infected and uninfected animals (Ye, 2012). Infected animals had a mean hematocrit level of 17.75%, while uninfected animals had a level of 26.03% in small ruminants, suggesting a significant decrease in hematocrit levels in infected animals, compared to uninfected ones. Similar observations were made by Ezebuiro et al. (2009) in Nigeria on the prevalence of trypanosomiasis in commercial livestock, where the hematocrit was 20.29% in trypanosomiasis-infected goats and 31.56% in uninfected goats. In a study by Faye et al. (2004), which examined the impact of *Trypanosoma congolense* infection on the reproductive performance of West African Dwarf (WAD) goats, results showed that the infestation resulted in elevated rectal temperature (38.8°C), abortions in 27.8% of infected goats, and a decrease in birth weight of offspring born to infected goats. In addition, a mortality rate of 61.5% was observed in kids born alive from infected goats during their first week of life. Furthermore, the concentrations of pregnancy-associated glycoprotein (PAG) and plasma progesterone were found to be lower in infected animals compared to the control group. Milk production and quality in dairy goats are also affected by trypanosomiasis. According to Lopes et al. (2016), goats infected with *Trypanosoma vivax* showed a rapid decline in milk production, a flattened lactation curve, reduced lactation persistence, as well as a significant decrease in milk fat and protein content. These results express that *Trypanosoma vivax* (*T. vivax*) infestation can have negative economic consequences on the milk production of goats.

Diagnosis methods of trypanosomiasis in goats

Animal trypanosomiasis caused by *T. vivax*, *T. congolense*, and *T. brucei* is the most significant vector-borne disease in ruminants (Morrison et al., 2023). These diseases are characterized by fever, anemia, and weight loss (Tariq et al., 2022; Morrison et al., 2023). Several diagnostic methods are used to diagnose Trypanosoma infection in animals when there are no clinical signs. Classical approaches to identifying *Trypanosoma* spp. involve microscopic examination of fresh or stained blood smears (Tariq et al., 2022). *Trypanosomes* can be identified in blood samples using a light microscope at 40X magnification (Tariq et al., 2022). Another step is to examine blood samples stained with Giemsa stain (Mafie et al., 2018). The Primo Star iLED LED microscope from Carl Zeiss, and FIND is a breakthrough, enabling fluorescence and bright-field microscopy (Tariq et al., 2022). The use of acridine orange fluorescence and Giemsa staining improves sensitivity for detecting trypanosomes in blood (Tariq et al., 2022). The formalin gel test (FGT) and ELISA are used to detect antibodies (Tariq et al., 2022). The formalin gel test (FGT) involves mixing one milliliter of serum with a solution of concentrated formalin (Tariq et al., 2022). If the serum immediately coagulates and becomes opaque, the result is considered positive (Tariq et al., 2022). ELISA involves antigen preparation, washing, incubation, and detection (Tariq et al., 2022). Polymerase chain reaction (PCR) is a more sensitive molecular method, particularly real-time PCR, which can identify subspecies (Tariq et al., 2022).

Prevalence of trypanosomiasis in goats across some tropical African countries

In southern Cameroon, Simo et al. (2005) observed a prevalence of 20% for *T. brucei*, 4.2% for *T. gambiense*, 15.2% for *T. vivax*, and 7.2% for *T. congolense* in goats. In a study conducted in a peri-urban area of Togo, Bastiaensen et al. (2003) observed an average prevalence of trypanosomiasis of 8.41% in goats. In the agropastoral zones of Sidéradougou, Samorogouan, and Barani in southern Burkina Faso, Sow et al. (2014) recorded a trypanosomiasis prevalence of 2.95%. The *trypanosomes* responsible for these infestations were primarily *T. vivax* or *T. congolense*. In Kenya, goats are most commonly carriers of *T. vivax* (O Ng'ayo et al., 2005). In the Mongo regions of southern Gabon, Maganga et al. (2020) recorded a prevalence of 7.8% of goats infected with *T. vivax*, *T. simiae*, *T. simiae Tsavo*, *T. congolense*, and *T. brucei*.

Methods of controlling trypanosomiasis in goats

Chemotherapy represents the main means of controlling *trypanosome* infestation in goats (Jaiswal et al., 2015). There are several chemical compounds used to treat trypanosomiasis, and among these, diminazene aceturate is the most commonly used trypanocide (Tariq et al., 2022). In addition to diminazene aceturate, other compounds such as

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isometamidium chloride, suramin, quinapyramine sulfate, and quinapyramine chloride are also available (Jaiswal et al., 2015, Tariq et al., 2022). Traditional medicine can also be considered an effective alternative to modern medicine in the fight against trypanosomiasis (Andre et al., 2017). According to Andre et al. (2017), aqueous extracts of *Guiera senegalensis* leaves showed trypanocidal activity against *T. brucei* in Burkina Faso.

Prevention and control of trypanosomiasis in goats require continuous monitoring of animal health, vector control measures, and appropriate treatments to minimize economic losses and impacts on food security. Therefore, clinical and experimental trials aimed at improving the prevention, diagnosis, and treatment of these diseases are necessary to help control and eradicate animal trypanosomiasis in Africa.

VIRAL DISEASES

Peste des petits ruminants

Impact of peste des petits ruminants on the production performance of goats

In Senegal, a study on the effect of peste des petits ruminants (PPR) on the productivity of goat herds showed that herds exposed to PPR experienced a threefold increase in natural mortality rates, four times more abortions in females, and a 30% decrease in birth rates and fertility (Grech-Angelini, 2012). In Nigeria, cases of PPR-related abortions were reported by Asuku et al. (2022). This study highlights the negative impact of the disease on sheep and goat production, emphasizing the risks of mortality and potential economic losses associated with abortions. Mortality rates of 53% have been recorded among goats in Nigeria (Ameh et al., 2000). In Africa, 25 countries have reported PPR epidemics in sheep and goats (African Union-Interafrican Bureau for Animal Resources, 2014). The significant outbreaks reported in Zambia, Tunisia, Uganda, Mongolia, Georgia, Liberia, Kenya, China, and Algeria, as well as on island environments in the Maldives and Comoros, resulted in a mortality of over 17,000 small ruminants (Jebara et al., 2012). A study conducted by Kindji (2006) in Northeast Benin on the socioeconomic impact of PPR estimated economic losses due to mortality at 8,224,07 USD, those related to morbidity at 647,30 USD, and 213,82 USD for the treatment of affected small ruminants. During the 2006-2008 PPR epidemic in Turkana, Kenya, more than a million animals perished and the total value, in terms of lost production, was estimated at USD 2.4 million (Njeumi et al., 2020). In the United Republic of Tanzania, during the same epidemic between 2006 and 2008, a total of 64,661 animals were slaughtered. Meanwhile, in Côte d’Ivoire, during the same period, affected animals were sold at half their usual market price (OIE, 2017).

Clinical signs and methods of diagnosing peste des petits ruminants in goats

Phylogeographic studies have traced the major axes of PPR dispersion and differentiation (Muniraju et al., 2014). According to Misinzo et al. (2015), *lineage I and II* viruses are predominantly present in West and Central Africa, while *lineage III* viruses are more common in East Africa and the southern Middle East. *Lineage IV* viruses are mainly localized in Asia and the Middle East, although some strains have been identified in North and East Africa (Misinzo et al., 2015). The clinical diagnosis of PPR is complex due to similarities with other diseases, such as *vesicular stomatitis* (SPPV) and *stomatitis* virus (GTPV) infections (Zewdie et al., 2021), rinderpest, pneumonic pasteurellosis and contagious caprine pleuropneumonia (Kinimi et al., 2020). The symptoms and lesions do not allow a clear distinction between these diseases. Skin lesions evolve from papules to nodules, vesicles, and pustules, then form scabs (Zewdie et al., 2021). Affected animals become weak, lose their appetite, run a high fever, and have breathing difficulties due to lesions in the respiratory tract and lungs. Lesions also appear in the mouth, nose, and eyelids, accompanied by excessive salivation. Mucous membranes become necrotic and ulcerated, leading to diarrhea in the case of nodules in the intestines (Zewdie et al., 2021). Histopathologically, skin changes (hyperkeratosis, acanthosis, hyperkeratinization, edema, degeneration of sebaceous glands and hair follicles) as well as lung lesions and proliferative alveolitis with occasional cytoplasmic inclusions in alveolar cells and macrophages are observed (Zewdie et al., 2021). In addition, inoculation experiments show consistent lesions and antigens in skin, lungs, and lymph nodes following inoculation of vesicular SPPV and GTPV in sheep and goats, with immunohistochemical detection of viral antigens (Zewdie et al., 2021). Serological tests include methods such as serum neutralization tests (VNT, SNT), indirect immunofluorescence assay (IFAT), and agar gel immunodiffusion assay (AGID, Kinimi et al., 2020; Zewdie et al., 2021). More sensitive and sophisticated tests, such as immunocapture ELISA and quantitative real-time PCR (qRT-PCR), are also available (Njeumi et al., 2020).

Prevalence of peste des petits ruminants in goats across some tropical African countries

Across the world, serological surveys have shown prevalence rates ranging from 30% to 45%, and even 55% in countries where PPR is enzootic (Diallo, 2006). Table 1 presents the prevalence rates of PPR in tropical Africa.

Methods of controlling peste des petits ruminants in goats

There is no specific treatment for this viral disease, but antibiotics can be administered to treat secondary bacterial infections, while careful nursing care is recommended to reduce morbidity and complications (Zewdie et al., 2021). Methods to combat PPR rely on sanitary prophylaxis measures. Vaccination against PPR is used as an effective method to control the spread of the disease and reduce mortality rates among animals in tropical Africa (Alemnew et al., 2022;

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Loum Gazida et al., 2022). Capripox-inactivated vaccines have been shown to be safe and effective. However, they require two doses to confer prolonged immunity (Zewdie et al., 2021). It was reported that vaccination can protect PPR for up to 1 year after vaccination and possibly for the economic lifespan of vaccinated animals (Diallo, 2006). Njoya et al. (2005) reported a highly significant effect of PPR vaccination with Bovipestovax on reducing small ruminant mortality in a peasant farming environment in the Sudano-Sahelian zone of Northern Cameroon. In Ethiopia, Alemnew et al. (2022) indicated that vaccination led to a significant decrease in PPR prevalence and a reduction in mortality rates among animals. These findings confirm the report of Loum Gazida et al. (2022), which supports that increasing mass vaccination campaigns, maintaining the cold chain to preserve vaccines, and the serious commitment of vaccination agents are the only possibilities for completely eradicating PPR. It is therefore important to continue efforts to combat and prevent PPR, especially through herd vaccination, to reduce its impact on animal health, food security, and the livelihoods of local populations.

Table 1. Seroprevalence of Peste des Petits Ruminants in goats of Tropical Africa from 2006 to 2022

Countries	Regions	Sample (Number)	Prevalence (%)	Reference
Benin	Departments of Borgou and Alibori in Northeast Benin	330	24.08	(Kindji, 2006)
Burkina Faso	Soum, located in the north of the country	878	23.01	(Sow et al., 2008)
Chad	Southern region of the country	1,699	48.9	(Mahamat et al., 2018)
Djibouti	Ali Sabieh, Arta, Dikhil, Djibouti, Obock et Tadjourah	1,215	6.83	(Moumin et al., 2018)
Ethiopia	National survey	4,585	9.4	(Waret-Szkuta et al., 2008)
	Dugda and Adami Tullu districts in the Showa administrative zone and Dodota district in the Arsi zone of the Oromia	407	46.68	(Gari et al., 2017)
Ghana	Regional State 74 villages in the 31 districts of the 10 regions of the country	1,534	45.50	(Otsyina et al., 2013)
Kenya	Turkana County	538	40	(Kihu et al., 2015)
Mali	The entire territory except for the Kidal region in the far northeast of the country	1,784	42.4	(Kamissoko et al., 2013)
Niger	Arid zone (Niamey, Tillabéry, and Tahoua) of the country	266	47.9	(Farougou et al., 2013)
Nigeria	The semi-arid region in the northeast of the country	1,571	50.4	(El-Yuguda et al., 2013)
	South-East, South-South, Centre-North, North-West and South-West agro-ecological zones	3,489	22.93	(Woma et al., 2016)
Rwanda	Bugesera, Kirehe, and Nyagatare districts in the Eastern Province of Rwanda; Gicumbi and Musanze districts in the Northern	316	13.6	(Shyaka et al., 2021)
Sudan	Province Northern, Eastern, Central, and Western states	1,459	48.2	(Intisar et al., 2017)
Tanzania	Arusha, Manyara, and Kilimanjaro regions in the north of the country	892	49.5	(Swai et al., 2009)
	Ngorongoro in the northern region of Arusha, and Ulanga, Kilombero, and Mvomero in the southeastern region of Morogoro	238 and 323	48.3 and 10.8	(Torsson et al., 2017)
Uganda	Karenga district in the Karamoja region in the northeast of the country	569	43.8	(Akwongo et al., 2022)

Rift valley fever

Impact of Rift Valley fever on the production performance of goats

The Rift Valley fever virus (RVFV) is now believed to be endemic in certain countries in Africa with tropical or subtropical climates, such as Senegal, Gambia, Mauritania, Zimbabwe, Namibia, South Africa (Chevalier et al., 2009; Paweska et al., 2010). Several species of mosquitoes, including the Aedes and Culex genera, act as vectors for transmitting the virus to animals (Pepin et al., 2010). In goats and sheep, this disease is primarily characterized by high stillbirth rates (20-30% in adults) and numerous abortions two weeks after herd infection (Adam et al., 2010; Archer et al., 2011). During an epidemiological study conducted by Munyua et al. (2010) on Rift Valley Fever in livestock of Kenya, the predominant symptoms were death, hemorrhagic syndrome, and miscarriage. These manifestations were observed in all species, affecting up to 30% of infected herds. Other clinical markers included labored breathing, coughing, loss of appetite, debility, and extensive nasal and oral secretions. In terms of disease and mortality rates, goats showed the highest percentages (4.6% and 1.9%), followed by sheep (1.5% and 0.3%, respectively). The high mortality and abortion rates within infected herds result in significant economic losses (Adam et al., 2010; Archer et al., 2011).

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Impact of Rift Valley fever on human health

In humans, transmission mainly occurs through direct contact with blood or other body fluids from infected animals (Arsevska et al., 2016). From November 30, 2006 to March 12, 2007, 684 cases were reported with a mortality rate of 23% in Kenya (WHO, 2007). During the first reported Rift Valley fever epidemic in Niger, 346 suspected human cases were reported, of which 38 were confirmed, resulting in 32 deaths (Doutchi et al., 2017). Patients had common risk factors such as mosquito bites, direct contact with dead or aborted animals, and regular consumption of milk from these animals (Doutchi et al., 2017). Ibrahim et al. (2021) observed a seroprevalence of 13.2% in humans during a study conducted on livestock and humans in the Somali region of Ethiopia. Due to the risks to human and animal health, as well as significant economic losses, it is crucial to maintain continuous epidemiological surveillance and implement prevention and control measures to prevent the spread of this disease.

Methods of diagnosing Rift Valley fever in goats

Real-time reverse transcription-polymerase chain reaction (qRT-PCR) is the current diagnostic method for Rift Valley Fever (RVF). It is a precise and sensitive molecular approach used to detect viral RNA (Sado et al., 2022). ELISA tests are also frequently used to detect antibodies produced in response to Rift Valley Fever virus infection (Ibrahim et al., 2021; Sado et al., 2022). The RVFV neutralization test is also used to assess the presence of RVFV-specific neutralizing antibodies in serum samples (Troupin et al., 2022).

Prevalence of Rift Valley fever in goats across some tropical African countries

The prevalence of RVF varies widely from region to region, ranging from 0.0% to 25.1% (Table 2). High-prevalence areas include the south-eastern shore of Lake Chad in Chad (18.8%), Zambezia province in Mozambique (25.1%), and Garissa County in Kenya (25.8%, Table 2). On the other hand, some regions report little or no prevalence (Table 2).

Methods of controlling Rift Valley fever in goats

Means of controlling RVFV include epidemiological surveillance to detect cases early, vector control through the destruction of mosquito habitats and the use of insecticides, and restricting the movement of infected animals (Fawzy and Helmy, 2019). Routine vaccination is considered the main means of controlling RVFV infections in animals in endemic countries to prevent human infections, socioeconomic losses, and epidemics (Fawzy and Helmy, 2019). Several vaccines are used, including the formalin-inactivated vaccine with alum adjuvant (Menya/sheep/258), the binary ethylenamine-inactivated vaccine with alum adjuvant (ZH501 RVF) from the Veterinary Serum and Vaccines Research Institute (VSVRI), as well as the live attenuated neurotropic Smithburn strain produced by VSVRI (Arsevska et al., 2016; Fawzy and Helmy, 2019).

Table 2. Seroprevalence of Rift Valley Fever in goats of Tropical Africa from 2014 to 2022

Countries	Regions	Sample (Number)	Prevalence (%)	Reference
Burkina Faso	Provinces of Yatenga, Seno, and Soum in the northern regions of the country	120	6.66	(Boussini et al., 2014)
Cameroon	Tsinga livestock market in the Yaoundé 2 district	168	2.4	(Sado et al., 2022)
	Lagdo, Pitoa, Boklé, Garoua, Kismatari, Poli, Touboro, and Dembo	355	2.3	(Poueme et al., 2019)
Chad	Southeastern shore of Lake Chad	144	18.8	(Abakar et al., 2014)
Congo	Mongala, Sud Ubangi, Nord Ubangi, Kwilu, Lomami, South Kivu, and Tanganyika	672	0.0 to 23.81	(Tshilenge et al., 2019)
Gabon	Mongo County in the southwest of the country	106	4.72	(Maganga et al., 2017)
Ethiopia	Adadle Woreda in the Somali region of the country	297	6.3	(Ibrahim et al., 2021)
Guinea	Prefectures of Beyla, Boffa, Boké, Coyah, Dabola, Dalaba, Faranah, Forécariah, Gaoual, Guéckédou, Kindia, Koundara, Kouroussa, Macenta, Mamou, Mandiana, and N'zérékoré	408	1.00	(Troupin et al., 2022)
Kenya	Garissa County	271	25.8	(Nanyingi et al., 2017)
	Nyandarua County	19	10.53	(Wanjama et al., 2022)
Mali	Mopti and Sikasso	290	3.1	(Dione et al., 2022)
Mauritania	Central and southern parts of the country	294	1.4	(Rissmann et al., 2017)
Mozambique	Zambezia Province	187	25.1	(Blomström et al., 2016)
Nigeria	Bodija Municipal Abattoir in Ibadan, southwest of the country	44	2.3	(Opayele et al., 2019)
Central African Republic	Ngawi market in the central commercial area of Bangui and the village of Ndangala located south of Bangui	219	5	(Nakouné et al., 2016)
Tanzania	East and West of the Rift Valley in the country	531	22	(Sindato et al., 2015)

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BACTERIAL DISEASES

Respiratory mycoplasmosis (Contagious caprine pleuropneumonia)

Impact of respiratory mycoplasmosis on the production performance of goats

Respiratory mycoplasmosis is characterized by severe serofibrinous pleuropneumonia, high morbidity (approximately 100%), and mortality (80-100%, Yatoo et al., 2019). Akwuobu et al. (2016) conducted an experimental study to investigate the effects of *Mycoplasma ovipneumoniae* and *Mycoplasma arginini* infections on WAD goats under one year old. The results indicated that all infected goats exhibited respiratory signs, such as coughing and nasal discharge, along with observed lung lesions in each case. Mortalities were also recorded in the infected groups, suggesting that infection with these bacteria is dangerous in young goats.

Methods of diagnosing respiratory mycoplasmosis in goats

Methods for identifying contagious caprine pleuropneumonia (CCPP) encompass differences in approaches. Firstly, serological tests are employed based on rapid latex agglutination techniques using the CapriLAT kit (RAI6224, Olorunshola et al., 2020). These tests are specifically designed to detect the presence of antibodies to PPCC in biological samples, specifically blood serum (Olorunshola et al., 2020). However, despite their usefulness, it should be noted that bacterial culture is considered the most indisputable reference for the diagnosis of CCPP. This method provides direct confirmation of the presence of the bacteria. Nevertheless, it is important to note that this method is slow (Abd-Elrahman et al., 2020). Mycoplasma growth and isolation are performed using agar and broth culture media (M0535-250G, Sigma Aldrich, USA). For selective isolation of *Mycoplasma* species, a special approach is employed, namely incubation on a specific agar medium (CC1A, Mycoplasma Experience Ltd. Product) is carried out for 7 days (Abd-Elrahman et al., 2020). In addition to these methods, CCPP can be identified by PCR. This molecular biology technique amplifies the DNA of the bacteria present in the sample, enabling it to be detected with a high degree of accuracy (Abd-Elrahman et al., 2020).

Prevalence of respiratory mycoplasmosis in goats across some tropical African countries

A pooled estimate of CCPP prevalence of 23.21% in tropical Africa was reported by Ahaduzzaman (2021), including 21.87% in Ethiopia, 47.22% in Kenya, 8.06% in Mauritius, 3.70% in Nigeria, and 37.13% in Tanzania. In a study carried out in Nigeria concerning the separation of *Mycoplasma mycoides* subspecies *Mycoides* in small ruminants, Egwu et al. (2012) detected various strains of *mycoplasma* in the lungs of both sheep and goats, whether they were affected by the condition or not. The identified strains encompassed *Mycoplasma ovipneumoniae* (30%), *Mycoplasma mycoides* subspecies *capri* (29.5%), *Mycoplasma mycoides* subspecies *mycoides* (13.5%), *Mycoplasma capricolum* (11.5%), with the least frequently isolated being *Mycobacterium bovis* (1.5%). Akwuobu et al. (2014) reported a prevalence of 29.8% for CCPP in a separate study in north-central Nigeria, during which they identified two species of mycoplasma, namely *Mycoplasma ovipneumoniae* and *Mycoplasma arginini.* Contagious caprine pleuropneumonia is prevalent in the districts of Agago and Otuke in Uganda, with seroprevalence rates of 17.7% and 23.3% in unvaccinated goats, respectively (Atim et al., 2016).

Methods of controlling respiratory mycoplasmosis in goats

Contagious caprine pleuropneumonia is treated with several antibiotics, among which macrolides, particularly tylosin, are considered the most effective (Yatoo et al., 2019). The antibiotics marbofloxacin and spiramycin have also proved effective against CCPP (Abd-Elrahman et al., 2020). The use of oxytetracycline has also been effective in treating CCPP, but prolonged use can lead to undesirable side effects in young goats, such as congenital malformations and an increased risk of potential resistance (Yatoo et al., 2019). Additionally, prophylactic use of minimal antibiotic doses may enable mycoplasmas to tolerate these treatments better (Yatoo et al., 2019). Other antibiotics such as fluoroquinolones (enrofloxacin, danofloxacin), aminoglycosides (streptomycin), and pleuromutilin (tiamulin) are also used to treat CCPP (Yatoo et al., 2019). In addition to antibiotic treatments, there are preventive measures to combat CCPP in goats. Vaccination is considered an effective method for the prevention of disease. Several vaccines have been developed against CCPP, including a whole-cell inactivated vaccine, a live attenuated vaccine, and a recombinant subunit vaccine (Yatoo et al., 2019). Farmers also employ traditional methods for CCPP control. In Kenya, the majority of surveyed farmers use medicinal plants (*Solanum aculeastrum*, *Albizia coriaria*, *Ekebergia capensis*, *Piliostigma thonningii*, *Euclea divinorum*) to treat respiratory disease symptoms, such as deep dry cough, extended neck, fever, and weight loss (Kama-Kama et al., 2016).

Brucellosis

Impact of brucellosis on the production performance of goats

Brucellosis can have detrimental consequences for agricultural economies, both in the short and long term, by causing abortions and infertility in animals, a decrease in milk production, as well as the birth of weakened offspring (Dahmani et al., 2022). A study conducted by Mahboub et al. (2013) into the impact of brucellosis infection on sheep and goats revealed that infection had no impact on the body weight of infected animals. Nevertheless, the number of offspring was reduced in goats infected with *Brucella melitensis* (Mahboub et al., 2013). In addition to its significant

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effect on performance, brucellosis also has adverse health consequences, as it interferes with crucial biological processes and functions of the liver and kidneys, which is manifested by alterations in the concentration of biochemical parameters in the blood (Mahboub et al., 2013). In a survey on the socioeconomic impact of brucellosis on animal production and reproductive performance in Kenya, it was reported that brucellosis had a significant impact on different aspects such as milk production (54.1%), meat (54.4%), infertility (66.0%), selling cost (64.3%), and treatment cost (62.3%). In Ethiopia, Tadeg et al. (2015) assessed the link between brucellosis prevalence and reproductive problems in goats and sheep. The results revealed a significant association between brucellosis seropositivity and the presence of reproductive abnormalities such as abortion, retained fetal membranes, and the birth of weak offspring. Furthermore, pregnant females were more vulnerable to brucellosis infection due to the growth stimulation of the bacteria in their reproductive tract. These findings are similar to those of the study by Tea et al. (2020) in the Dalaba prefecture of Guinea, where similar effects of brucellosis were observed in small ruminants.

Impact of brucellosis on human health

Human infection can be transmitted by coming into direct contact with vaginal fluids, placental material, and fetuses that have been aborted by infected animals, or by consuming unprocessed milk or dairy products from these animals (Ducrotoy et al., 2014). Edao et al. (2020) found a prevalence of 2.6% of brucellosis among individuals associated with animal production systems in southern Ethiopia. In a study conducted in Chad on brucellosis in nomadic pastoralists and their livestock, a prevalence of 3.5% of this disease in humans was reported (Schelling et al., 2003). These studies also highlighted a significant association between human brucellosis and assistance during parturition and the presence of seropositive animals within a household. Similar observations were reported in Eritrea by Omer et al. (2002). The results of these studies emphasize the importance of implementing preventive and control measures for brucellosis in animals to reduce the transmission of this disease to humans and limit its socioeconomic impact.

Methods of diagnosing brucellosis in goats

Diagnosis of brucellosis in small ruminants relies on a range of specific methods. Among these, the Rose Bengal Plate Test (RBPT) is the most commonly used serological tool in tropical Africa (Kamga et al., 2020; Tea et al., 2020; Lokamar et al., 2020). Rose Bengal Plate Test relies on visible agglutination when antibodies directed against Brucella antigens react, forming characteristic “dewy” lumps (Kamga et al., 2020; Tea et al., 2020; Lokamar et al., 2020). Enzyme-linked immunosorbent Assay is a serological method also frequently used to detect the presence of specific antibodies produced in response to Brucella infection. Enzyme-linked immunosorbent Assay offers advantages in terms of sensitivity and quantification of immune reactions and is used as a confirmatory test for RBPT-positive samples (Kamga et al., 2020; Legesse et al., 2023). The Serum Agglutination Test (SAT) is also a diagnostic method for brucellosis based on the agglutination reaction between Brucella antigens and specific antibodies present in serum (Bertu et al., 2010). Molecular PCR is also widely used for its sensitivity and specificity in detecting Brucella DNA (Legesse et al., 2023).

Prevalence of brucellosis in goats across some tropical African countries

Studies on the prevalence of brucellosis in goats have been carried out in countries such as Burkina Faso, Cameroon, Ethiopia, Ghana, Guinea, Kenya, Nigeria, and Togo. Prevalence rates vary considerably from one region to another, ranging from 1.1% to 36.84% (Table 3).

Methods of controlling brucellosis in goats

Different strategies are used to combat brucellosis. It is essential to remove and destroy parturition material, including aborted fetuses and placentas, by incineration to avoid exposure to other animals, such as dogs, farm cats, and children (Ganter, 2015). Daily cleaning of feces maintains hygiene, while regular disinfection, recommended at least three times a year, reduces the incidence of disease within the herd (Burns et al., 2023). The use of vaccines, such as *B. abortus* and *B. melitensis* in cattle, is proving useful in reducing disease prevalence, but their use is recommended as a last resort after other control methods have failed (Burns et al., 2023). The Rev. 1 *B. melitensis* vaccine controls brucellosis in small ruminants, mainly sexually immature females, offering long-lasting protection while potentially causing abortion in pregnant females and excretion of the organism in milk (Tizard, 2021). The Rev.1 vaccine was developed using streptomycin as a selective agent from a virulent field strain of *B. melitensis* (Tizard, 2021). It is administered by subcutaneous injection or deposition in the conjunctiva of lambs and kids aged three to five months. Conjunctival vaccination is generally considered safer than subcutaneous injection (Tizard, 2021). As a general rule, the entire flock should be vaccinated simultaneously at the end of the lambing or lactation season, especially when rearing under extensive conditions (Tizard, 2021)

The World Organization for Animal Health does not recommend antibiotic treatment of animals for brucellosis, underlining the importance of alternative preventive and control measures (Wareth et al., 2021; Burns et al., 2023).

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Table 3. Seroprevalence of brucellosis in goats of tropical Africa from 2013 to 2022

Countries	Regions	Sample (Number)	Prevalence (%) Diagnostic test			Reference
			SAT	RBPT	iELISA	
Burkina Faso	Bam Province	300			4.3	(Tialla, 2022)
Cameroon	Western, Central, Southern, and Southwestern regions of the southern part of the country	452		1.3	1.1	(Kamga et al., 2020)
Ethiopia	Tigray Regional State in the northern part of the country	495		5.5		(Teklue et al., 2013)
Ghana	Northern, Ashanti, and Greater Accra regions	286		10		(Jarikre et al., 2015)
Guinea	Dalaba Prefecture	90		10.3		(Tea et al., 2020)
Kenya	Baringo County	155		36.84		(Lokamar et al., 2020)
Nigeria	Plateau State	851	5.9	10.1		(Bertu et al., 2010)
Togo	Northern part of the country	221			8.8	(Dean et al., 2013)

RBPT: Rose Bengal Plate Test, SAT: Serum Agglutination Test, iELISA: Indirect enzyme-linked immunosorbent assay

CONCLUSION

Gastrointestinal parasites are prevalent in goats, resulting in growth retardation and reduced slaughter weight. Sarcoptic mange mites have detrimental effects on goat production and reproduction, and severe infections can even lead to death. Trypanosomiasis causes decreased hematocrit levels, abortions, low birth weight, and high mortality rates in goats. Peste des petits ruminants and Rift Valley fever have high seroprevalence rates in certain endemic regions. Contagious Caprine Pleuropneumonia presents high morbidity and mortality rates, while brucellosis reduces litter size and disrupts vital organs in goats. The present study can be considered for an overall understanding of major goat diseases and their control in tropical Africa.

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Availability of data and materials

All data are presented in the published manuscript.

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Authors' contributions

Kétomon Pierre Challaton drafted the first version of the manuscript. Aboudou Habirou Kifouly contributed to data collection. Kadoéito Cyrille Boko, Coovi Guénolé Akouedegni, Goué Géorcelin Alowanou, Mawulé Sylvie Hounzangbé-Adoté contributed to the critical revision of the manuscript. All authors checked the last draft of the manuscript and confirmed it before submission to the journal.

Conflict of interests

The authors declare that they have no conflict of interest.

Ethical considerations

All ethical issues have been checked by the authors, including plagiarism, double submission, and data originality.

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