AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

PREVALENCE AND RISK FACTORS OF MANGE MITES OF SMALL RUMINANTS IN THE NORTHERN REGION OF GHANA

ABDUL-RAZAK MOHAMMED RAJI

MASTER OF PHILOSOPHY

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A thesis submitted to the School of Graduate Studies, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in partial fulfilment of the requirements for the award of Master of Philosophy degree in Biology

JANUARY, 2024

DECLARATION

STUDENT'S DECLARATION

I Abdul-Razak Mohammed Raji, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …….

DATE: …….

SUPERVISOR'S DECLARATION

We hereby declare that the preparation and presentation of this work were supervised in accordance with the guidelines for supervision of thesis/dissertation/project as laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Asante-Mampong.

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Abstract

Mange is a debilitating skin disease posing a significant threat to the health and productivity of animals worldwide. In the Northern region of Ghana, the burden of mange infestations has become a concern for small ruminant farmers, many of whom depend on these animals for their livelihoods. A study was therefore conducted to ascertain the prevalence of mange in small ruminants in the region and to assess farming practices that predispose animals to the disease. Sheep and goats drawn from ten administrative districts of the region were screened for mange through visual inspection, palpation of the skin, and general clinical examination of animals. Samples were then taking to the laboratory for isolation and identification of mites. Questionnaires were also used to assess the knowledge of farmers on the disease. A total of 3, 949 sheep and 5,588 goats were screened for the disease, during which tissue from infected animals were scraped for laboratory examination. A prevalence of 4.7% in sheep and 12.6% in goats were recorded, with an overall prevalence of 9.4% among the two species. Two species of mites were identified in goats namely; *Sarcoptic* and *Psoroptes* mites. Infection involving *Sarcoptic* mite only constituted 91% whilst a mixed infection of *Sarcoptic* and *Psoroptes* mites constituted 9%. However, only *Sarcoptic* species were identified in sheep. On the knowledge, attitude and practices of farmers, 76.3% of respondents had no training in animal production, whilst 27.5% of them had no housing facilities for their animals, with only 8.1 % intensively housing their animals. Also, 77.1% of the respondents supplemented the water requirement of their animals with what they obtained from free-ranging, with only 18.4% providing the full water requirement of their animals. While, 90.1% of the respondents could recognize mange, 67.2 % of the respondents had ever recorded mange in their flock, with only 19.8 % having had some education on mange. In conclusion, the dominant mange causing mite in sheep and goats in the Northern region is the *Sarcoptic* species. Although

majority of farmers could recognize mange in their animals, poor husbandry practices such as lack of housing, inadequate feeding and watering were some of the factors that exposed animals to the risk of infection with mange. It is recommended that public education on mange be intensified. Also, there is the need for further studies to ascertain the genetic diversity of the two mite species identified in the current study.

DEDICATION

I dedicate this work to my family

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I wish to express my profound gratitude to Dr. Ismail Coffie my principal supervisor and Papa Kofi Amissah-Reynolds the co-supervisor for their guidance and immense contribution and support in the course of this study. I also like to extend my sincere gratitude to Dr. Denis Dekugmen Yar, Mr. Shaibu Waale, and all the students in the AHPC lab (2023 cohort) at Pong-Tamale, I am very grateful.

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CHAPTER ONE
1.0 INTRODUCTION

1.1 Background to the study

The menace of pests and diseases remains a major challenge to livestock production in Ghana and across the globe. Pests and diseases significantly affect animal health and productivity, resulting in economic losses and food insecurity. Mange is a disease that affects various animal species, as well as humans (Moroni *et al*., 2022). This debilitating skin disease caused by mite species, poses a significant threat to the health and productivity of animals worldwide, including small ruminants. Four important mite genera causing mange are *Demodex*, *Sarcoptes*, *Chorioptes*, and *Psoroptes* (Ali *et al*., 2021). Alasaad *et al*. (2012) described mange as an emerging and re-emerging parasitic disease that poses a threat to human and animal health globally. It is estimated that over 130 million humans are infected with the disease at any given time as cited by El-Moamly (2021), and it affects over 150 mammal species (Moroni *et al.,* 2022) such as cattle, sheep, goats, pigs, dogs in the domestic setting. In Ghana, mange has been reported as one of the most commonly occurring diseases in small ruminants, by farmers (Nuvey *et al*., 2023).

In the Northern region of Ghana, small ruminant production plays a vital role in the livelihoods of rural communities. Sheep and goats are very prolific and can comparatively multiply within a short period. For instance, goats are noted for their hardiness and their ability to thrive under minimal attention (Baah *et al.,* 2012). However, mange infestations among these animals, have emerged as a common problem, leading to economic losses and impacting both animal welfare and human health. The disease causes severe damage to the animals' skin, resulting in loss of economic value, reduced productivity, and, in some cases, death. The burden of mange infestations has therefore become a significant concern for small ruminant farmers in the Northern region of Ghana.

According to the FAO (2021), animal diseases impact directly, the livelihoods, food security, and nutrition of farming households with negative consequences on national and international livestock value chains, including trade restrictions. In effect, pests and diseases of animals result in significant consequences including economic and food losses to man.

1.2 Problem Statement

Livestock production in Ghana is still largely done extensively. Animals are at best housed at night and left to roam on their own during the day. This does not only affect total control over animals by farmers and/or caretakers but also increases the risk of disease transmission and spread among animals. According to Opoku-Agyemang *et al*. (2017), inadequate housing and management practices, and lack of isolation and separation facilities for animals affected by mange are some of the contributing factors to the spread of the disease. Mange accounted for about 4.21% of the total reported animal diseases in the country during the 2011/2012 Ghana Agriculture Survey (Osei-Akoto *et al*., 2014). It affects almost all domestic animals such as sheep, goats, cattle, pigs, dogs, and rabbits among others.

However, despite the evident impact of mange on small ruminant production, there is a lack of comprehensive information on the epidemiology of mange in small ruminants in the Northern region of Ghana. Understanding the prevalence, species composition, and distribution patterns of mites causing mange is crucial for designing effective control and prevention strategies. Furthermore, the zoonotic potential of mange mites and their impact on both animal and human health requires careful investigation.

1.3 Justification and Significance of the Study

This study's significance lies in its contribution to addressing the knowledge gap regarding the epidemiology of mange in small ruminants in the Northern region of Ghana. By providing accurate

data on prevalence and species identification, the study will enable the development of targeted and effective control measures. Improved understanding of the epidemiological characteristics of mange mites will also aid in identifying potential zoonotic risks and implementing appropriate preventive measures.

Additionally, the study's findings will have practical implications for small ruminant farmers, veterinary professionals, and policymakers in Ghana. The identification of prevalent mite species as well as the practices and attitudes of farmers which increases the risk of animals getting the disease will inform the development of tailored management strategies, including optimized diagnostics, treatment protocols, and preventive measures. Ultimately, the research outcomes will contribute to enhancing the health, welfare, and productivity of small ruminants, benefiting the rural communities relying on this sector.

1.4 Research Questions

The study sought to answer the following questions:

1. What is the prevalence of mange among small ruminants in the Northern Region of Ghana?
2. What are the dominant species of mites causing mange in small ruminants in the Northern Region of Ghana?
3. What are the attitudes and practices of farmers which increase the risk of animals being infected with mange?

1.5 Objectives

The main research objective of this study was to determine the prevalence of mange in small ruminants in the Northern region of Ghana. Specifically, the study sought to:

1. Ascertain the prevalence of mange among small ruminants in the Northern region of Ghana.
2. Identify the major species of mites causing mange in small ruminants in the study area.
3. Identify the practices and attitudes of farmers which increases the risk of animals being infected with mange.

CHAPTER TWO
2.0 LITERATURE REVIEW

This chapter discusses literature related to the current study, and it is categorized into nine sections. Thus, it aims to synthesize existing research on mange in general, its causative agent, biology of the causative agent, epidemiology, prevalence, types, and socio-economic effects of the disease in Ghana and across the globe as a whole.

2.1 Overview of Mange

Mange is a contagious skin disease, marked by crusty, pruritic dermatitis and loss of hair, as a result of a variety of parasitic mites burrowing in or living on the skin (World Organization for Animal Health, 2019). The disease in humans is commonly known as scabies. The term scabies is derived from the Latin word 'scabere', meaning 'to scratch' and it is seen where the acarine itch mite *Sarcoptes scabiei* parasitizes the skin of a human or an animal, often after direct skin-to-skin contact with an already infested host (Ramchurn *et al*., 2020). Mange mites have a broad range of hosts because of their ability to adapt to new hosts making them spread easily across the globe (Niedringhaus, 2019). Over 200 families of mites and several thousands of species, from which some have evolved to become major animal pests have been established (Benti *et al.,* 2020).

About 50 mite species in 16 families and 26 genera are considered to cause mange in livestock, poultry, companion, and laboratory animals, whereas humans specifically are host to the species *Sarcoptes scabiei* (World Organization for Animal Health, 2019). Some important genera of mites affecting animals include *Psorobia, Chorioptes, Demodex Psoroptes,* and *Sarcoptes* (Ketzis, 2023).

2.2 Mange (Scabies) in Ghana

Infections caused by *Sarcoptes* species among humans and animals have been reported in Ghana a number of times (Kaburi *et al*., 2019). For instance, in spite of earlier treatment of reported cases of scabies in people in the North-East region, a 71% prevalence was reported (Amoako *et al.*, 2020). In the Sekyere East district of Ashanti, a prevalence of 11.58% of the disease in humans was reported (Ofori-Amoah *et al*., 2021). In Accra, an investigation among school children revealed a scabies prevalence of 11.2% (Kaburi *et al.*, 2019). Scabies may result in pain, itch, and systemic complications from secondary bacterial infections to the host (Kaburi *et al.*, 2019). In animals, scabies is known as mange. Even though mange has been identified as one of the most frequently reported animal diseases in Ghana (Nuvey *et al*., 2023), there is very limited data regarding the distribution and frequency of the disease in the country. According to the Ghana Agriculture Production Survey, mange was among the top five diseases of animals reported in the country, with 4.2% of farmers recording the disease in goats, sheep cattle etc. (Osei-Akoto *et al*., 2014). In a study to assess the prevalence, farmers' knowledge and management of mange in small ruminants in the Ejisu-Juaben municipality, Opoku-Agyemang *et al*. (2017), reported 71% and 100% positive cases of mange in goats and sheep respectively.

2.3 Biology of Mites

Mites are tiny arthropods of about 1mm in size or less, identifiable largely under a microscope or a hand lens (Shibeshi *et al*., 2013) as shown in figure 1 below. They are small, wingless, and belong to the class Arachnida, and the subclass Acari often called Acarina (Ali *et al*., 2021). Adult mites are circular in shape with spine-like projections on their dorsal surface, and four pairs of legs, with no distinctive head (Elsheikha & Wright, 2015). The female mite is about 0.3 to 0.5 mm long by 0.3 mm wide, whilst the male is about 0.25 mm long by 0.2 mm wide (Elsheikha & Wright, 2015).

The mange mite was first classified under the genus *Acarus* and designated as *Acarus scabiei* DeGeer but was later classified under the superfamily Sarcoptoidea and family Sarcoptidae (Arlian & Morgan, 2017).

The family Sarcoptidae is sub-divided into three, namely; Sarcoptinae, Teinocoptinae, and Diabolicoptinae with a total of 16 genera and 118 species under them, all of which inhabit the skin of mammals as cited by Arlian and Morgan (2017). The body is divided into prosoma and opisthosoma with four pairs of legs in the adult and nymph (Ali *et al*., 2021) and three pairs of legs in the larvae (CDC, 2018). The legs are divided into segments, namely: coxa, trochanter, femur, genu, tibia, tarsus, and pretarsus (Mullen & Oconnor, 2019).

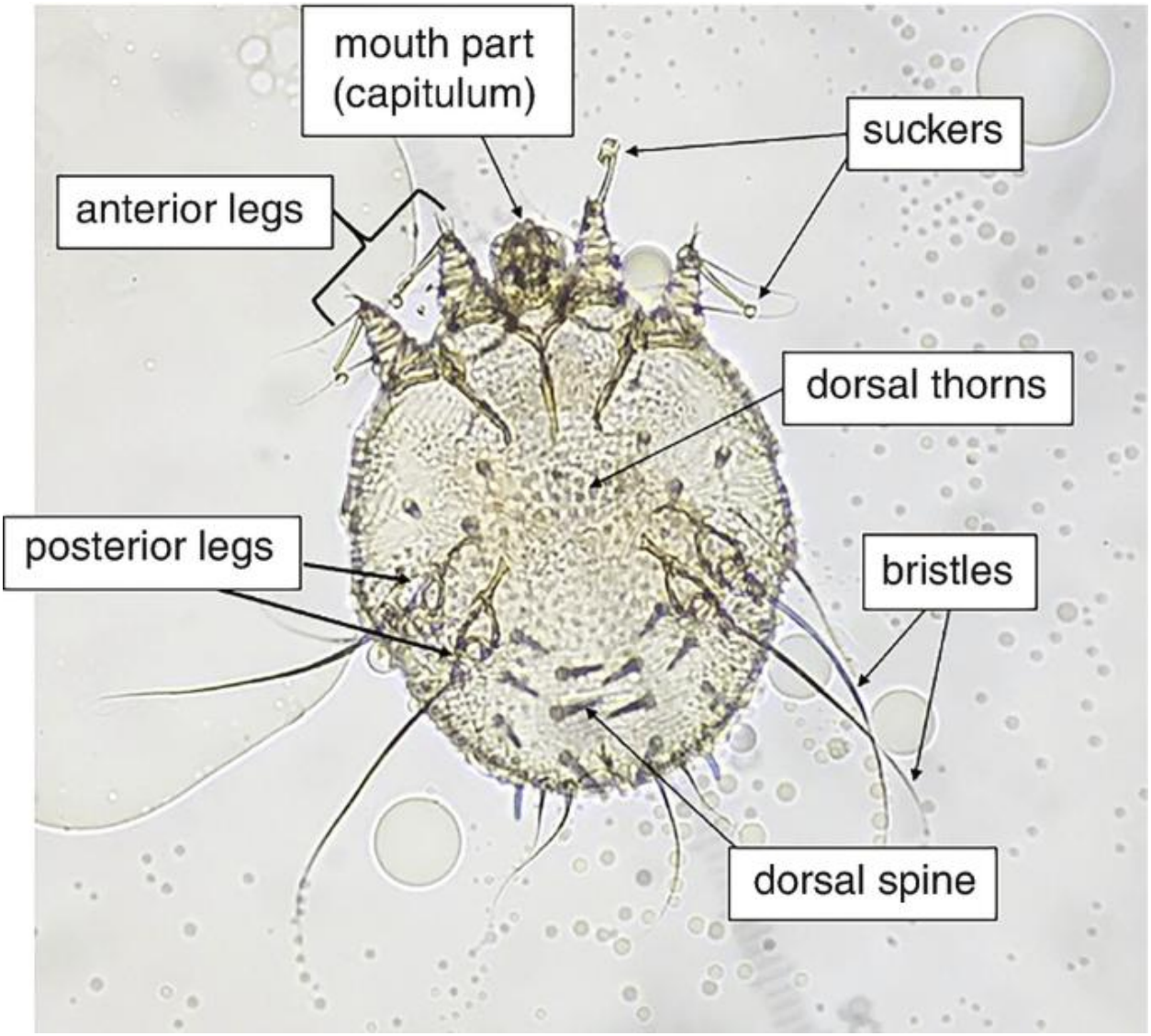

Figure 1: A labelled image of *Sarcoptes* mite (Yotsu *et al*., 2023)

2.3.1 Life Cycle of mange mite

The entire life cycle of mites lasts between 17 – 21 days in the host (Dryden, 2022). These hosts include humans and domestic animals such as cattle, sheep, goats, dogs etc. as cited by Kebede and Hirpa, (2022). The life cycle of the mite is composed of four stages namely: egg, larva, nymph, and adult (CDC, 2023). However, Mullen and Oconnor (2019) on the life history of mites, described the developmental stages to consist of the egg, prelarva, larva, protonymph,

deutonymph, tritonymph, and adult. The adult, nymph, and larval stages of the parasite are all infective (El-Ghany & Wafaa, 2022). Female mites burrow into the skin making tiny holes in which they lay eggs over a period of 2–3 weeks (Elsheikha, & Wright, 2015). A single mating keeps the female fertile for the rest of its life, the impregnated female then exits their moulting pouches to find a suitable site for a permanent burrow (CDC, 2023). Adult females usually live for two weeks or more, producing about 14 to 20 eggs during this time, each of which hatches in four days. Eggs are deposited singly at the rate of one egg per day, which are attached with a sticky substance to the host skin (Talley & Sparks, 2008). Eggs hatch in about 3 days and the immature stages exit the burrow, mature, mate, and move on to make other burrows (Elsheikha, & Wright, 2015). However, mites can live freely off their host for 2–3 weeks in suitable environmental conditions, therefore making transmission via fomites very possible (Elsheikha, & Wright, 2015).

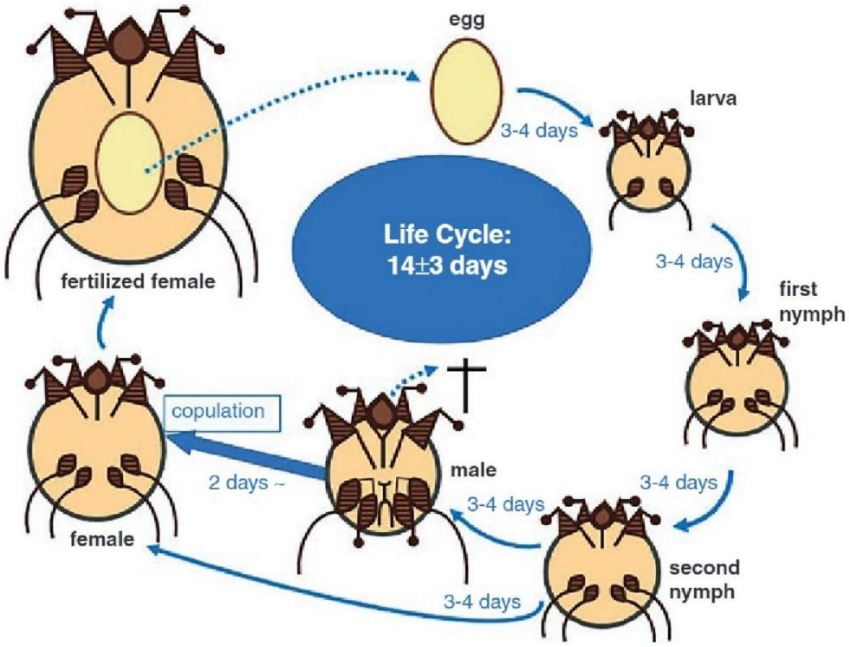

Figure 2: The life Cycle of a *Sarcoptes Species* (Yotsu *et al*., 2023)

2.3.2 Morphological and Behavioral Characteristics of Sarcoptic Mite

The body (idiosome) of *Sarcoptes scabiei* is oval, tortoise-like, dorsally convex, and ventrally flat (Arlian & Morgan, 2017). Attached to the dorsal idiosoma are stout lateral and dorsal setae, cuticular spines, and coarse, transversely ridged, cuticular striations (Arlian & Morgan, 2017). The adult has 4 pairs of short sucker-bearing legs that are stubby with unjointed pedicels in both males and females (University of Copenhagen, 2011). The two anterior pairs of legs with blade-like claws on the tarsi and stalked empodium with distal pads, extends beyond the margin of the idiosoma, whilst the two posterior pairs have one or two blad-like claws on the tibiotarsi and remain within the body margin (Niedringhaus *et al.*, 2019). The anterior gnathosoma also bears specialized feeding structures which includes chelicerae and pulps whereas the posterior idiosoma bears sensory setae (Tiwari *et al*., 2023). Male *Sarcoptes* are more mobile than females, travelling down the burrows dug by females in search for a copulation partner, under the influence of mate-seeking pheromones (Saari *et al*., 2018).

2.3.3 Morphological and Behavioral Characteristics of Psoroptic Mite

Psoroptes species are large (0.4-0.8 mm long) non-burrowing mites which feed on tissue fluids as cited by Scott and Miller (2010). The non-burrowing mites feed on lipid emulsion of the lymph, skin cells, and skin exudates of their host by cutting short the epidermis as cited by Amer *et al.* (2015). The oval bodied parasite is dorso-ventrally flattened and can be distinguished from other mites by a sucker-like ambulacral disk on a relatively long, 'segmented' ambulacral stalk which constitutes a pretarsus as cited by Amer *et al*. (2015). They have biting and chewing mouthparts which cause inflammation of the epithelial surface of the skin where they are largely found

2.3.4 Morphological and Behavioral Characteristics of Chorioptes Mite

The body of a typical *Chorioptes* mite is oval in shape with the first pair of legs being short, unsegmented with suckers attached to the ends as cited by Robertson *et al*. (2012). *Chorioptes* mites are non-zoonotic have a 2- to 3-week life cycle, and can live off the host for only a few days (Robertson *et al*, 2012). The adult *Chorioptes* mite measures about 200-300 μm in length and has four pairs of long legs that extend past the body margin, with some of the legs having short, un-jointed pedicel (pretarsus) at the tip (University of Saskatchewan, 2023). They are largely found on cattle, horses and occasionally sheep, and parasitize the surface of their host (University of Saskatchewan, 2023).

2.4 Epidemiology of mange

Mange is a common parasitic skin disease among small ruminants and other hosts distributed globally. Even though data on the epidemiology of mange is still inadequate and probably differ between animal species and areas of the world (Mohammed *et al*. 2020), it may also vary depending on the causative agent, host factors, and environmental conditions. The incubation period of the disease varies from 10 days to 8 weeks, depending on the severity of the infection on the affected animal, the body part affected, the number of mites transmitted, and the animal's state of health (Dryden, 2022). Studies have shown that younger animals are more susceptible to the disease than older ones (Shirzad *et al*., 2010). Additionally, animals with poor nutrition, poor hygiene, and high stocking density are more prone to the disease (Garedew *et al.*, 2010).

Chorioptic scab mite infests all domestic animals, especially cattle, sheep, goats, and horses, affecting their legs and feet (Talley & Sparks, 2008). Fesseha *et al*. (2021) observed in the Malle district of Kenya that, the most prevalent of the three species of mite in goats, was *Sarcoptes*, followed by Psoroptes and Demodex respectively. In sheep, the most important mite species are

the psoroptic mange and *Sarcoptes scabiei var ovis* (Mohammed *et al*. 2020). Benti *et al*. (2020) also reported *Sarcoptes scabies, Psoroptes ovis* and *Demodex caprae* as the most economically important species of mites affecting goats and sheep. Kebede and Hirpa (2022) also reported *Sarcoptes, Demodex* and *Psoroptes* species in cattle in Ethiopia. Other studies in Africa suggest the disease is widespread among domestic ruminants in the region. In the Oromia State of Ethiopia, Kebede and Hirpa (2022) have reported a prevalence of 22.40% in cattle, whereas Kassayeq and Kebede (2010) reported 8.11% and 0.95% in goats and sheep respectively. In the Eastern Amhara region of Ethiopia, Seid *et al*. (2014) reported prevalence of 7.5% and 1.2% in sheep and goats respectively. In Benin, Salifou *et al.* (2013) reported a prevalence of 28.33% in small ruminants, and 9.5% in humans in contact with the animals, revealing the public health importance of the disease.

2.5 Immunologic effect of mange

When scabies mites infest a host, they burrow into the skin, thereby releasing substances that induce inflammatory and immune responses by the host as well as substances that can thwart some aspects of these responses, enabling the mites to avoid the host's protective mechanisms (Arlian and Morgan, 2017). Also, when invading females deposit eggs under the skin, they induce hypersensitivity, inflammation, and skin rashes (El-Ghany & Wafaa, 2022). These notwithstanding, some studies have revealed that haematological indices such as pack cell volume (PCV), haemoglobin (Hb) concentration and red blood cell (RBC) count, among infested animals are not significantly different from non-infested animals however, infested animals had a significantly higher white blood cell (WBC) count than non-infested animals (Ogundiyi *et al.*, 2012). In a synthesis and meta-analysis of immunological and clinical pathological changes

associated with *Sarcoptes scabie* infection, Næsborg-Nielsen *et al.* (2022) observed a significant decrease in total red blood cells (RBC) in all cases of mange, whereas haemoglobin and iron decreased only in severe cases of the disease. Kido *et al*. (2011), observed significantly lower total protein, Albumin, and Glucose levels in the serum of severely mange-infested raccoon dogs as compared to non-debilitated ones. Singh *et al*. (2011) observed a state of significant oxidative stress in mange-infested dogs, attributable to the overproduction of free radicals by inflammatory cells recruited to deal with the parasites, therefore exhausting the antioxidant system of the infested animal. Furthermore, immunoglobulim E (IgE), eosinophils, and mast cells have been found to be elevated in affected animals showing Type I typpersensitivity response to the disease (Næsborg-Nielsen *et al.,* 2022).

2.6 Clinical Signs and Lesions of mange

Mange mite infection presents two forms of signs of the disease, namely; a thick scaly crust on the epidermis of the skin as part of the host's immune response commonly known as parakeratosis and loss of hair as cited by Simpson *et al.* (2016). Mange mite invasion is generally characterized by piercing the host's skin, sucking lymph as well as feeding on young epidermal cells (Benti *et al*., 2020). Fertilized female mites make burrows that are zigzag in nature in the top epidermal layer of the host animal's skin, whilst obtaining nourishment from the serous exudate, a liquid oozing from the damaged tissues (Zahid, 2015). The activities of these mites may result in affected animals exhibiting severe itching, leading to constant rubbing, biting, and scratching of the skin, followed by hair loss in localized areas, especially around the ears, eyes, muzzle, elbows, and hocks. The acute irritation leads to the animal scratching its body against inanimate objects, causing the skin damage and exposing the animal's skin to secondary viral and bacterial infections as cited by Ali *et al.* (2021). The goat follicle mite causes dermal papules and nodules on the host

skin, as a result of the hair follicles or gland ducts becoming obstructed and producing swellings, trapping the mites within these lesions (Talley & Sparks, 2008).

2.7 Diagnosis

Accurate diagnosis of mange is crucial for appropriate treatment and prevention of further transmission. The diagnosis of mange is generally based on the physical inspection and observation of skin lesions on affected animals. Even though the history, morphological examination and distribution of skin lesions can be indicative of the disease, scabies infection can be confirmed with the identification of mites, eggs or faeces in skin scrapings or biopsies (Leung & Miller, 2011). This involves the scraping of the surface of the skin of suspected infected animals with a scalpel blade or a dermal curette to collect a sample of skin cells and mites (Sasaoka *et al*., 2021). The sample may then be treated with a buffer solution or not and then examined under a microscope for the presence of mites or their eggs. Another diagnostic method for mange is the use of tape strips, also known as acetate tape impression where a strip of transparent adhesive tape is pressed onto parts of the body infected with the disease to capture some samples of the parasite (Sampaio *et al*., 2017). The sample is then examined under a microscope for the presence of mites or their eggs. Tape stripping is less invasive than skin scraping and can be used to sample different areas of the body, but it may not be as effective in detecting deep burrowing mites. Other techniques used in the diagnosis of mange infection include histo-pathological examination of bioptic samples; microscopic identification of mites, eggs, eggshell fragments and/or mite faecal pellets from skin scrapings; epiluminescence microscopy and high-resolution video-dermatoscopy; intradermal skin tests; and the use of mange detector dogs as cited by Angelone-Alasaad *et al*. (2015). Blood samples may also be used for antibody detection (Tajima *et al*., 2019).

2.8 Treatment and Control of Mange

Mange control in domestic animals is essential for the health and welfare of the animals and for economic reasons. According to Alemu *et al* (2022), the use of acaricides such as deltamethrin, diazinon, and fenvalerate among others for the treatment of mange is one of the commonest options with varying rates of success. However, the prolonged use of acaricides can lead to the development of resistance. Furthermore, Benti *et al*. (2020), enumerate ivermectin, diazinon, phoxin coumaphos and dipping with insecticides, as some common but important treated for mange. Treatment of affected animals with ivermectin plus permethrin, however, has proven more effective and powerful against the disease as cited by Mohammed *et al.* (2020). These drugs especially the ivermectin group, however, are being over-exploited by farmers and other users, and gradually leading to a decline in the efficacy of the drugs. Some of the areas of misuse of these drugs are the dosage, time interval for a repeat administration, and withdrawal period among others. The use of hot lime sulfur either as spray or dip for infected animals is also found to be effective against *sarcoptic, psoroptic,* and *chorioptic* mites in sheep (Ketzis, 2023). Furthermore, sprays formulated from permethrin-based chemicals can as well be effective against mange in sheep and goats (Ketzis, 2023). The use of integrated pest management strategies, such as the combination of acaricides with environmental and biological control measures, can be an effective way to control mange in domestic animals. Like many infectious diseases, vaccination could also be an effective tool for the control of mange in domestic animals, even though there is no available commercial vaccine yet (El-Ghany & Wafaa *et al*. 2022). According to Alemu *et al.* (2022) the use of herbal remedies, such as essential oils and plant extracts, may offer a promising alternative to synthetic acaricides for mange control.

2.9 Socio-Economic Effect of Mange

Several studies have highlighted the socio-economic effects of mange in animal production, emphasizing its impact on small ruminants, such as sheep and goats. Mange infestation leads to reduced productivity, increased management costs, and potential losses for farmers. The infestations cause intense itching and discomfort in affected animals, leading to reduced feeding and grazing time. As a result, animals with mange may experience reduced weight gain, retarded growth, reduced milk yield in dairy animals, and subsequently death as cited by Yasine *et al*. (2015). Studies have estimated that mange infestations in small ruminants can cause losses in milk and wool production, reduced growth rates, and increased mortality rates, leading to substantial economic impacts on livestock farmers (Gari *et al.*, 2004). In a study focusing on dairy goats, Sarcoptic mange was found to negatively impact milk production, with infected goats producing significantly less milk than healthy ones (Elmajdoub *et al.*, 2018). Mange also causes economic loss to the farmer by way of animal mortality, poor growth and reproduction, and often a rejection or downgrade of infested animals at the tannery (Demissie *et al*., 2000). In Indonesia, Sarcoptic mange among goats accounted for significant economic losses in the goat production chain (Lastuti, 2018). Mange causes severe damage to the skin and in some cases, anaemia, poor physical condition, decrease in the production of milk and meat as well as reduced reproductive capacity and growth rates, all leading to serious economic losses as cited by Ogundiyi *et al*. (2012). Mange infestations lead to severe pruritus and discomfort, affecting the overall welfare of animals. Mange-infested animals may face reduced market value and restrictions on trade and movement due to the contagious nature of the disease. In some regions, mange outbreaks can lead to trade embargoes or quarantines to prevent the spread of the disease to other flocks or herds (Mekonnen *et al.*, 2017)**.**

CHAPTER THREE
3.0 MATERIALS AND METHODS

3.1 Study Area and Inclusion Criteria

The study was conducted in the Northern region of Ghana. The region is made up of fourteen administrative districts, and covers an area of about 26,911 (km^2) square and is located between latitudes 0.30N and 10.30N and longitudes 0.31W and 0.30W, with predominantly grassland vegetation, making livestock rearing an important economic activity of the area (Northern Regional Coordinating Council, 2023).

The vegetation of the region consists predominantly of grassland, especially savanna with clusters of drought-resistant trees such as baobabs or acacias. Livestock rearing in the region forms an important part of the economic activity of the area. The industry is agro-based in the form of processing agricultural produce such as groundnuts into edible oil and shea-nuts into shea-butter. Several rice mills operate in the area.

The districts in alphabetical order were numbered from 1 – 14. The numbers were written in pieces of papers, folded and mixed together. Ten different pieces of the folded papers were then randomly selected. The selected districts were; Gushiegu located in the eastern corridor of the region, with a distance of 114 km from the regional capital Tamale (Ghana Statistical Service, 2014), Karaga located in the North-Eastern part of the Region, and lies between latitudes 9º 30’ South and 10º 30’ North and longitudes 0o East and 45’West (Karaga District Assembly, 2021), Kumbungu, located in the northern part of the region and covering a land mass of 1,599 km sq (Kumbungu District Assembly, 2021). Others are Nanton which was carved out of the former Savelugu-Nanton district, Nanumba North located in the eastern part of the Region and lies between latitudes 8.5º N and 9.25º N and longitudes 0.57º E and 0.5ºE (Ghana Statistical Service, 2014), Saboba, Sagnerigu,

Savelugu, located in the northern part of the region, Tolon, and Yendi. Figure 3 shows the map of the region, and the selected districts.

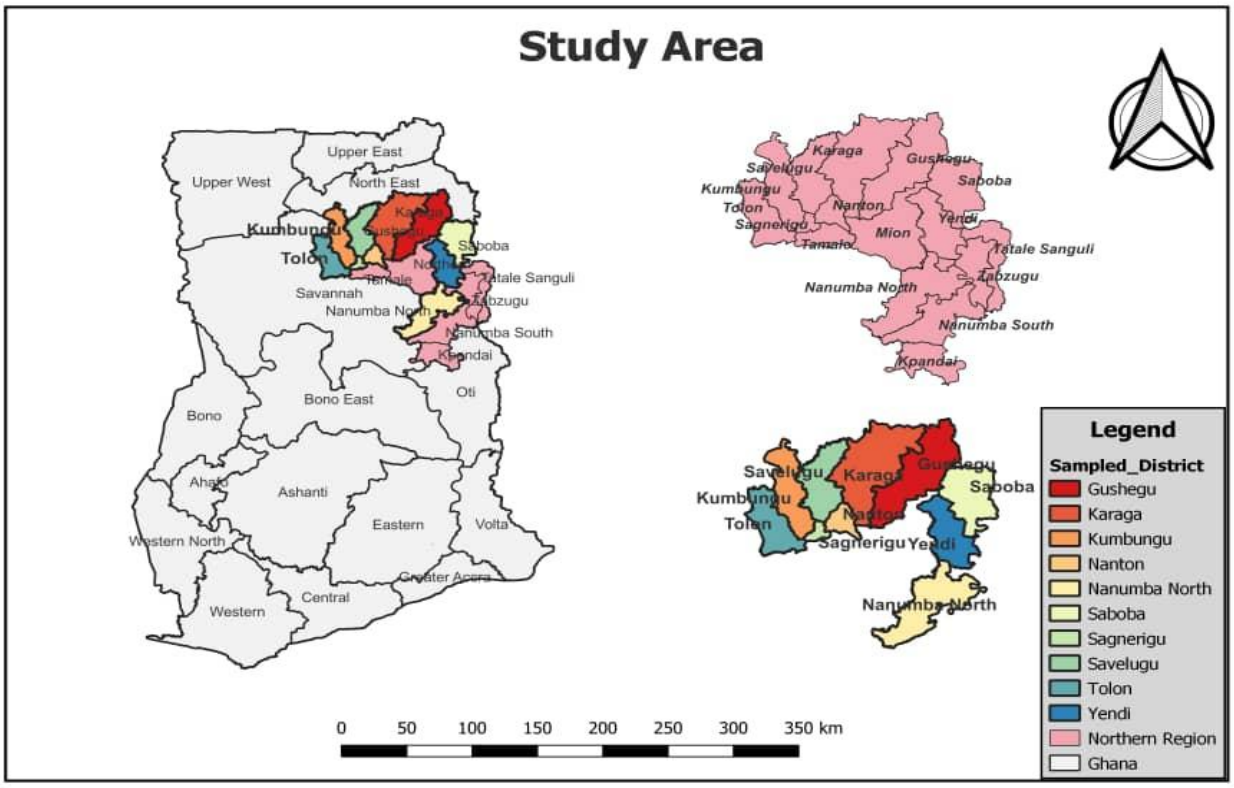

Figure 3: The map of the Study Area

3.2 Research Design

The study was in three folds; quantitative descriptive research, a random field isolation of mange mite from infected animals and laboratory examination of mange mites.

3.2.1 Quantitative descriptive research

Study one involved the use of questionnaires as the main instrument for the collection of data. The study concentrated on identifying the knowledge, attitude and practices of farmers on mange in small ruminants. The questionnaire was structured on the following themes; demographics of respondents, general perception or knowledge on mange, recognition of mange and choice of treatment of mange. The questionnaires were administered across ten administrative districts/municipalities/metropolis in the Northern region of Ghana between November 2022 and March 2023.

3.2.2 Isolation of mange

Small ruminants (sheep and goats) across ten administrative districts of the northern region of Ghana were screened for mange infections through visual inspection, palpation of the skin and general clinical examination of animals. Clinically infected animals demonstrate itching, hair loss, inflammation, hyperkeratosis, erythema and pruritic skin lesions (Niedringhaus *et al*., 2019) in severe cases. Parts of the affected skin of clinically infected animals such as hairless parts, the edges of active lesions with pruritis, crust etc. were scraped with the aid of forceps and surgical blades. The samples (scrapped skin) were then placed into petri dishes and mixed with phosphate buffer saline (PBS) solution and sent to the laboratory on ice for examination.

3.2.3 Laboratory Examination

The scraped samples were treated with 10% KOH solution in test tubes, placed in water bath exposed to a heat source for about 20 minutes. The samples were then centrifuged at 1500 rpm for 5 minutes (Adane *et al.*, 2018). The supernatant was discarded and smears were made from the sediment on glass slides, which were then examined under a light microscope.

3.3 Data Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 28.0. Prevalence was calculated as a percentage of total samples that were positive for mange, thus the number of samples/animals with mange out of the total number of animals screened was expressed as a percentage. Other parameters such as the demographics of respondents, knowledge and husbandry practices of farmers among others were expressed as percentages.

3.4 **Ethical Clearance**

Ethical Clearance with reference number CHRE/AP/195/024 was obtained from the Committee on Human Research and Ethics of the University of Energy and Natural Resources, Sunyani. A copy of the approval letter is shown in appendix II.

CHAPTER FOUR
4.0 RESULTS

This chapter presents the outcome of the current study, which comprise of the use of questionnaire to obtain quantitative data, clinical screening of sheep and goats and sampling during a field survey, and a laboratory isolation and identification of mange mites. It is broadly categorized into two sections, with each section further divided into sub-sections with tables and/or figures.

4.1 Objectives One and Two: Prevalence and Identification of Mange Mite

4.1.1 Prevalence of Mange in small ruminants

A total of 9, 537 small ruminants were screened for mange, as shown in Table 4.1 below. These include 3, 949 sheep, representing 41% of the animals screened, and 5,588 goats representing 59%. Of the total sheep screened, 186 of them were diagnosed of mange representing a prevalence of 4.7%. Out of the 5,588 goats screened, 706 were diagnosed of mange, giving a prevalence of 12.6%. The overall prevalence of mange among sheep and goats in the study area is 9.4%.

As shown in Table 4.1, three administrative districts namely; Karaga, Nanumba North, and Sagnerigu municipality recorded zero prevalence in sheep, with Savelugu municipality, Yendi municipality, and Gushegu recording 15.2%, 13.7%, and 10.2% respectively. The rest are Nanton 4.5% and Kumbungu 0.7% as well as Saboba and Tolon both of which recorded 0.3 % each. In goats, the Savelugu municipality recorded the highest prevalence of mange at 30.5% followed by 22.5% and 21.2% for Gushegu and Yendi respectively. The rest are Nanton 14.3%, Nanumba North 12.0%, Karaga 6.3%, Kumbungu 7. 2%, Tolon 6.8% and Saboba 5.6%. The Sagnerigu municipality recorded the lowest prevalence of the disease in goats (0.5%).

Infections in goats were more common and severe than in sheep. Infected sheep largely had alopecia (loss of hair) at infected body parts such as the neck and brisket, whereas, those of goats were characterized by loss of hair in mild cases, with pruritis, thickened, rough skin lesions and crust in severe cases on affected body parts as shown in plate 4.1 below. Affected body parts in goats include; the ear, the neck region, the limbs, the nuzzle, and the inguinal region as shown in plate 4.1.

Table 4.1: Prevalence of Mange by District

District/Municipality	**Sheep**			**Goat**		
	No of animals screened	No of positive cases	% Prevalence	No of animals screened	No of positive cases	% Prevalence
Saboba	756	2	0.3	414	23	5.6
Sagnerigu	373	0	0	382	2	0.52
Savelugu	388	59	15.2	371	113	30.5
Kumbungu	712	5	0.7	763	55	7.2
Nanton	376	17	4.5	349	50	14.3
Nanumba North	21	0	0	1119	134	12.0
Tolon	301	1	0.3	660	45	6.8
Gushegu	694	71	10.2	924	208	22.5
Yendi	227	31	13.7	255	54	21.2
Karaga	101	0	0	351	22	6.3
TOTAL	3949	186	4.7	5588	706	12.6

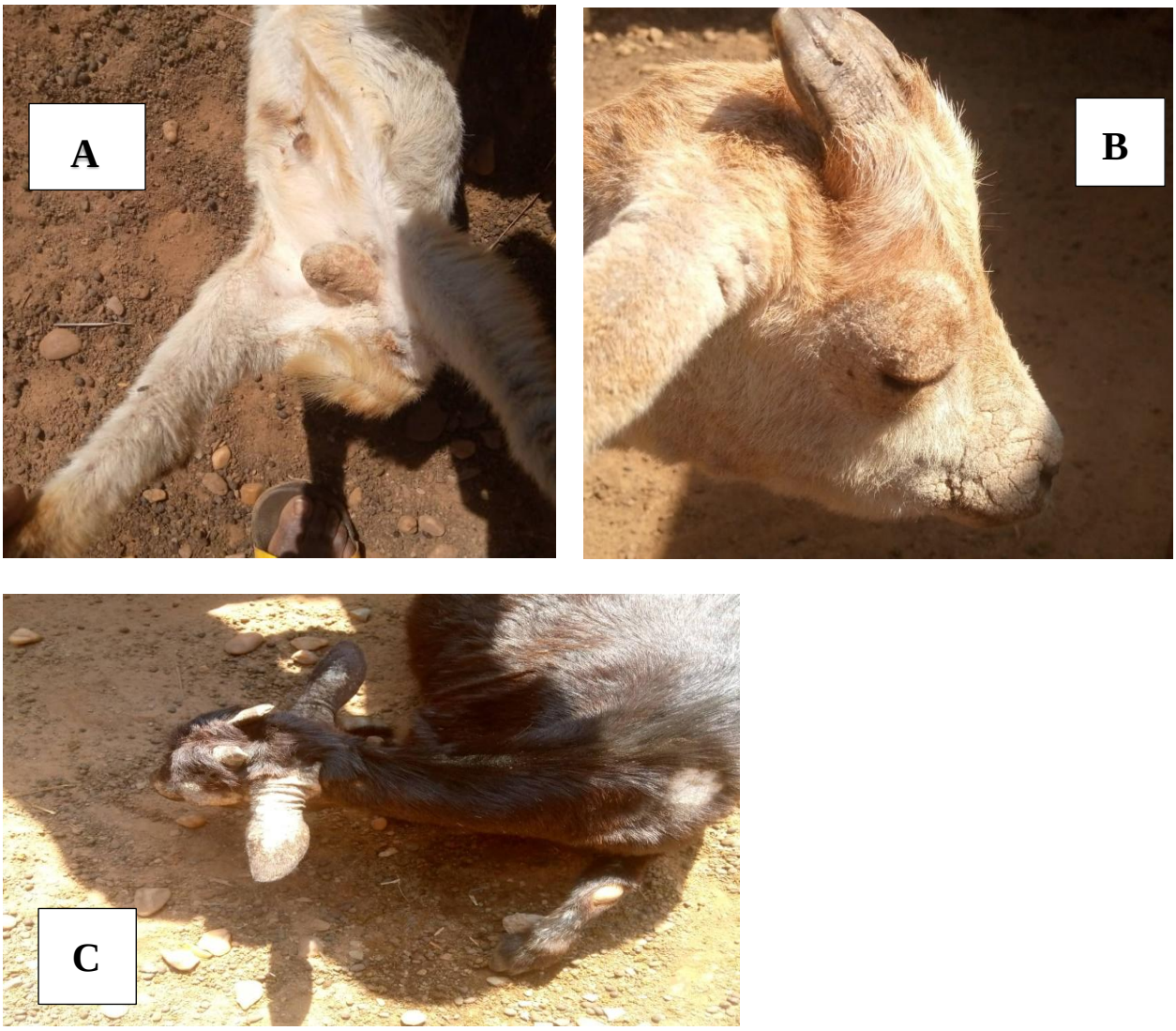

Plate 4.1: *Mange Infested Goats* ***(A, B and C)***

Source: Author's Field Survey from Saboba District

4.1.2 Microscopic Identification of Mange Species

Two main species of mange mites were microscopically identified in goats in the current study. These were *Sarcoptic* species and *Psoroptes* species. Samples diagnosed with *Sarcoptic* species constituted 91% of the total cases diagnosed, whereas samples diagnosed of a mixture of *Psoroptes* and *Sarcoptic* species constituted 9% of the total cases. Thus, the prevalence of *Sarcoptic* species in goats is 15.5 %, whereas *Psoroptes* constituted 1.5 % in the same species. Plate 4.2 shows the species of mites isolated in the current study. In Sheep, only *Sarcoptic* species were identified.

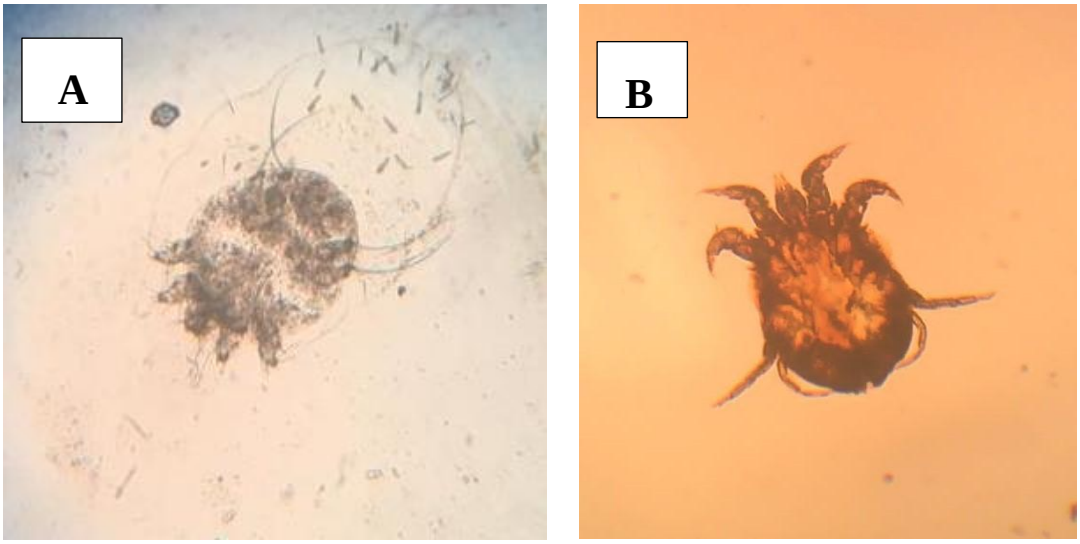

Plate 4.2:*A - Sarcoptic mite, B – Psoroptes mite under the microscope (X 10)*

Source: Author's Lab. Result

4.2 Objective Three: Knowledge, Attitude, and Practices of Farmers on mange

4.2.1 Demographics

As shown in Table 4.2, a total of 584 small ruminant farmers participated in the current study, comprising 93.1 % males, and 6.9 % females. Of the total respondents, 50.3 % have no formal education, with 14 %, 21.9 %, and 13.8 % representing respondents with basic, secondary, and tertiary levels of education respectively. Out of the 584 respondents, 42.1 % have been keeping small ruminants for 8 years and above, whereas 36.7 % and 21.2 % of the respondents have been keeping the small ruminants for 4 – 7 years and 1 – 3 years respectively. Farmers keeping sheep only constituted 14.2 % of the total respondents, whereas those keeping goats only were 44.5 %, with those keeping both animals constituting 41.3 %. These species are kept generally based on personal preferences (86 %) whereas, 8% and 5.7% of the respondents' choices of species are influenced by religion and culture respectively. Also, 62.3 % of the respondents kept other animals aside from small ruminants and pets, whereas, 21.4 % and 16.3 % of the respondents respectively, kept cattle and pets along with their small ruminants.

4.2.2 Husbandry Practices

As presented in Table 4.3, the study reveals that 76.3 % of the respondents have had no training in animal production, whereas 23.7% have had training in the trade. Furthermore, 72.5% of the respondents, provided housing for their animals whereas 27.5% had no housing facilities for their animals. Despite an overwhelming majority of 72.5% having housing facilities for their animals, 42% of the respondents, have their animals opened at all times, whilst 49.9% open their animals at time intervals. However, only 8.1% intensively house their animals. The study further reveals that 80.3% of the respondents have their animals freely grazing with supplementary feeding,

10.1% have their animals solely grazing without any supplementary feeding, whilst 9.7% do zero grazing of their animals. For animals drinking water, 77.1% of the respondents supplement the water requirement of their animals in addition to what they obtain from their free-ranging, 18.4% provide the full water requirement of their animals whereas 4.5% do not provide water at all, leaving the animals to search for their own sources of drinking water.

Table 4.2: Demographics of Respondents

Parameter	Category of Respondents	Percentage (%)
Sex	Males	93.1
	Females	6.9
Level of education	Basic	14
	Secondary	21.9
	Tertiary	13.8
	Non	50.3
Number of years keeping small ruminants	1 -3 years	21.2
	4 – 7 years	36.7
	8+	42.1
Type of small ruminant kept	Sheep	14.2
	Goat	44.5
	Both	41.3
Other animals kept	Cattle	21.4
	Pets	16.3
	Others	62.3

Source: Field Data 2024

Table 4.3: Animal husbandry practices

Parameter	Category of Respondents	Percentage (%)
Training on animal production	Yes	23.7
	No	76.3
Animal housing	Available	72.5
	Not available	27.5
How often animals are opened	At all time	42.0
	At time intervals	49.9
	Not at all	8.1
Mode of feeding animals	Roam in search	10.1
	Farmer provides	9.7
	Roam + provides	80.3
Mode of watering	Roam in search	4.5
	Farmer provides	18.4
	Roam + provides	77.1

Source: Field Data 2024

4.2.3 Knowledge of Mange

In the current study, 90.1 % of the respondents can recognize the disease mange whereas 9.9 % had no idea about the disease as shown in Table 4.4 below. Also, 67.2 % of the respondents have ever recorded mange in their flock whereas 32.8 % had never recorded the disease before. Of the 584 farmers who responded to the questionnaires, only 19.8 % have had some education on mange whereas 80.2 % have never had any form of education on mange.

Table 4.4: Knowledge of Mange

Parameter	Category of Respondent	Percentage (%)
Mange recognition	Can recognize	90.1
	Cannot recognize	9.9
Mange record	Recorded before	67.2
	Never recorded	32.8
Mange education	Educated on mange	19.8
	No education on mange	80.2

Source: Field Data 2024

4.2.4 Treatment of Mange

As shown in Table 4.5 below, the most popular treatment of choice among the respondents is ivermectin according to 79.2 % of the respondents whereas 15.5 % and 5.3 % respectively, prefer other treatments and acaricide. The other treatments include; dirty oil, neem oil extract,

Table 4.5: Treatment of Mange

Parameter	Category of Respondent	Percentage (%)
Choice of treatment for mange	Acaricide	5.3
	Ivermectin	79.2
	Other	15.5
Are there other effective but costly medications?	Yes	8.4
	No	91.6

Source: Field Data 2024

4.2.5 Effect of Education on Husbandry Practices

Of the 23.7 % of the respondents, who have had some training on animal production, 35.2 % of them have no formal education, 31.2 % have education up to tertiary level, with those with secondary and basic levels of education constituting 20%, and 13.6% respectively, as shown in table 4.6. Of the 76.3% who have not had any training on animal production, 55.4% have no formal education, 21.4 % have secondary level education and 14% and 9.1% have basic and tertiary level education respectively.

Of the 72.5% of respondents who provided housing for their animals, 49% have no formal education, 22.1% have secondary level education, whilst 15.9% and 12.9% respectively have a tertiary and basic level of education. Of the 27.5% of respondents who did not provide housing for their animals, 55% have no formal education, 20.8% and 15.4% respectively have secondary and basic levels of education, with 8.7% having tertiary level education.

Of the 49.9% of respondents who open their animals at time intervals, 54.7% have no formal education, whilst those with basic, secondary, and tertiary levels of education constituted 15.6%, 15.9%, and 13.8 % respectively. Of the 42% whose animals are open all the time, 66.7% have no formal education, with 15.6%, 13.3%, and 4.4% having secondary, basic, and tertiary levels of education respectively. In the case of the 8.1% who practised zero grazing, 42.5% have no formal education, whereas, 30.1%, 16.4%, and 11.1% respectively have secondary, tertiary, and basic levels of education.

On feeding, out of the 80.3% who provide some feed in addition to what their animals scavenge for, 48.9% have no formal education, and 24.2%, 14%, and 12.9% respectively have secondary, tertiary, and basic education. Furthermore, 63.6% of the 10.1% whose animals solely survive on

scavenging have no formal education, whereas 16.3%, 10.9%, and 9.1% have basic, tertiary, and secondary levels of education respectively. Lastly, 49% of the 9.1% who practice zero grazing, have no formal education, with 19.6%, 17.6%, and 13.5% respectively having tertiary, basic, and secondary levels of education.

Of the 77.1% who provide water in addition to what their animals roam in search of, 51.8% have no formal education, 22.2% have secondary level education whilst 13.3% and 12.6% respectively have tertiary and basic level education. Also, of the 18.4% who provide the total water needs of their animals, 43% have no formal education, whilst 21, 19, and 17% respectively have basic, secondary, and tertiary levels of education. Finally, 70.8% of the 4.5% whose animals roam in search of their water requirement, have no formal education, whereas, those with secondary and tertiary level education constitute 12.5% each. Respondents with basic education in this category, however, constitute 4.2%.

Table 4.6: Effect of Education on husbandry practices:

Level of education	**Training on Animal production**		
	Yes *(n = 125)*	No *(n = 406)*	
Basic	13.6	14	
Secondary	20	21.4	
Tertiary	31.2	9.1	
Non	35.2	55.4	
	Provision of housing		
Basic	12.9	15.4	
Secondary	22.1	20.8	
Tertiary	15.9	8.7	
Non	49	55	
	Intervals of opening animals		
	at all time (n = 226)	at time intervals (n = 276)	not at all (n = 45)
Basic	11.1	15.6	13.3
Secondary	30.1	15.9	15.6
Tertiary	16.4	13.8	4.4
Non	42.5	54.7	66.7
	Mode of feeding animals		
	roam in search	I provide	roam + provide
Basic	16.3	17.6	12.9
Secondary	9.1	13.5	24.2
Tertiary	10.9	19.6	14
Non	63.6	49	48.9
	Mode of watering		
Basic	4.2	21	12.6
Secondary	12.5	19	22.2
Tertiary	12.5	17	13.3
Non	70.8	43	51.8

Source: Field Data 2024

CHAPTER FIVE
5.0 DISCUSSION OF RESULTS

This chapter discusses in details the results presented in chapter four above. The discussion also takes into consideration the trends and characteristics of the outcome of the study, subjecting them to critical analysis and possible implications. It also compares the outcome of the current study with similar studies undertaken in the past.

5.1 Objectives One and Two: Prevalence and Identification of Mange Mite

5.1.1 Prevalence of Mange in small ruminants

In the current study, the most popular small ruminant is goats, which constituted 59% of the animals screened compared to 41% of sheep. This result supports the 2017/2018 Ghana Census of Agriculture Report, which described goats as the most reared ruminant in Ghana. The preference for goats over sheep may be attributed to the ability of goats to thrive with very little investment and attention. According to Monteiro *et al*. (2017), the intelligence, agility, and independence of goats, coupled with their high level of resistance to diseases, puts them ahead of other ruminant species.

Prevalence may be defined as the component of a population that has a specific characteristic in a given time period (National Institute of Mental Health, 2023). In the current study, mange prevalence of 4.7% was recorded in sheep whereas 12.6% was recorded in goats. These figures are however, far higher than what was reported by Ogundiyi *et al* (2012) who found 0.08% in sheep and 0.53% in goats, with the indication that goats were 6.23 times more susceptible to the disease than sheep in Ogun State, Nigeria. Similarly, Pal *et al.* (2019), reported prevalence of 4.76% and 4.55% in goats and sheep respectively at Jimma town in Kenya. The results also affirm

the finding of Opoku-Agyemang *et al*. (2017) who reported an overall higher incidence of the disease in goats than in sheep. The results reveal the pervasiveness of the disease among small ruminants in the region. The results also suggest that poor husbandry practices such as inadequate housing among other factors employed by farmers, expose animals to infections. These infections in turn inflict great discomfort and skin lesions such as irritation, exudation, crusts, and scabs on the skin, thus, the current study brings to the fore, the peculiar consequences the study area stands to suffer if nothing is done about the disease. The importance of sheep and goats include the provision of manure, savings, insurance, farm portfolio diversification, and strong social relations (Adams *et al*., 2021).

In the current study, three administrative districts namely Karaga, Nanumba North, and Sagnerigu municipality recorded zero prevalence of mange in sheep. In these same districts however, the prevalence of mange in goats were 6.3%, 12.0%, and 0.52% respectively. In the current study, the population of the screened sheep in some districts such as the Nanumba North was very limited, probably contributing to the zero-prevalence recorded. Alternatively, better husbandry practices compared to what was given to goats, such as housing and supplementary feeding could be the reason for the zero prevalence. The study reveals a comparatively low general prevalence among sheep than in goats which could be attributed to the less susceptibility of sheep to the disease. This is affirmed by Seid *et al*. (2016), who reported prevalence of 7.5% and 1.2% in goats and sheep respectively in the Amhara region of Ethiopia. It also supports the finding of Ali *et al*. (2021) who reported prevalence of 1.51% and 0.42% in goats and sheep respectively in the Malakand division of Pakistan. In sharp contrast, however, Mohammed *et al* (2020) recorded a higher prevalence in sheep (24.5%) compared to (23.33%) in goats. In goats, four districts recorded prevalence above

the average prevalence (17%) in the study area ranging between 30.5% to 14.3%. This affirms the severity of the disease in goats across the study area.

5.1.2 Microscopic Identification of Mange Species

Even though *Demodex ghanensis* was first isolated from the eyelid of two breeds of Ghanaian cattle (Oppong *et al*., 1975), the current study, identified mite species from two genera of mites namely, *Sarcoptes and Psoroptes.* Thus, two of the four important genera of mites; *Demodex, Sarcoptes, Chorioptes*, and *Psoroptes* were associated with mange cases in sheep and goats. The result supports the findings of Opoku-Agyemang *et al*. (2017) who reported *Sarcoptes* species in sheep and *Demodex folliculorum* in goats in the Ejisujuaben municipality of the Ashanti region. This is inspite of the Ejisujuaben municipality being a forest area unlike the Northern region where the present study was conducted. In Nigeria however, Ogundiyi *et al*. (2012) reported only *Sarcoptes* mite species namely, *S. scabiei var. ovis* and *S. scabiei var. caprae* in sheep and goats, respectively. In the Amhara State of Ethiopia, Demissie *et al*. (2000) reported that, 87% of mange cases in sheep and goats are caused by *Sarcoptes* species, a result that affirms the outcome of the present study. Pal *et al*. (2019), also identified *Sarcoptes* and *Demodex* in sheep and goats in Southwest Ethiopia. Fesseha *et al*. (2021), reported *Demodex*, *Psoroptes*, and *Sarcoptes* Species in goats in Southern Ethiopia. In all these previous studies however, *Sarcoptes* species run through the results just like the present study. However, the current study shows that *Sarcoptes* species are more common in goats than *Psoroptes* species. Prevalence of mange mites is influenced by a number of factors including ecological factors and climatic conditions as revealed by the findings of Fesseha *et al*. (2022). These could therefore account for some of the variations in the outcomes of the previous studies and the current study as there are differences in the agroecology of the study areas.

5.2 Objective Three: Knowledge, Attitude, and Practices of Farmers on mange

5.2.1 Demographics of the respondents

In the current study, males constituted 93.1% of the respondents as against 6.9% of females, exposing the dominance of men in the animal production space just like many areas of the economy, with very low participation of women. This result is quite different from the findings of Baah *et al*. (2012), who reported 67% males and 33% females in a similar study. The finding further deviates from that of Opoku-Agyemang *et al*. (2017) who reported a 60:40 ratio of men to women in the rearing of small ruminants in the Ejisujuabin municipality of the Ashanti Region. In both previous studies, however, men dominated women. This may be attributed to the burden of some management practices such as flock structure maintenance, recognition and management of ill health (Baah *et al*., 2012), as well as general routine practices involved in animal production. Furthermore, access to resources and ownership of property by women in some parts of the country including the study area is a major challenge due to some socio-cultural practices. In the Northern region, even though most rural households depend on agriculture based-livelihoods, women's access to resources for farming is limited (Adam, 2020). In typical African homes where the man is the head, the property of women including animals if any at all, may be considered under the custody of the man and hence counted as part of his possessions. For example, N-yanbini and Owusu-Ansah (2024) explained that, in Northern Ghana, under which the study area falls, decisions relating to land are largely made by men leaving women with less or no options at.

Education plays a pivotal role in the success of individuals as it helps the person to think, feel and behave in ways that help achieve their objectives. However, about half of the respondents in the current study, have no formal education, a factor that can slow the necessary growth of the sector. This is however not quite different from the findings of Baah *et al*., (2012) who reported 43% of

participants with no formal education. These findings imply that about half the farmers may not be able to self-access information including write-ups on disease updates, treatment, and other disease prevention and control measures since they cannot read.

Whilst education is very important in every facet of life, combining it with hands-on experience is even better. Moreover, hands-on experience is gained over a period of time as one practices the act of feeding, disease recognition, and changes that may call for immediate attention in livestock. Therefore, about 79 % of the respondents keeping small ruminants for over 4 years is a good source of experience for them to be able to manage their animals well.

In the current study, the ratio of people keeping goats to sheep was about 3:1 with close to about the same proportion keeping both animals. The preference for goats as against sheep is their hardiness and their ability to thrive under minimal attention compared to sheep (Baah *et al.*, 2012). Goats are also very prolific and can comparatively multiply within a short period. For those who keep both animals, the advantages offered by goats may compensate for any challenges that may come with sheep thereby producing a synergistic result.

5.2.2 Husbandry practices

Whilst experience is good for every trade, training is an important tool that can be used to improve productivity. However, the majority of the respondents (76.3 %) have had no training of any form in animal production. The mandate of agricultural extension authorities includes education of farmers on new technologies, pests, and diseases, as well as ways of improving and maximizing production. However, agricultural extension services in Ghana are saddled with challenges such

as lack of appropriate extension materials, inadequate funding and staffing sometimes making their accessibility to farmers difficult in some communities (Antwi-Agyei and Stringer, 2021)

On housing, the majority of the respondents (72.5%) have housing facilities for their animals, these include animals who only come to spend the night and go out during the day and those that are not allowed to go out at all. However, 27.5% of the respondents not having housing at all for their animals could be a source of disease transmission among animals in contact. This does not, however, negate the traditional free-range system of keeping small ruminants which according to Adams *et al*. (2021) is economically viable if placed in the correct perspective

This notwithstanding, 42 % of the respondents rarely keep their animals in their pens at any time including the night. Typically, such farmers may not have trained their animals to get used to their pens even though available, hence they roam and spend the night anywhere they find themselves. This exposes the animals to all kinds of predation and adverse weather conditions, as well as diseases. Unlike sheep, goats will typically locate their pens or some shelter when it is raining to avoid being wet.

The profitability of small ruminant production can be increased with adequate feeding as cited by Duku *et al*. (2010), however, livestock feeding remains a major challenge in Ghana. In the current study, the results affirm the typical semi-intensive system of keeping livestock which is dominant in Ghana, with an overwhelming majority (80.1 %) of the respondents, providing some feed to their animals, whilst the animals roam in search of the remains. This kind of situation may, however, not necessarily address the nutrient needs of the animals, leading to their poor performance. Baah *et al.* (2012) avered that the main sources of feeding livestock include agro-

industrial by-products, household waste from food preparation, and forages from vast lands publicly or privately owned.

The importance of water to animals includes thermo-regulation, lubrication, medium for chemical reactions, digestion, absorption, milk production, cushion, and mineral balance among other things as cited by Wakchaure *et al*. (2015). Again, typical of the semi-intensive system, the majority of the farmers provide some volume of water in addition to what the animals roam in search of.

5.2.3 Knowledge of Mange

Disease control begins with the ability to recognize its occurrence. Therefore, the majority of the respondents being able to recognize the disease is a good start for its control effort. However, 10% of the respondents were unable to recognize the disease could impede any control effort especially when most of the farmers release their animals at a particular time.

The results affirm mange as a common occurring diseases in small ruminants in Ghana, with 67.2 % of the respondents recording the disease in their flock. This also implies that the majority of the respondents may have experienced the effect of the disease, as well as various ways of handling the disease which can be useful.

Mange in small ruminants is one of the problems in local animal production characterized by a culture of the unwillingness of the farmer to seek proper treatment from appropriate authorities (Opoku-Agyemang *et al*., 2017), probably due to a lack of proper education on the disease. In the current study, however, the majority of the respondents may be lacking this education, since about 80 % of them have never had any education on the disease. According to Demissie *et al*. (2000), although farmers appreciate the serious challenges posed by mange, they still underestimate the importance of the disease. This emphasizes the importance of education on the disease and the

consequences of not being adequately educated on it. Mange like many diseases may present some signs similar to other diseases, which may require some technical expertise to differentiate. Also, some background information including the epidemiology, appropriate response upon suspicion of the disease as well as other general prevention and control measures which could be useful in the fight against the disease, can largely be disseminated through education or training.

5.2.4 Treatment of Mange

In the present study, the majority of the respondents found ivermectin effective in the treatment of mange, however, this presents a risk of abuse of the drug, as most of them use it without consulting a veterinarian due to ease of access. Espinosa *et al*. (2020) avered that antiparasitic drug abuse can affect parasite–host interaction. When anti-parasitic drugs are continuously used, they interfere with the host immune system due to inadequate available parasitic antigens to drive efficient and protective stimulation as cited by Espinosa *et al.* (2020). In the present study, a quarter of the respondents used treatments other than ivermectin and acaricides. These other treatments often used by farmers include; smearing used motor oil (dirty oil) on affected surfaces on animals and the use of neem seed oil extract on affected animals. However, used motor oil contains toxic chemicals and heavy metals (USEPA, 2022) which can leach into the tissues of the animals on which it is applied and eventually end in the meat of food animals. Neem products on the other hand are known for their bitterness, which residues can in the long term accumulate in the tissues of food animals, rendering the meat undesirable. The results also show that the use of topical acaricides for the control of mange is not very popular as only 5% of the respondents resorted to its usage. Acaricides are chemicals with a cidal effect on organisms of the acarine group. Popular acaricides used topically include; *chlorinated hydrocarbons* such as *dichlorodiphenyltrichloroethane* (DDT), *organophosphorous* compounds (e.g., Diazinon),

carbamates (e.g., carbaryl), *pyrethroids* (e.g., permethrin and flumethrin), and *formamidines* (Nicholson *et al.,* 2019).

5.2.5 Effect of Education on husbandry practices

The role of extension programmes in enhancing farm productivity cannot be over-emphasized (Danso-Abbeam *et al.*, 2018). This role includes; the transfer of technology, support for rural adult learning, and dissemination of agricultural knowledge and information, through pieces of training in specific subject matter areas (Danso-Abbeam *et al.*, 2018). The current study reveals that the proportion of respondents with no formal education constituted the highest among farmers without any formal training in animal production. The inability of people with no formal education often to read and write sometimes serves as a barrier to their participation in formal pieces of training. Also, the educated categories may likely have had some stints with agriculture science in the classroom during which some animal husbandry lessons may have been acquired. In Ghana, however, the study of agriculture in schools now has been made optional.

Shelter is a basic need of all living things, which should better be explained by people with education. In the current study, the educated categories collectively constituted 51% of the 72.5% who provided housing for their animals. This proportion is higher considering that the non-educated category of respondents is a little over half of the total respondents. On the other hand, the non-educated category constituted 55% of the 27.5% who do not have housing for their animals.

CHAPTER SIX

6.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Findings

The present study provides data on the status of mange in small ruminants, the species causing the disease, as well as its distribution in the Northern region of Ghana. The study also ascertained the knowledge of farmers, as well as their prAactices and attitudes which predispose animals to the disease.

The study revealed that mange is a problem of small ruminant production (especially goats) in the Northern region of Ghana causing severe damage to the skin of infected animals and reducing their value, thereby reducing the economic fortunes of farmers.

The overall prevalence of the disease among small ruminants in the Northern region of Ghana, is 9.4%, with 4.7% and 12.6% in sheep and goats respectively. The disease is also, more common and severe in goats than in sheep. The most dominant mange causing species in the study area is *Sarcoptes* mite accounting for over 90% of the infections in goats with about 9% mixed infections comprising both *Sarcoptes* and *Psoroptes*. In sheep, however, only *Sarcoptes* species were isolated.

The study also revealed that, despite the lack of formal training of the majority of farmers on animal husbandry and diseases, farmers largely have the ability to recognize and diagnose mange by themselves due to its frequent occurrence among their animals. However, socio-cultural practices such as lack of education, unequal gender participation in farming, and attitudes and practices of farmers such as poor husbandry practices including inadequate housing, inadequate provision of feed and water among others are some of the factors that contribute to the spread of the disease or predisposes animals to mange infestation.

6.2 Conclusion

In conclusion, the prevalence of mange among small ruminants in the Northern region of Ghana is high, especially in goats, and this is exacerbated by the attitudes and practices of farmers such as poor husbandry practices including lack of housing facilities, inadequate feeding and watering among others, which puts the animals to risk of infections. Also, the species of mite causing mange in sheep and goats in the Northern Region of Ghana are *Sarcoptes* and *Psoroptes* species.

6.3 Recommendations

Having identified poor husbandry practices such as lack of housing and inadequate feed and water supply to animals by farmers, as a key factor of the spread of mange, there is the need for public education on the need for farmers to provide these basic necessities of life to their animals, and to have control over their movement. Veterinary authorities in the study area must therefore step up their efforts in reaching out to farmers, and other stakeholders to instill good husbandry practices and attitudes including periodic screening of animals and treatment, in the public.

Whilst the present study identified the species of mites causing mange in the study area, thereby providing some clue on the treatment and control options for the disease, a further study to ascertain their genetic variations is recommended.

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APPENDICES

Appendix I: Questionnaire

Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED)
Department of Biological Science

This is an academic exercise to investigate farmers knowledge and practices on mange in small ruminants, with respect to the identification of the disease, its control measures and preferred options of control in small ruminants. The exercise targets small ruminant farmers in the Northern region of Ghana. Your participation is very much appreciated, and your anonymity is assured.

Do you consent to take part in this research exercise? Yes [ ] No [ ]

Please fill in one response for each question by ticking (√) or writing briefly.

Part 1 (Respondents' bio-data) Sex……
Contact…… District……

Level of education	Basic		Secondary		Tertiary		Non	
Religion	Islam		Christianity		Traditional		Non	

A. Experience on animal rearing						
1. How long have you been rearing small ruminants?	1 – 3 yrs		4 – 7 yrs		8 yrs +	
2. Which small ruminant do you keep?	Sheep		Goat		Both	
3. Any reason for your preference in 2 above?	Religion		Culture		Personal preference	
4. What other animals do you keep?	Cattle		Pets		Others	
5. Have you had any training on animal rearing?	Yes		No			
B. System of livestock keeping/Husbandry practices						
6. Do you house your small ruminants?	Yes		No			
7. How often do you open them?	Opened at all times		Opened at time intervals		Not opened at all	
8. How do your small ruminants get feed?	Roam in search		I provide feed		Roam + I Provide	
9. How do they get drinking water?	Roam in search		I provide water		Roam in search + I provide	
C. Disease (mange) recognition/Knowledge on mange						

10. Do you know mange disease?	Yes		No			
11. Have you recorded mange in your animals before?	Yes		No			
12.What signs did the animal(s) show if you answered yes above?						
13.Have you had any education on mange/animal diseases?	Yes		No			
D. **Mange Control**						
14. What chemicals/medications for the treatment of mange do you know?	Acaricide/Spray		Ivermectin/injection		Other	
15. Specify if you chose other in (15) above						
16. Which treatment method do you prefer?						
17. Is your preference for the treatment method above influenced by cost?	Yes		No			
18. If yes, are there other methods which may be costly but effective than your choice?	Yes		No			
19. specify if you answered yes above.						
E. This section is for the researcher only						
Number of animals screened	Sheep		Number positive for mange	Sheep		
	Goat			Goat		

Appendix II: Letter of Approval

UNIVERSITY OF ENERGY AND NATURAL RESOURCES, SUNYANI
COMMITTEE FOR HUMAN RESEARCH AND ETHICS

P. O. Box 214, Sunyani www.uenr.edu.gh +233 (0) 352 290 386 chre@uenr.edu.gh

OUR REF.: CHRE/AP/195/024 **DATE:** April 10, 2024

Applicant:
Abdul Razak Mohammed Raji

Akenten Appiah -Menka University of Skills Training and Entrepreneurial Development,
Post Office Box 40,
Mampong – Ashanti.

Dear Applicant,

LETTER OF APPROVAL

Protocol Title: **Epidemiological Study of Mange in Small Ruminants in Northern Region of Ghana**
Proposed Site: Northern Region
Sponsor: Principal investigator

Your submission to the Committee for Human Research and Ethics on the above-named protocol refers. The Committee has considered the amendments made in response to the comments raised by the Committee for Human Research and Ethics and has approved the protocol.
The approval is for a fixed period of one year, beginning April 2024 to March 2025 renewable thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only and should adhere to the provision of the Ghana Data Protection Act, **Act 843 2012**. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data. The committee should be notified immediately in the event of any adverse effects on participants or of any unforeseen events that might affect continued ethical acceptability of the project.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever comes first. It should also be informed of any publication arising from the study.

Thank you for your application.
Yours faithfully,

Prof. Samuel Fosu Gyasi
Chairman