Biosecurity and animal husbandry in goat herds in Zambia and Sweden

– a comparative qualitative interview study

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Gry Martineau

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Abstract

In Zambia, goats have an as important role for the wellbeing of humans as humans have for the goats they care for. Infectious diseases are common and can have devastating effects for the animals and thereby their owners and all others that benefit from these goats. Improved animal husbandry and basic infection control measures could therefore be key for farmers of both small and large herds and help maintain and improve animal health and welfare.

Sweden is a rich country, in both an economical aspect as well as in educational level. The goat industry is small, most goat farmers are smallholder farmers and only a few farms of larger scales exist in the country. There are many laws that regulate how one should take care of one's animals and there are many seminars and lectures that farmers can attend to increase their knowledge and further improve their animal husbandry and thereby improve the productivity of their animals.

Based on the literature, quarantine routines for new or sick animals, stable hygiene, feed hygiene and parasite control are important areas to protect one's herd from infections. Maintaining a good general health in the herd by providing a correct diet, clean drinking water in sufficient amounts, shelter from the weathers and a stress-free environment are other important factors.

The aim of this study was to describe the animal husbandry in Zambia and Sweden; what is alike and what differs? How do farmers know what to do and how to manage their goats? Are there any lessons that can be learned and implemented in either country? Answers to these questions were sought by conducting semi-structured interviews with goat farmers from both countries.

Ten interviews with Zambian goat owners with farm size ranging between 7 and 35 goats, and five interviews with Swedish goat owners with between 8 and 64 animals took place over Zoom, Microsoft Teams and WhatsApp during October and November 2021. The interviews were recorded and then transcribed in English, the same day or shortly after. Themes in the answers were sought within these transcriptions.

The interviews indicated that the health situation of goats is better in Sweden, and it was less common for animals to die of infections than in Zambia. The general biosecurity appears higher than compared to Zambian goat farms, despite Zambian farmers having received goat specific training in higher extent than the Swedish farmers. The cause for the difference in biosecurity measures implemented is not clear, but the level of knowledge or difference in available funds and means might be conceivable reasons.

A similarity in the goat husbandry, however, is that farmers in both countries have apparent problems costs for veterinary care. In Sweden, the lack of goat specific knowledge amongst veterinarians was another factor for the reluctancy of contacting veterinarians and several farmers preferred conducting their own research, mainly by reading information online, when their goats fall ill.

Keywords: Biosecurity, animal health, animal husbandry, goat health, goat diseases, goat herding, Zambia, Sweden, qualitative research, farmers' perceptions.

Sammanfattning

I Zambia har getter en betydande roll för människors väl och ve, men samtidigt är människan väldigt viktig för getternas hälsa. Infektionssjukdomar är vanliga och påverkar getternas förmåga till produktion och därigenom påverkas alla de som har nytta av det getterna bidrar med. Mer kunskap inom djurhållning och smittskydd kan därför ha stor betydelse för både små som stora besättningar och kan bidra till att förbättra djurvälfärd och därigenom förbättra människors liv.

Sverige är ett förhållandevis rikt land, både när det gäller ekonomi och kunskapsläge. Getindustrin är dock väldigt liten och endast ett fåtal stora kommersiella besättningar finns. Djurhållning är strikt reglerad av lagar och regler och det finns många organisationer där medlemmar får kontinuerlig tillgång till nya råd och rön, samt ofta veterinärkonsultation.

Baserat på tillgänglig litteratur är karantänsrutiner för nyinköpta och sjuka djur, stallhygien, foderhygien och parasitkontroll viktiga områden för att skydda besättningen från infektioner. Likaså är det viktigt att bibehålla getternas generella hälsa genom att erbjuda en korrekt diet, rent dricksvatten i tillräcklig mängd, skydd från väder och vind samt en allmänt stressfri miljö i så stor utsträckning som möjligt.

Målet med denna studie var att beskriva hur gethållningen ser ut i Sverige och Zambia; vilka likheter och skillnader finns det? Hur vet getbönderna vad de ska göra och hur de ska hantera sina getter? Finns det lärdomar från ettdera landet som kan implementeras i det andra landet? För att besvara dessa frågor genomfördes semi-strukturerade intervjuer med getbönder från respektive land.

Tio intervjuer med zambiska getbönder med mellan 7 och 35 getter, och fem intervjuer med svenska getbönder med mellan 8 och 64 getter genomfördes via Zoom, WhatsApp eller Microsoft Teams under oktober och november år 2021. Intervjuerna spelades in och transkriberades på engelska snart efter att intervjuerna ägt rum. Olika teman bland de transkriberade svaren söktes.

Intervjuerna indikerade att den generella gethälsan är bättre i Sverige och det var ovanligare att djur dog på grund av infektionssjukdomar än i Zambia. Biosäkerhetsrutiner implementerades i högre grad i de svenska besättningarna, trots att fler av de zambiska getbönderna hade fått getspecifik träning. Vad skillnaden i biosäkerhet beror på är sannolikt multifaktoriellt, men skillnader i kunskapsläge, tillgång till resurser eller något annat är tänkbara faktorer.

En likhet mellan gethållning i de två länderna är att getbönder i båda länder har problem med veterinärpriser. I Sverige lyftes även problematiken med veterinärers brist på getspecifik kunskap som en faktor till motviljan att kontakta veterinär. Flertalet av de svenska bönderna föredrog att själva leta efter information och svar (samt har resurser för att göra det) istället för att kontakta veterinärer när djuren insjuknar.

Nyckelord: Biosäkerhet, djurhälsa, djurhållning, gethållning, gethälsa, getsjukdomar, Zambia, Sverige, kvalitativ forskning, lantbrukarperspektiv.

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Abbreviations

AMR	Antimicrobial resistance
CAE	Caprine Arthritis and Encephalitis
CCPP	Caprine Contagious Pleuro-Pneumonia
CDC	Centers for Disease Control and Prevention
CNS	Central Nervous System
FAO	Food and Agriculture Organization of the United Nations
FHM	Folkhälsomyndigheten (The Public Health Agency of Sweden)
FMD	Foot and Mouth disease
GDH	Gård- och djurhälsan (Farm and Animal Health)
GDPR	General Data Protection Regulation
JV	Jordbruksverket (Swedish Board of Agriculture)
kg	Kilograms
MFL	Ministry of Fishery and Livestock in Zambia
NE	Nationalencyklopedien (The National Encyclopaedia)
OIE	Office International des Epizooties (The World Organization for Animal Health)
PPR	Peste de petits ruminants
PREM	Poverty Reduction and Economic Management Unit
RS-virus	Respiratory syncytial virus
SIANI	Swedish international agricultural network initiative
SSI	Semi-structured interview
SVA	Statens veterinärmedicinska anstalt (National Veterinary Institute)
TBP	The Borgen Project
TWB	The World Bank
UNDP	United Nations Development Programme
WHO	World Health Organization
WFP	World Food Programme

1. Introduction

Goats play an important role for the welfare and economy of many people around the world, especially in low to low-middle income countries like Zambia. Their ability to utilize nutrition from a wider range of plants than other livestock, their resistance to heat stress and water deprivation, as well as their disease resilience make them better equipped to survive in harsh conditions. This makes them perfect livestock to keep for sustaining a small household. They produce milk and wool, their faeces can be used as fertilizers for crops, they can be a source of meat and fast income when need arise and are therefore of great importance to many.

Goat mortality rates due to infectious disease are high in Africa, which has a great impact on smallholders' livelihoods, and disease causes a great decrease in animal productivity. Many diseases spreading in goat herds are also zoonotic, meaning they can affect humans as well. This coupled with the ever-growing demand of animal-based human food means that infectious diseases of goats can have devastating effects on health and well-being of millions of humans.

In Zambia, many smallholder farmers lack the necessary knowledge to maintain a healthy and highly productive herd. Veterinary services can be hard to access, and it is not always easy to do find science-based information regarding goats and goat diseases. More than this, many lack the necessary funds to invest in the goat husbandry required for optimal productivity in the herd. Further, the fact that food and water might be scarce for some parts of the year complicates matters more.

In Sweden the situation is different: poverty is less common and few to almost none are dependent on goat farming for their survival. Goats are often kept as pets or as a hobby and the few commercial herds focus mainly on milk production and cheese making. Goat meat is not a popular source of protein, most likely because of cultural habits rather than for any attributes of the meat. When it comes to animal welfare and disease control, there are strict laws that regulates how to keep and care for one's goats. Government resources go in to spreading information about biosecurity, animal welfare and health, and the government is obliged to make sure that veterinary services can be reached by everyone in the country.

By examining how goat husbandry looks like in both Zambia and Sweden, this author hopes of finding key elements for how to keep one's animals healthy, leading to improved well-being of both animals and humans.

The purpose of this study was to examine how goats are kept and cared with focus on biosecurity and infection control in Zambia and Sweden. This was done through interviews via video link or voice call with farmers from both countries.
The questions this study hoped to find answers to were:

1. How does the goat husbandry look in both countries?
2. What measures are taken to reduce sickness and prevent the spread of infections in goat herds?
3. How do the farmers in both countries know what to do and how to manage their goats?
4. Are there any measures or routines from one country that could be implemented to help improve the general health and wellbeing of goats in the other country?

2. Literature Review

2.1. Semi-structured interviews

Interviews are a kind of conversation where one of the parties are more or less in charge of the conversation (Gillham 2000). There are different kinds of interviews involving different levels of control, and the interviewer might steer the interview to varying degree depending on the information sought. For example: listening to other people's conversations are the most unstructured form of interview, whilst structured questionnaires with simple and closed questions are the most structured form. Semi-structured interviews (SSI) fall somewhere in the middle on this scale.

In research purposes the interviewer's goal is often about creating new knowledge and must therefore enter the stage with an open mind to not miss something of importance (Gillham 2000). By allowing the interviewee to steer the conversation it is often possible to make them feel heard to a greater extent and to find out what they find important. This might be achieved with open ended questions, allowing the interviewee to respond freely until they feel satisfied and then ask any potential complementing questions if there is something that needs to be further explored.

According to Gillham (2000) any interview should be set off with an introduction: a presentation of the interviewer, the project and the purpose of the interview, a clear idea of why this certain interviewee has been selected and a description of how the interview will be performed. This way everyone involved have a clear idea of what to expect and can feel more secure in the situation.

Gillham (2000) further states that the biggest advantage a SSI holds against a questionnaire is the richness of the answers one might receive, as well as the likelyhood of getting responses (it is far more likely that someone will respond to a question asked face to face rather than a question sent in writing). The greatest disadvantage is the time consumption and practicalities that need to be solved for it to work.

2.2. Description of the two countries and the importance of goats

2.2.1. Zambia

Zambia is a landlocked country in south central Africa and borders to eight other countries (Zambia Tourism 2021; Wikipedia 2021). The capital is Lusaka, located in the south-central part of the country. The Zambian population is concentrated mainly around Lusaka in the south and the Copperbelt Province in the north, as these are important economical hubs.

The climate is classified as humid subtropical or tropical wet and dry and the seasons are divided into cool dry season from May to August, hot and dry season from September to November and wet season from December to April (Zambia Tourism 2021). Average monthly temperatures rarely go below 20 degrees Celsius, however night frost can occur during the cool and dry season in places protected from the wind. An average of 1250 mm of rain falls in the north and approximately 750 mm in the south each year and almost only during the rainy season.

There are currently just under 18 million citizens in Zambia, almost 10 million of these live in rural areas and many of these have some kind of farming as primary source of income (FAO 2021; WFP 2021). According to The World Bank (2021), Zambia's population is rapidly growing and is estimated to be doubled in 25 years.

According to the organization World Food Programme (WFP) (2021), The World Bank (TWB) (2021) and The Borgen Project (TBP) (2017), more than half of Zambia's populations lives below the poverty line (an internationally established daily income of $1,90, calculated by the value of the goods needed to sustain an average adult), and approximately 42 percent are classified as extremely poor. Despite this, the country in large reached middle-income status in the year 2011. Poverty is at its worst in the rural parts of the country, where 83 percent live below the poverty line.

The climate changes, coupled with the ongoing pandemic of Covid-19, worsen the situation even more. Prolonged dry seasons, even higher temperatures and floods during the rainy season threatens the production of food. This hits hard on smallholder farmers, who are responsible for approximately 90% of Zambia's food production (Rushton *et al.* 2017; WFP 2021).

Rushton *et al.* (2017) states that family-based smallholder farming is the most common livestock system in sub-Saharan countries. They can often not invest much

into their farming, and so the output is also low. Many farmers also have a mixed practice, having different species of livestock as well as growing crops of different kinds, both for private and commercial use. They further explain that as the urbanization progresses and the population grows, the demand for animal based human food increases, leading to a need for more productive systems and denser animal populations in the herds.

Smallholders are often dependent on every single animal they have for their own survival, which makes animal health a major issue. Rushton *et al.* (2017) states that approximately 18% of the whole livestock population dies due to infectious diseases in low- and lower-middle income countries. Veterinarians can be too expensive to consult for many smallholder farmers, and living in remote areas, as many smallholder farmers do, can make veterinary services difficult to access. Many instead contact community animal health workers or pharmacists directly to get help, these however often lack in both supplies and knowledge and treatments might therefore not be adequate.

In 2019 approximately 3,5 million goats were estimated to live in the country (MFL 2019).

The role and importance of goats in Zambia

For most households in Zambia goats play an important role not only as a source of income, but also as a source of meat, milk, wool, and manure. The presence of goats in the household improves a family's status in the village, and they are often used for sociocultural purposes, such as for dowry payments (FAO 2019; Namonje-Kapembwa *et al.* 2016; Rushton *et al.* 2917; Seijan *et al.* 2017; UNDP 2021).

Goat meat is an important product in countries like Zambia (Hammarberg & Persson 2020). The relatively small size of the animals make them suited for meat production in parts of the world that lacks refrigerators or freezers, as the meat can be utilized before it gets bad. Meat and milk from goats are also rich in micro-nutrients, which are essential to maintain health and well-being (Rushton *et al.* 2017). It is estimated that 1-3 million deaths among children every year is due to the lack of micronutrients.

With their ability to utilize nutrition from lean pastures and a wide variety of plants the goat is the second most occurring livestock animal in Zambia among rural households (Namonje-Kapembwa *et al.* 2016). However, low productivity among the smallholder livestock farmers is a concern.

According to the Ministry of Fishery and Livestock (2019) most households had between 1-5 goats in 2018, a few households had over 30 goats and there where even fewer with more than 100 goats. Approximately 80% of Zambian livestock population belongs to smallholders, they create jobs and plays an important role for the fight against poverty. The livestock sector is largely underdeveloped and the funds it does receive is mostly directed towards cattle production. The production of goats in Zambia is associated with limited knowledge about husbandry and disease control, high mortality rates and low productivity (Namonje-Kapembwa *et al.* 2016).

Trading with goats is often informal and one of the ways that farmers can turn animals in to money, although there is no standardized system for trading, no formal rules or system of pricing (Lysholm *et al.* 2020) and the animals sold are rarely checked by veterinarians for health issues prior to the purchase (MFL 2019).

This informal form of trading is often done directly between farmer and customer, but it is not uncommon for there to be a trader who functions as a middleman and considerable number of animals are also sold and bought in markets (Lysholm *et al.* 2020). Animal markets often take place in more urban areas where animals from near and far are mixed. According to a field study by Lysholm *et al.* (2020) it is not rare for animals to exhibit signs of clinical disease in these markets; however, they are often not recognised as such by the traders. This increases the risk for disease transmission and farmers buying animals from these markets and the farmers trading like this have a high risk of bringing disease home to their own herd.

Goat husbandry in Zambia according to literature

About 60% of smallholder farmers in Zambia graze their animals on communal lands in the hot and dry season and many keep their goats tethered or in paddocks during rainy seasons as a method of keeping the goats from eating the crops grown in the fields during this time (MFL 2019; Mitternacht 2019). While grazing on communal lands, it is common for the goats of one herd to intermingle with those from another (Mitternacht 2019).

Goats in Zambia rarely receive any supplements to their feed, such as minerals, salt or concentrates (MFL 2019; Sejian *et al*. 2017). During the rainy season, grass contains high concentration of energy and nutrients, but as the grass gets dryer and dryer the nutrients are exchanged by fibres, which ultimately leads to feed with very low nutritional quality that does not meet the goat's needs for proteins, energy, and minerals. This in turn leads to decreased productivity in form of physical growth, reproductivity and survivability of kids.

Water for the animals is another challenge for Zambian goat farmers as it does not occur in abundance (Seijan *et al.* 2017). During the rainy seasons goats mostly cover their need for water by going to a nearby stream or ponds formed by the rain. This, as well as the intermingle on the communal pastures, presents a risk in form of the spread of infectious diseases between herds.

During the hot and dry season, the streams and ponds dry up and farmers often must take their animals across long distances to find water or transport water from communal wells or water tanks to the farm (MFL 2019). This is a heavy chore and seldomly suffices to cover the goats need for liquid. According to the Ministry of Fishery and Livestock (2019) many farmers rank the lack of a steady water supply as the number one biggest challenge they face with their herd.

Sheds and goat houses are often ventilated mostly by natural draft, which might not be adequate for removing environment heat, moisture, carbon dioxide, dust, gases from the digestive system, ammonium from urine and airborne infectious organisms to a necessary level (Sejian *et al.* 2017). Shade from the sun during daytime is mostly found under trees or bushes and the goats are seldomly kept inside during the peak of the sun.

2.2.2. Sweden

Sweden is a rather small country in northern Europe, it borders to 3 other countries and almost the entire east part of the country is coastal, as well as the most southern and south-eastern parts (National Geographic 2021; Swedish institute 2021). Large forests cover half of the country and over 100 000 lakes are spread out all over the land. In southern Sweden large fields of crops dominate the landscape and to the north and west mountains are most prominent. The most northern portion is above the Arctic Circle.

The Swedish climate has four seasons: summer, autumn, winter and spring (Swedish Institute 2021). In summer (June to August) temperatures range between 15 and 30 degrees Celsius, rain is common but serious draughts have happened (the last in 2018). In autumn (September to November) temperatures start to drop down closer to zero degrees Celsius and heavy rains and floods are common. Winter (December to February/March) is even colder, and snow is common, especially further north in the country. There daily temperatures range between 0 and -20 degrees during this season. In spring the temperatures start to rise again and ice and snow melts, which often creates flooding of streams and rivers.

The current population is just above 10 million people, which makes Sweden one of the least populated countries in Europe (SCB 2020). The population is mostly

concentrated to the south (National Geographic 2021; Swedish institute 2021). By global standards, absolute poverty does not exist in Sweden. The national definition of poverty is based upon being able to afford, not only absolute necessities, but also four of the following six components: "unforeseen expenses, a week's holiday per year, a meal with meat or fish every other day, satisfactory heating and housing, capital goods and bills." (TBP 2020). By these standards 17.1 percent of the population lived in poverty or in risk of poverty in 2019 (SCB 2020; TBP 2020).

According to the Swedish Board of Agriculture there were 20 000 goats in the country in the year 2018, divided on approximately 2400 owners of whom 60 % had some kind of financial business involving the goats (JV 2019c). Only 2 % of goat farmers in Sweden owned 50 goats or more at that time.

The role and importance of goats in Sweden

Goats do not play an equally important role in Sweden as in Zambia or many other low- and middle-income countries (Hammarberg & Persson 2020). In the 1800s there were almost no goats in the country and in the 1960s there were only about 3000 goats in Sweden. Their numbers have increased for the last decades and there are approximately 20 000 goats now, divided on approximately 2400 owners (JV 2019a). There are no complete registers for goat farms in Sweden, but in 2015, 140 goat milk farms were estimated to exist in Sweden. Only about 60 of these are registered as food producing for commercial purposes.

Milk production and cheesemaking are the main usage areas for Swedish goats, but their skin is also used for leather and their eating preferences makes them useful for keeping away small trees and bushes (JV 2019a; NE 2021; SVA 2021). Their social demeanour makes them appreciated as pets and according to an investigation by the Swedish Board of Agriculture approximately 40% of goats in Sweden are kept as a hobby (JV 2019a).

Goat meat is not a popular source of protein for native Swedes, possibly due to cultural heritage rather than any fault of the meat (Hammarberg & Persson 2020; NE 2021). However, the popularity of goat meat is increasing, and meat is often sold directly to consumers via farm shops or web shops but also sometimes to restaurants.

The relatively slow growth of goats (compared to sheep) makes meat production unsuitable as a main purpose for the goats in a financial business (Johnsson 2015). Male kids are often in surplus and are mostly euthanised and the carcass is discarded. A survey study by Bandt (2009) indicated that the cost for raising kids compared to what farmers can earn from the meat, as well as long transportation

route to the slaughterhouse are important factors for this. According to statistics report 2019:01 from The Swedish Board of Agriculture, several slaughterhouses in Sweden do not even accept goats for slaughter, which of course complicates the situation for the farmers further.

Goat husbandry in Sweden according to literature

Animal husbandry is highly regulated in Sweden, with the Swedish Board of Agriculture as the closest governing authority (JV 2021c). They make rules for how stables and enclosures must be built – all the way from size of the pen to ventilation systems and noise control. They also govern the minimal amount of time spent outside for the animals, how much feed and water the animals must have access to and all other aspects that affects the wellbeing and health of animals in the country, for example when related to hygiene and management of disease. These rules are all made in consultation with veterinarians and animal behaviour experts to ensure good animal welfare.

Other than the Swedish Board of Agriculture, there are also several organizations that provides advice and services regarding, for example, health and biosecurity. They also provide education and training, as well as continuously distributes updates on the latest research regarding goat farming (GDH 2021).

During the summer, goats are often moved between pastures where they spend all or most of their days. By Swedish law, goats are to be kept outside on pasture for large parts of the day during the period 1 May to 15 October, unless extreme weathers or other conditions make this a risk for the welfare of the animals (JV 2021c).

Goats in Sweden are often kept in stables during the winter, often with free access to outdoor paddocks or enclosures. The floor is often covered with straw or wood shavings as a deep litter bed and when one layer gets dirty a new layer is added (JV 2021c). This provides a dry and soft layer for them to lay and walk on and provides extra warmth as the bacteria in the underlaying straw metabolises faeces and urine (Källström 2008). When the goats are released to summer pastures, the stable is usually emptied using manual labour or with the help of machines, and sometimes washed with high pressure water. Cleaning of the stables are required by law at least once a year (SJVFS 2019:22).

By law, farmers are also required to have sufficient knowledge and proficiency about goats and goat husbandry to keep goats (SJVFS 2019:22). The goats should get daily supervision, during which the farmers should be able to detect signs of disease and take action against it. The law also states that sick or injured animal, as

well as animals close to parturition, should be separated from the rest of the herd. It is however not recommended to separate animals from the herd completely unless entirely necessary for the health and wellbeing of the rest of the herd (e.g., in case of a contagious disease), due to increased stress levels in the goat who gets separated (Hammarberg 2015).

Other than grazing in the summer or being fed with hay and branches, goat farmers are recommended (and sometimes obligated) to provide concentrates (often different kinds of grains and/or peas with higher protein levels than roughage), salt and minerals to their goats (SJVFS 2019:22). This helps the animals maintain energy levels and an effective immune system, even when the animal is in peak lactation or in late gestation. Extra supplements of selenium during the end of the gestation period are recommended (Hammarberg & Persson 2020).

2.3. Goats: a description

Goats are originally mountain living animals which is reflected by their agility, climbing skills and the shape of their hoofs (Hammarberg & Persson 2020). The weight of an adult goat normally ranges between 50 to 100 kg depending on breed, access to food and other factors. They are curious and social animals and enjoy exploring their surroundings and this combined with their ability to climb can make it difficult to build a fence that keeps them in. In each herd there is a strong hierarchy, and they can often be considered more aggressive against their own kind than sheep or cattle. If the herd feels threatened, they will line up in a defensive line, rather than flee.

Goats exist all over the world, currently the highest number of domestic goats can be found in developing countries (Hammarberg & Persson 2020). This is likely due to their ability to utilize a wider variety of plants for food and that they generally do not need as much resources as other livestock, such as cattle, to thrive.

2.3.1. Diet and nutritional needs

Goats are ruminants, and when allowed to choose freely, leaves from bushes and small trees make up approximately 60% of their diet, the rest is a mix of herbs and grass (Spörndly & Glimskär 2018). Apart from this, goats are also known to eat bark from trees, buds, and small branches.

Goats often eat their food in head height or higher and they often stand on their hind legs to eat and can even climb to reach good food (Hammarberg & Persson 2020; Sanon *et al*. 2007). This is a trait that helps them resist internal parasites as they

rarely graze near their own faeces. Because of that, they have a rather poor internal defence against such infections. The high speed of their bowel movement also makes them less sensitive to toxins compared to other ruminants (Hoste *et al.* 2011), this also means they metabolize medicines faster, and therefore often require higher dosages than other ruminants, for example of deworming drugs (Hammarberg 2015b).

Minerals are important in many physiological functions related to growth, reproduction and immune system (Mayasula *et al.* 2021). As the presence and availability of minerals in the goats feed can vary, mineral supplements can be important. According to Mayasula *et al.* (2021), the lack of trace minerals (like zinc and copper) in feed and fodder to livestock animals can cause a production drop of 20-30%.

2.3.2. Reproduction

Goats normally reach sexual maturity at an age of 5 months (Hammarberg & Persson 2020; Zambia Farmers Hub 2017). In Zambia, the goats' oestrus cycle is not dependent on the season and kids can be born continuously throughout the year. In Sweden, however, the reduction of daylight hours during the autumn triggers the doe to come into heat and goats in Sweden can reproduce until mid-winter. As the gestation period is 5 months, kids are normally born in early spring to late summer.

The first 48 hours post-partum the milk from the mother contains high levels of antibodies, this milk is usually referred to as colostrum. After this time the milk is rich in fat and protein, which gives the kids what they need to survive and grow. Unfortunately, some diseases, like CAE, can be transmitted in colostrum and milk, and therefore it is sometimes better not to let the kids suckle, but rather feed them with a bottle when the mother carries a known pathogen.

Physical health and body condition as well as the presence of a mature male and access to feed and water all impact on the heat period and the animal's capacity to get pregnant and maintain pregnancy until partum. This puts more weight on the importance of protecting one's herd from infections as it directly impacts their productive abilities.

2.3.3. Common breeds in Zambia and Sweden: similarities and differences.

According to Visser (2017), breeds native to South Africa are common in most southern African countries. However, the highest percentage of goats in these

countries are of no specific breed, but rather shaped by (and named after) the geographic regions in which they live. Examples include the Pedi, Nguni and Xhosa goats. Size, coat colour, length of ears and shape of horns are used to differentiate between them. Their body weight normally range between 40-50 kg, with low meat yields. They do however have a high reproductive ability, making them profitable in low-input farming. They also are more resilient than the Boer goat and needs less feed (Visser 2017).

The goat breed native to Scandinavia is a relatively small dairy breed, a fully grown goat usually weights between 50 and 75 kg (Hammarberg & Persson 2020). If cared for and fed properly, they can produce up to 10 litres of milk per day during peak lactation. The average milk production per goat per year in Sweden is somewhere around 700 litres, where the best farms have productions as high as almost 2000 litres per goat per year (Bonow 2017). This makes them superior to large cattle when it comes to milk production in relation to amount of feed.

The African dwarf goat can be found in both countries as well and has been showed to be trypanotolerant and to better resist infection by intestinal nematodes and insect borne diseases than any other goat breed, making them important especially in low and low-middle income countries (Chiejina & Bahnke 2011). The adult weight is approximately 20-30 kg, and they measure 40-50 cm at withers (Bosso *et al.* 2007). In Africa, this breed is used mainly for meat, despite their rather small physique, possibly due to their high fertility and reproductive ability.

The Boer goat, that can be found Zambia as well as Sweden (although in low numbers), is a goat breed that focuses on meat production rather than milk (Hammarberg & Persson 2020). They have a higher growth rate and good muscle composition already as kids. Adults can reach a weight up to 100 kg. They can be in heat all year round and farmers can therefore adapt the supply of goat meat to when they expect there to be a demand for it.

The Angora goat is also present in both countries (Hammarberg & Persson 2020; Visser 2017). In Sweden it is mainly used for its wool (mohair), as it has very fine fibres and lustre that sheep wool lacks. Under the right circumstances a good goat can produce between 5-10 kg of wool per year. Their body size is smaller than the Scandinavian breed and they rarely gets as big as 50 kg.

2.4. Biosecurity: keeping one's goats healthy

Delabbio (2006) defines biosecurity as "any practices, policies, or procedures employed on a farm to prevent and/or control disease entering onto the farm or moving around the farm.".

Salisi *et al.* (2012), conducted an experiment in goat herd in Malaysia, which showed that improper management routines and lack of bio security is a major source of production loss, and the implementation of a herd health programme can help increase the goats body weight and improve general health as well as decrease the mortality rate.

2.4.1. Prevent transmission between animals

Hammarberg & Persson (2020) describes the importance of the correct use of quarantine as a way of preventing the introduction of new diseases to one's herd. The risk of introducing an illness is highest when a new animal is to be brought into the herd, or when animals are allowed to interact with those of other herds. The animals carrying the pathogen might not be affected, but a naïve herd might fall badly ill from the introduced disease.

By placing newly bought animals in quarantine, separate from the rest of the herd, but preferably with an animal with less individual value, for a recommended period of at least three weeks, one can largely prevent the introduction of new pathogens (Hammarberg & Persson 2020). During these weeks, the animal coupled with the newcomer would start to exhibit symptoms for most infectious diseases if the new animal carried any contagious pathogens or vice versa. If the new animal, and any animals it might have been coupled with, remains healthy, it is then relatively safe (infection-wise) to release it into one's herd. If not, the farmer can choose whether to try and treat the new animal or euthanise/slaughter it. During quarantine it can also be appropriate to test the new animals for, and treat against, parasites, both endo – and ectoparasites, as well as hoof related issues.

The risk of disease spreading in a herd is influenced by, among other things, the herd size, pen size and the group division (SVA 2021c). Age sectioning can help protect young kids from pathogens present in groups with older animals, and by always tending to the goats in order most sensitive to least sensitive (for example, start by tending to the youngest and take the adult goats last). If there are sick goats in a separate area, tending to these goats last can help decrease the risk of bringing the pathogen to the rest of the herd.

The hygiene of the people who interact with the animals, as well as the tools and equipment used amongst them, also play a crucial part in infection control as pathogens can travel with these from one animal to another or one herd to another (Hammarberg 2015). Therefore, it is important to use clean clothes, shoes, and tools, as well as carefully washing one's hands between handling other animals other than one's own, or after handling animals in quarantine.

2.4.2. Prevent infection from environment

Hygiene of the stables and enclosures is also vital. By keeping the floors/ground dry and clean, many of the hoof related illnesses can be prevented. It also helps preventing bacterial infection in the udders of lactating goats (Waldemarsson 2021; JV 2021c; Fischer *et al.* 2020).

A deep litter bed has the advantage of providing a soft place to lay, not needing to be cleaned out very often (by law at least once a year) as well as provide an additional heat source for the goats due to bacterial metabolism (the bed "burns") (Källström 2008). When choosing bedding material for a deep litter bed, it is important to take the materials' water absorbing ability into account as a bed that is too wet will not burn adequately, and thus not produce heat as it is supposed to, if it gets too wet. Straw is better than wood shavings in this aspect, but peat is even better.

Having a raised floor, with gaps in between the floorboards which allows faeces and urine to pass, is another solution (Källström 2008). It provides a hard, but dry substratum for the goats and allows for gathering of the refuse.

Proper ventilation is also important when animals spend a lot of time indoors, as the build-up of ammonium, dust and pathogens can otherwise have a negative impact on the health of the goats (SVA 2021c).

Infections with intestinal parasites is very common in the goat population all over the world (Ahmad *et al.* 2021; Torres-Acosta & Hoste 2008). The use of anthelmintic drugs is a common strategy for protecting one's herd but increasing resistance to this kind of medication in the nematode population makes it vital to complement drugs with other methods. According to Ahmad *et al.* (2021), breaking the parasites life cycle is the main goal in all parasite control measures, and apart from drugs, regularly changing to clean pastures can help reduce the goats contact with parasites in their infective states and thereby reduce the risk of infection.

The same goes for the use of antimicrobial drugs, and more frequent use of these kinds of medicines increases the risk of antimicrobial resistance (AMR) (Rushton

et al. 2017). This is a global issue as it not only poses a threat in the livestock industry, but in human medicine as well (FHM 2021). By improving animal husbandry in ways that prevent disease from entering one's herd, the use of antimicrobial drugs, and the risk for AMR, is reduced.

2.4.3. Helping the goats immune defence

The stress hormone cortisol has been shown to affects the immune system negatively (Caroprese *et al.* 2015), and all actions to reduce stress in one's herd can therefore help improve the health and resistance of the goats in it.

Animals of higher rank in the hierarchy will have first access to the best feed, the most comfortable and safe sleeping spots and will be the first in line to get milked in milk producing herd (Alvarez *et al.* 2009; Aschwanden *et al.* 2008). To reduce stress in the herd, it is important to make sure all animals have access to feed, water, shelter and a dry place to sleep – even the lowest ranking goats (Miranda-de la Lama & Mattiello 2010).

Providing a fibre-rich feed to goats is a good way of preventing gastro-intestinal disturbance, a completely grass-based diet increases the risk of acidosis, diarrhoea, overgrowth of bacteria, such as those of the *Clostridium* spp. and *Listeria* spp. - as it is easier for the bacteria in the rumen to access the sugars from grass than from more fibre rich feed (Hammarberg & Persson 2020).

Other than roughage and branches, goats also require a number of supplements to their diets in order to reach optimal growth, health, and production (Hammarberg & Persson 2020). The mineral content of the Zambian soils is, for this author, unknown, but a study performed by Ogebe *et al.* (1996) showed that West African dwarf goats that were supplemented with minerals in their drinking water improved their health, compared to goats that had not received any supplements. Dissolving the minerals in the drinking water was also shown to be the most effective way of ensuring the goats ingested them in high enough quantities.

In a review article by Caroprese *et al.* (2015), different supplements and their impact on the immune defence are discussed. For example: giving fish oil to pregnant dairy goats have been shown to have positive effects on the cell-mediated immune defence, as well as the number of plasma lymphocytes, and reduced feed-energy availability late in the pregnancy is a risk factor for post-partum metritis and mastitis. Linseed is rich in poly-unsaturated fatty acids, which have been shown to enhance production of antibodies to *Salmonella* spp. that cause abortions in late gestation in sheep.

Goats are more well adapted to water stress than sheep, because of their lower turnover rate, although there is big variation in how well different goat breeds can handle a lack of liquid (Semaida *et al.* 2021; Sejian *et al*. 2017). Although goats can handle being without water better than many other types of livestock, a shortage of water will lead to decreased intake of feed and milk production declines, as well as physical growth and resistance against infections. Further on, the water provided for the goats must maintain good quality and cleanness, as many infectious pathogens can spread via faecal contamination.

Many goats have horns, which they use as weapons for defence or in fights with rivals (Alvarez *et al.* 2009). As goats often are kept in much smaller spaces than in the wild, fights for resources might increase in both numbers and in aggressiveness (Aschwanden *et al.* 2008). Horns can cause great damage to soft tissues of both pen mates and the humans who tend to the goats and can thereby lead to increased stress levels in the herd. By removing the horns when the animals are young, the stress levels in the stables can be reduced significantly and the milk yields increased (Alvarez *et al.* 2009; Hammarberg & Persson 2020).

Because goats dislike rain more than other livestock, another stress reducing measure is to make sure the goats have some kind of shelter from the weathers, or the stress and discomfort of standing in the rain can impact on the production, physical growth, as well as their general health negatively (Stachowicz *et al.* 2019). A shelter also provides shade, which can be vital to reduce heat stress.

Vaccination can be another measure to help improve the general health of the herd (Arrieta-Villegas *et al.* 2020; De Cremoux *et al.* 2012; Michael *et al.* 2021; Jo *et al.* 2014). It allows for immunization and the development of antibodies against diseases, providing protection at an earlier stage of life, thereby improving the physical growth of kids and general health in the herd (Smith & Sherman, 2009).

2.4.4. Surveillance and control

Since goats store their fat in the abdominal cavity instead of subcutaneously, it can be difficult to correctly assess whether they are being fed enough or have recently thinned out due to disease (Hammarberg & Persson 2020). Their role in nature as prey has made them hide signs of disease and pain as much as they can, so when it is discovered that the animal is sick the disease has often progressed too far, making it impossible to treat it. This makes thorough daily checks of one's goats vital to allow early detection, and thereby early treatment – which might make the difference between life and death (SVA 2021c).

Regular faecal samples can be a helpful way of monitoring the prevalence of intestinal parasites as well as determine the cause of diarrhoea – and the treatment for it (Salisi 2012). With advantage, one can implement the routine of analysing the goats faeces, and possibly deworm (only if necessary), before putting the goats on a clean pasture (as described above).

Shahudin *et al.* (2018) emphasizes the importance of veterinarians as advisors to optimize production and decrease the cost of running the farm, more than just treat sick animals. By including a veterinarian early on, Shahudin *et al.* (2018) believes farmers can improve the general health and well-being of the animals, leading to lower costs and economic losses due to diseases.

2.5. Some important infectious goat diseases described in literature

According to Rushton *et al.* (2017), approximately 18% of livestock in Africa dies of infectious disease each year. According to a study by Taylor *et al.* (2001) 61% of emerging human infectious diseases derive from animals – so called zoonoses. Most of these, 97%, have their main reservoir in the animal population. According to this study, helminthic infections were overrepresented amongst zoonoses.

According to the National Veterinary Institute (SVA) the current health status of goats in Sweden is generally good (SVA 2021a). Intestinal and external parasites, feed-related diseases and mastitis occur and impact the goats negatively, as well as the farmer financially. But thanks to strictly regulated import rules, husbandry laws and control and eradication programmes, as well as extensive information campaigns, Sweden is free of many of the most severe infectious diseases in the goat population (JV 2021b; SVA 2021a).

2.5.1. Gastrointestinal diseases

Diarrhoea is rather common in goat herds all over the world and can have both feed-related as well as infectious causes (Hammarberg & Persson 2020; Fischer *et al.* 2020; SVA 2021b). Acidosis is caused by a diet with too little fibre, mouldy hay, or bacterial overgrowth in the rumen due to a rapid change in feed or a much heavier intake of concentrates than normal. One very serious infectious reason for diarrhoea is overgrowth and toxin production of the bacteria *Clostridium perfringens.* Clostridiosis almost always leads to the death of the animal affected.

Internal parasites are also known for causing problems in goats all over the world (Ahmad *et al.* 2021). Liver flukes, or worms of the *Fasciola* genus, affects the liver

of ruminants in both Zambia and Sweden and can be a cause for stunted growth and decreased production in goat herds. Economic losses due to rejection of the infected liver and skinny cadavers make this an important parasite to goat farmers. The *Fasciola* parasites require a moist environment to spread, and seasonal fluctuations in prevalence is therefore common.

Haemonchus contortus is another, and one of the most harmful, helminths for both goats and other ruminants globally (Ahmad *et al.* 2021) and is the most harmful of the intestinal worms in Swedish goat herds (SVA 2021b). It is a blood sucking parasite that can be responsible for feticide, stunted growth, decreased productivity and death. It is sensitive to cold and therefore survives the Swedish winter inside of the animals, during warm and humid weather the parasite reproduces efficiently on the pastures (SVA 2021b).

Other harmful intestinal parasites that can cause severe diarrhoea in goats in both Zambia and Sweden, are coccidia, mainly *Eimeria ninakohlyakimovae,* and *Cryptosporidium parvum* (Salisi *et al.* 2012; Siddique *et al.* 2021). The parasites can also affect humans, mainly children up to five years of age, and according to Siddique *et al.* (2021) cryptosporidium related diarrhoea was reported to be the leading cause of child death in 2016 world-wide. The parasites spreads via oocysts (eggcells) in faeces, and faeces contaminated food and water. Infected does are the main source of infection for goat kids, and coccidiosis have been shown to lead to high mortality at weaning (Salisi *et al.* 2012).

Rift Valley fever, caused by a bunya virus, is present in Zambia but not Sweden (Dautu *et al.* 2012; FAO 2010; 2020; SVA 2021b). It spreads mainly with mosquitos and causes haemorrhagic diarrhoea and vomiting and has a high mortality rate (up to 95%) in young animals. Abortions is a common symptom for pregnant animals infected with the virus.

2.5.2. Tick borne diseases

Ticks can cause big problems in goat herds in both Zambia and Sweden, both directly, by feeding on the blood of the animal causing anaemia and by toxins in their saliva, as well as indirectly by transmitting infectious pathogens (tick borne diseases, TBD) (Naseer *et al.* 2021).

Heartwater, caused by the bacteria *Ehrlichia ruminantium,* is a TBD of great import to Zambian goat farmers (Naseer *et al.* 2021; Newhard *et al.* 2021). It is a disease that causes increased vascular permeability in many organs including the brain and heart, leading to fluid leakage and accumulation in body cavities. Newhard *et al.*

(2021) describes it as one of the most important diseases in African livestock production.

Other TBDs with a great importance for Zambian goat farmers are East Coast fever (ECF), caused by *Theileria parva*, babesiosis caused by *Babesia ovis* and anaplasmosis caused by the bacterium *A. marginale* (Ajith *et al.* 2017; Naseer *et al.* 2021; Simuunza *et al.* 2011). The ticks responsible can be found in the entire country, but the prevalence of the diseases in the ticks varies depending on the season and the region.

TBDs indigenous to Zambia affects nonindigenous breeds the most, as the native animals have a better immune defence against it. Non-indigenous breeds often have a higher productivity and is often kept for that reason, but since the TBDs affect them worse the ticks therefore pose a great threat to the livelihood of their owners (Simuunza *et al.* 2011).

One of these, which is important in Zambia and Sweden both, is anaplasmosis, caused by *Anaplasma phagocytophilum*. It is associated with high fever, reduced appetite and bowel movements, cough and difficulties breathing (SVA 2021b). Reduced physical growth in kids and reduced milk production in lactating goats can be seen, as well as an increased sensitivity to other infections due to a reduction in white blood cell count.

2.5.3. Respiratory diseases

The risk of pneumonia and coughing can be caused by both environmental factors, such as dust levels (often correlated to dry season or a high animal density and inadequate ventilation), as well as bacteria, viruses, and parasites (Hammarberg & Persson 2020; SVA 2021b).

Antibodies against the disease contagious caprine pleuro-pneumonia (CCPP) have been found in Zambian goats, however, the bacteria itself has not been found (Lysholm 2021). It is caused by a bacterium of the *Mycoplasma* species: *Mycoplasma capricolum* subsp. *capripneumoniae* (FAO 2010; Lysholm *et al.* 2020). Due to fluid and fibrous tissue in the lungs, the goats affected have a hard time breathing and oxygenating themselves and septicaemia and death occurs (SVA 2021b).

The intestinal parasite *Muellerius capillaris*, or nodular lungworm, cause cough in sheep and goats all over the world (López *et al.* 2017). Goats often get diffuse interstitial lesions in the lungs as a result of the immune system trying to get rid of the parasites. The severity of the reaction can vary from almost no lesions to severe

interstitial pneumonia. Infection of this parasite is also associated with increased risk of secondary bacterial infections.

In Sweden, different *Mycoplasma* species, *Mannheimia haemolytica, Pasteurella multocida, Bibersteinia trehalosi* and *Corynebacterium pseudotuberculosis* are common bacteria associated with diseases of the airways (Hammarberg & Persson 2020; SVA 2021b).

2.5.4. Udder diseases

Mastitis, or inflammation of the mammary gland, is another common problem, especially in milk producing herds (Hammarberg & Persson 2020; SVA 2021b). It is often caused by pathogens entering the udder via the milk canal in the teat shortly after milking.

Bacteria of the species *Staphylococcus* are common to find in the milk or udders of goats in Sweden, with or without the presence of clinical mastitis (Rosengren *et al.* 2010). The bacteria produces toxins which can lead to damage and inflammation in the tissue – causing clinical mastitis (Schelin *et al.* 2011).

Clinical mastitis is often painful for the goat, and cause fever, inappetence and decreased well-being in general for the individual affected (Järnberg 2013). This leads to decreased milk production and the milk produced is often not appropriate for consumption, neither by humans nor goat kids as they can also get sick from it.

Subclinical mastitis can be of great importance as well, as it can be harder to detect infection as the animals show no clinical symptoms – only changes in the milk can be seen (Järnberg 2013). This might result in a lack of biosecurity measures necessary to prevent the spread of the pathogen in the herd, and many animals might get affected.

Poor hygiene when milking, incorrect milking techniques, stress and unsatisfactory environmental hygiene are all factors associated with mastitis as the bacteria can spread from one goat to another via hands of farmers and milking equipment as well as the bedding in the stables (Hammarberg & Persson 2020; SVA 2021b).

2.5.5. Lameness

Lameness related to the hoofs can be due to mechanical, chemical, metabolic or infectious reasons (Waldemarsson 2021). Foot rot and contagious ovine digital dermatitis (CODD) are two hoof diseases caused by bacteria that occur (although rarely) in Sweden, the latter is not considered officially present in the country.

Overgrown hoofs or abnormal shape of the hoofs due to uneven wear are more common reasons for lameness. These in turn can cause damages in the hoofs which allows for bacteria to infect it.

Allowing the goats to walk in urine and faeces increases the risk of hoof related problems as the urine helps soften the hoof wall and many of the bacteria related to hoof diseases can be found in goat faeces (Waldemarsson 2021). *Fusobacterium necrophorum* is one and together with *Trueperella pyogenes* it can cause eczema due to irritation. If co-infection with *Dichelobacter (D.) nodosus* occurs, foot rot appears. The eczema can further develop to a more severe inflammation when *D. nodosus* reach deeper into the skin. This causes swelling, severe pain and often fever.

When affected by CODD the wall of the hoof gets weakened and in serious cases can cause the entire hoof capsule to detach from the foot (SVA 2021b). The bacterial species *Treponema* is believed to be involved in this disease. Only two confirmed cases have been reported in Sweden so far, and that was on sheep (Waldemarsson 2021).

2.5.6. Other diseases

Caprine arthritis and encephalitis (CAE) is a chronic infectious disease present all over the world, for which there is no treatment or cure (Schultz *et al.* 2020). Due to the great impact it has on animal welfare and farmers' economy, there is an active control program for the disease in Sweden (Hammarberg & Persson 2020; SVA 2021b). In the year 2020, 249 Swedish goat farms participated in the program (SVA 2021b), and a pilot study by Andersson (2019) indicated that CAE was present in about 14% of Swedish goat herds, including some that were a part of the CAE control program (Andersson 2019).

CAE is caused by small ruminant lenti-virus (SRLV) and exists in most goat- and sheep producing countries (Hedlund-Salenstedt 2021). It spreads from one animal to another with white blood cells that can be found in blood, saliva, mucus, and colostrum. Therefore, direct nose to nose contact, contaminated tools or milk from infected animals are the main sources of spread (SVA 2021b).

The virus is closely related to the sheep's maedi-visna virus and can therefore spread between goats and sheep, although there have been no reported cases of this in Sweden (however, there is no active search for it either) (Hammarberg & Persson 2020). There are different forms of the disease, depending on which organ system gets infected (Hedlund-Salenstedt 2021). Paralysis of the hind legs that over time spreads to the front, standing completely still with low head, problems with vision,

pneumonia and inflammations in the joints are all symptoms that can be seen with this disease. The udders can also be affected, which will lower milk production. A general decrease of the affected animals immune defence makes it more susceptible to other diseases as well (Hammarberg & Persson 2020; Hedlund Salenstedt 2021) However, most infections with this virus passes without any clinical symptoms, which complicates the surveillance (SVA 2021b).

The bacterium *Corynebacterium pseudotuberculosis* is responsible for causing caseous lymphadenitis (CLA), associated with boils or abscesses in lymph nodes and can be hard to get rid of once it enters a herd (Dorella *et al.* 2006). It is a common disease in small ruminants and can be found in most countries of the world, it impacts the production greatly and thereby can cause significant economic losses. According to Dorella *et al.* (2006) it can affect humans as well, although it is uncommon, and is mainly transmitted by handling infected animals without proper hygiene routines.

Transmission of CLA among goats or sheep occurs mainly through contamination of superficial wounds, by coughing or licking on the broken skin of another animal in the vicinity (Dorella *et al.* 2006).

Anthrax is a disease which can affect most warm-blooded animals, including humans (FAO 2010; SVA 2021b). The bacterium, *Bacillus anthracis*, sporulates when it comes in contact with oxygen, and these spores can survive in carcasses and in the soil for more than 100 years. Because of this, there is no country that is classified as “free” of the disease.

Cattle and small ruminants are most susceptible and sensitive to the disease and dead animals can be found, without previously noticed symptoms. Unclotted dark blood can be seen coming from body orifices long after the animal has died. Clinical signs prior to death, in noticed, include high fever, strained breathing, bleeding in mucus membranes and sometimes blood in the milk. The animal usually dies within 48 hours.

In Zambia, anthrax is endemic, and outbreaks occur yearly in the human population (Gianetti *et al.* 2019). Humans are usually infected by ingesting or handling infected meat and is often associated with suboptimal vaccination of livestock. Anthrax outbreaks in Zambia normally increase during the dry season, when both wild animals, livestock and humans gather around the floodplains (Gianetti *et al.* 2019). Sweden’s latest reported case of Anthrax was in 2016, after an old anthrax-grave had been disturbed (SVA 2021b).

Orf is caused by the ovine parapoxvirus and affects mostly young goats that lack immunity and can even infect humans (Hammarberg & Persson 2020; SVA 2021b). Orf gives redness, blisters, and scabs in the skin around the mouth and nostrils. These lesions are painful and as a result affected kids might stop eating and can cause acute clinical mastitis in the lactating does (Simulundu *et al.* 2017). This disease is present in both Zambia and Sweden (SVA 2021b; Simulundu *et al.* 2017).

Foot and mouth disease (FMD) is a highly contagious viral disease affecting all cloven-hoofed animals (SVA 2021b). It is endemic in large parts of the world, however, between the years 2006 and 2009, Zambia was the country with the highest level of loss of livestock units due to this disease in the world (TWB & TAFS forum 2011). Sweden is currently free from the disease (SVA 2021b). FMD causes painful vesicles between the toes of the hoof, as well as in and around the mouth of the affected animals, this leads to lameness, increased salivation, decreased appetite and a significant drop in milk production among lactating animals can be noticed, although goats are not as sensitive to the disease as cattle (Mitternacht 2019; SVA 2021b). The virus can be transmitted via aerosols (airborne droplets), direct contact, indirect contact consumption of contaminated meat, milk, or feed.

Peste des petits ruminants (PPR) is another highly contagious infectious disease caused by a morbillivirus, affecting sheep and goats around the globe (OIE 2021). The virus targets the animal's immune system, leaving them immunosuppressed (Mitternacht 2019). Fever, depression, loss of appetite and a heavy nasal discharge can be seen. In time, the nasal discharge thickens, which can cause dyspnoea due to occlusion of the nasal cavities. Erosive lesions might develop in the oral mucosa leading to hypersalivation. Bronchopneumonia and watery, sometimes haemorrhagic, diarrhoea are also common symptoms with this disease. Combined, the symptoms often lead to the death of the animal affected. Antibodies against this disease have been found in a few goats in Zambia, but the disease is not officially present in the country (Mitternacht 2019). It is not currently present in Sweden (SVA 2021).

According to a study by Muleya *et al.* (2019), rabies is endemic in Zambia. The disease is caused by a virus in the family *Rhabdoviridae* and is transmitted via saliva or brain tissue from an infected animal (CDC 2019). Dog bites or licking on broken skin is the main way for transmission to humans but contact of infectious material on mucous membranes or eyes are possible ways of transmission as well. Rabies causes tens of thousands of human deaths every year, 95% of which occurs in Asia and Africa, and half of these are children under the age of 15 years (WHO

2021). Even though urban rabies has dogs as it is main reservoir, the population of wild animals are important for the spread of sylvatic rabies (Epiwebb 2021).

The main symptom for rabies is changes in behaviour: wild animals can lose some of their timidity and domestic animals can become shy or aggressive (Epiwebb 2021; SVA 2021b). The virus infects nervous tissue and causes a meningitis, which is the cause of the behavioural difference. Eventually, paralysis occurs – often firstly of the muscles involved in swallowing, and the animal might have difficulties eating and drinking. The paralysis spreads to other parts of the body and seizures prior to death are common. An infected animal can live for months before symptoms develop. When symptoms appear, the infected animal usually dies within ten days, when the respiratory musculation cease to function.

3. Material and Methods

SSIs have been conducted via video link or internet phone calls with goat farmers in Zambia and Sweden. To recruit Zambian farmers for the project, a Zambian veterinarian went out to farms she deemed fit for the study and asked them. She brought her phone and mobile internet as well as interpreted the interviews. No limitations or demands was made from the authors side regarding the size of the herds or the purpose of the goat farming. One Zambian goat farmers with a larger herd for commercial purposes were contacted directly over WhatsApp, contact information to him was acquired with the help of the supervisors of this project.

Swedish goat farmers have been recruited by posting information about the project and contact information to the author on a Facebook page for Swedish goat farmers, with help from the board of the Swedish goat breeding association. The farmers were then allowed to contact the author of the project via email if they wished to participate in the study.

Ten Zambian farmers were included, as well as five Swedish goat farmers. The size and the purpose of the goat herds varied between hobby/pets, fulfilling household needs and commercial.

The interviews were conducted in English or Swedish and was recorded on the authors computer. The interviews were transcribed by the author during or shortly after the interview took place. The transcriptions are not verbatim, but the meaning and essence have not been altered. This was done partly to enable analysis of the data, but also to anonymise the data. The Swedish interviews were translated to English in the transcription process.

The interview questions were made by the author of this paper, with help and guidance of the supervisors. They are based on information regarding biosecurity, animal husbandry and infectious diseases learned during 5 years of veterinary school and what could be found in literature research. The interview guide can be found as an appendix (Appendix 1) to this paper.

The interviewer started with wider questions, and the interviewee was allowed to answer the questions freely – as exhaustive as they wished. More narrow questions could follow up the answers if the author felt there were some aspects the interviewee had not answered or there was something that needed clarification. The purpose of the interview guide was not to be a script for the interview, but rather a help to remember all aspects the author wished to discuss with the farmers. As such, there are differences in the interviews the way in which questions were asked.

3.1. Information and consent

Prior to the interviews, the interviewees were given short information about the study and its purpose, they were asked if they agreed to their personal information being gathered and used in accordance with the law of General Data Protection Regulation (GDPR). They were also asked if they agreed to the interviews being recorded and was informed that they did not need to answer any questions they did not wish to answer and that they could choose to not be a part of the study at any time – if so, all information and recordings of them would be deleted. No recordings would be published anywhere and the data from the interviews would be published anonymously. All farmers agreed to these terms.

The recording was conducted with the pre-installed program X-box Game bar on the authors personal PC laptop and were not saved on any cloud based hard drive. The interviews were held on WhatsApp, Zoom and Microsoft Teams. Transcription of the interview was done on the author's personal PC, any quotations in the text are based on this transcription and are therefore not verbatim, although the meaning remains intact.

4. Results

4.1. How does the goat husbandry look in both countries?

The farms included in the study were of different sizes and purpose. In Zambia, the herd sizes were 35, 33, 30, 26, 20, 15, 12, 10, 7 and 7. In Sweden, the herd sizes of the surveyed herds were 64, 50, 13 and 8. One farmer did not give a number but said to have a small herd mainly as a hobby.

4.1.1. Farm management and source of income

In Zambia, eight of the interviewees was the owner of the farm, two were employed as caretakers and worked full time on the farms. Six of ten farmers had the goats for meat and only one farmer used the goats also for their milk. Two farmers in the study had another main source of income (not counting the owners of the farms with caretakers) other than keeping goats: one had a full-time job away from the farm and the other with growing vegetables. Nine out of ten farmers in this study also earned money from the goats by selling live animals.

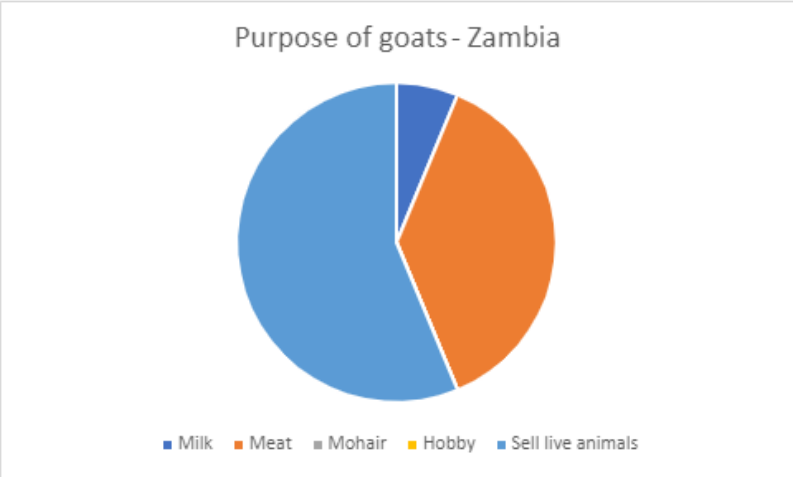

Figure 1: The main purpose for keeping goats in Zambia.

Six out of ten farmers also had other species of livestock, mainly cattle and poultry and eight farmers also grew crops or did gardening of vegetables parallel to animal husbandry. Maize was the most common type of crop grown (n=7), followed by household vegetables (n=6), groundnuts (n=2) and chili (n=1).

Only two Swedish farmers reported on having the goats as their main source of income, these were the ones with the largest herds. One used the goats for mohair, which was used to make clothing and sold in the farm shop and the other used the goats for their milk, to make cheese and dairy products she could sell in her farm shop and to restaurants, as well as directly to consumers. Both sold meat as well, mainly directly to consumers. Out of the three remaining Swedish goat farms, two used the goats for milk as well, for their own consumption, but had the goats mainly as a hobby, as companions and to help maintain an open landscape. One farm only had the goats as a hobby. Two of these three had plans to expand their goat farm and start up a dairy business, selling cheese and dairy products to restaurants and private consumers.

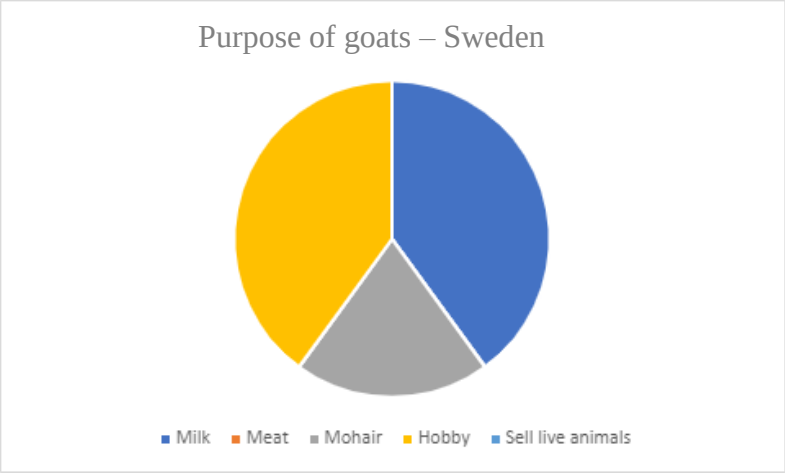

Figure 2: The main purpose for keeping goats in Sweden.

Three Swedish goat farms had other livestock as well: the one with goats for mohair also had sheep for their wool and two of the farms who mainly kept the goats as a hobby now but with plans of starting a dairy business also had a few beef cattle, one had horses as well. The farm who kept goats only as a hobby also had sheep, pigs, chicken, and ducks. Almost all Swedish farmers also had cats and dogs.

4.1.2. Housing system and grazing routines

In both countries, how the goats were kept varied depending on the season. During dry season/summer, goats were mainly kept on pasture, and during rainy season/ winter, most farmers kept their goats enclosed in a pen or house.

In Zambia during dry season, three out of ten farmers kept their goats on free range grazing without a house, two farmers kept their goats on pasture during the day and indoors at night, one farmer had the goats free range grazing but with access to a house and one farmer kept the goats in a paddock/pen during this season.

During rainy season, three farmers kept their goats tethered or indoors all day, two farmers had the goats in a paddock/pen with access to a house, one farmer kept the goats on free range pasture with access to a house, another kept them on pasture during the day and indoors at night.

Three farmers in Zambia kept the goats in the same way all year round. One farmer kept their goats in the same pen with access to a house, one farmer kept the goats on free range pasture without a house, and one farmer allowed the goats to graze during the day and kept them tethered during night throughout the year.

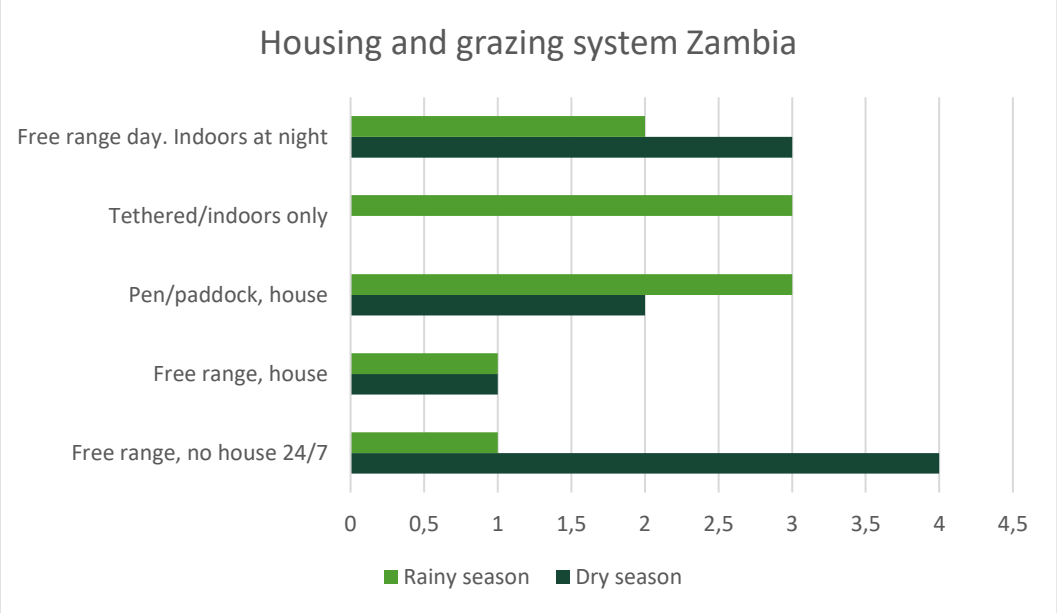

Figure 3. Housing and grazing system, Zambia.

Three Zambian farmers kept their own land on which the goats could graze, the remaining seven farmers allowed the goats to graze on communal land. Here they often intermingled with goats of other herds, only one of these farmers actively tried preventing their goats from interacting with other goats. Five farmers regularly

moved the goats to new areas for grazing, four did so to secure feed of different varieties and in sufficient amounts. One farmer said they changed pasture every week to help prevent disease and infections.

No Zambian farmer reported on having any material for bedding in the goat house, but all interviewees cleaned out manure from the stables regularly and often used the manure for fertilizer for the garden and crop production. Once a week was the most common interval for cleaning (n=3), followed by once every two weeks (n=2). Every day, twice a week, once a month and once every three months were the other intervals reported.

In Sweden, during summer, three Swedish farmers kept their goats on pasture in large paddocks on private land without any house/shelter. One Swedish farmer had their goats indoors at night but allowed them to graze freely during the day and the last Swedish farmer had their goats in the same paddock with free access to an uninsulated house all year round.

Four of five farmers in Sweden rotate between different pastures during the grazing season and two of these interchanged pastures with other species of animals (cows and horses) to protects their herd from intestinal parasites. One farm had the same 3 hectares of grazing land all year round every year.

In the Swedish winter, two farmers said they keep the goats indoors with access to outdoor paddocks, two farmers kept them entirely or almost entirely indoors – one of whom lets the goats out during the daytime 2 days a week.

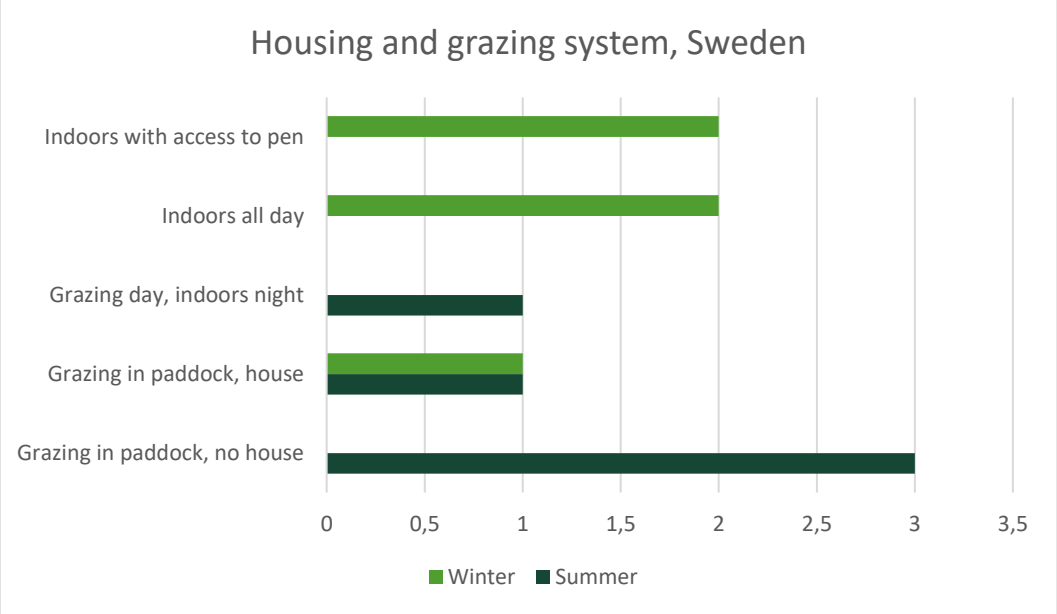

Figure 4. Housing and grazing system, Sweden.

Four out of five Swedish farmers used a deep litter bed of straw in the stable, which got refilled regularly to keep it clean and dry. One used wood shaving but with the same principle. Three out of five emptied the litter bed and cleaned the stable out during summer when the goats are outside, two farmers reported on not having emptied or cleaned the stables at all since they got their goats in 2018 and 2019.

4.1.3. Feeding routines and water supply

During summer or dry period, the goats in both countries lived mainly on what they could find themselves whilst grazing. The goats who were kept tethered, in a paddock and indoors during rainy season were fed with mainly cut grass.

One farmer in Zambia supplemented the goats feed with maize bran only during dry season, two reported on supplementing with maize bran only during the rainy season and four farmers gave maize bran all year round. Out of these four, two also provided the goats with vegetables. No additional branches or such were given at any time of the year. None of the Zambian farmers reported on giving concentrates, minerals, or access to salt at any time.

During winter in Sweden, goat feed consisted of silage, haylage or hay, supplemented with concentrates according to need (pregnant or lactating goats, kids and in case of low nutritional value in the roughage), as well as minerals and salt. All five farmers reported on making sure the goats had access to branches, small trees and/or tree trunks during winter as well. Four farmer provided free access to roughage and minerals, one farmer gave roughage twice a day instead partly because it reduced the wastage, another farmer did not provide free access to minerals, but instead gave this sporadically. Three out of five farmers also gave free access to salt and minerals during summer.

The concentrates used were mainly different grain and peas, either grown on the farm or bought, and sometimes bought as feed pellets. Pregnant goats also received additional selenium by all farmers.

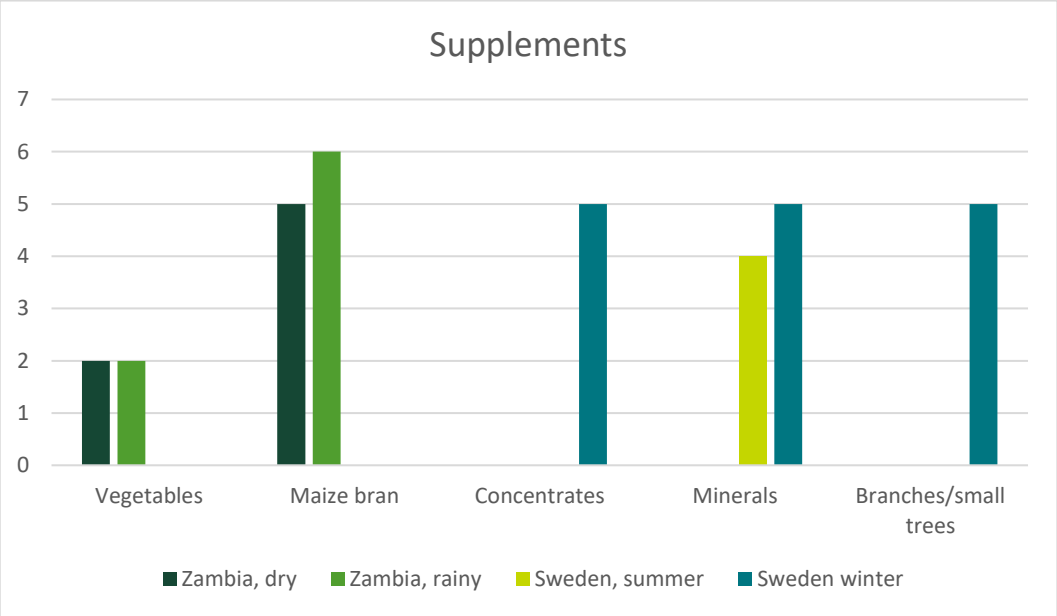

Figure 5. Supplements given to the goats in the two countries, depending on the season.

Water was given mainly in troughs or buckets in both countries; however, one Zambian farmer said the goats only drink from a nearby stream all year round and another let the animals drink from a communal water reservoir which many other animals have access to. The others fetched water either from nearby streams or rivers or from communal wells. Seven farmers in Zambia fetched new water once a day, and said they cleaned out the bucket mechanically before refilling it.

In Sweden, farmers reported that they cleaned the water tub/cups/buckets mechanically between once a day, thrice a week, or once a week. The water they gave the animals mainly came from private wells and is sometimes complemented with water from streams running through the enclosures.

4.1.4. Herd size management

In Zambia, seven farmers had continuous breeding of the goats throughout the year, two said they bred the goats so the kids were born in the rainy season and, one farmer did not answer this question. Only one farmer said to select which animals to breed: only the ones who appear healthy and strong were allowed to reproduce.

Slaughter of animals mainly took place when there was an immediate need for food or money – then they either kept the meat for their own consumption or sold to others. Only one farmer reported that they regularly slaughtered animals before big holidays, like Christmas or New Years to be able to sell the meat. This farmer selected animals who had not reproduced well for some time to slaughter.

All five farms in Sweden responded to have active breeding of their goats. Breeding took place from late in the summer to early autumn when they let the breeding buck enter the paddock of the does. The does were then pregnant during winter, when kept indoors, and gave birth in the spring. Selection of breeding animals differed between the farms, but general health, physical appearance and social demeanour was something all farmers took into consideration. Udder health and milk yield was also important, mainly to those who had dairy goats. The bucks were selected through their lineage and health status and purchased as young.

Young bucklings were sent to slaughter mainly in the autumn, although one farmer planned on sending them already before summer and one farmer never slaughtered animals – they only sold buckling as breeding males to other farms. The young does were kept on the farm or sold to other farms. The two bigger farms also sent older does to slaughter regularly: the farmer who used them for mohair sent all animals not intended for breeding to slaughter after they reached 2 years of age, as well as very old breeding goats when they were no longer fit for breeding. With the meat they made sausages, which they sold in their farm shop. The large dairy farm sent old does, does with problems with their udders or does who kick during milking as well as the bucklings. They did however only slaughter when they had customers willing to buy the meat.

4.1.5. Health situation

In Zambia, only one farmer claimed to have no known health issues in the herd. Five farmers reported having problems with diarrhoea and coughing, three of these had also noticed the goats losing weight. Mange was reported from two farms and a total of four goat farmers said to have problems with abortions. Two farms had a disease which made the goats hypersalivate and die, one of which also said the goats "run mad" before they die.

The farmer of one larger Swedish herd claimed to have had just about every goat disease possible in Sweden during the 25 years they have been working with goats, but that the goats are currently healthy. The owner of this farm said this is not because her goats are sicker than any other herds, but rather contributes this to their ability to very early recognize if a goat is sick and call the veterinarian for advice, possible testing, and treatment. Some years ago, the herd suffered from foot rot, which took the owners years to get rid of and they are now very careful not to introduce the infection again. They also reported to be part of a CAE control program.

The other big Swedish farm also reported on having over all healthy animals. They had occasional cases of clostridiosis caused by an overconsumption of starch rich food, where they can find one or a few animals dead in the paddock during summer or need to euthanise a goat in the stable during winter. Since they have a dairy farm, the owner stated that it is not uncommon with mastitis. They had rarely seen any diarrhoea, coughing or other symptoms of illness on the goats. They were also part of the CAE control program, and when decontaminating the farm in the year 2000, they also got rid of pseudo-tuberculosis.

Out of the three remaining Swedish goat farms, one more was part of the CAE control program. One other farmer said that their number one health concern was the uncertainty of whether their goats have CAE and pseudo-tuberculosis or not, as the owner cannot afford decontamination. At the third farm, endo parasites were common, but cause no direct problems for the goats' health to the owner's knowledge.

4.2. What measurements are taken to decrease sickness and prevent the spread of infections in goat herds?

In Zambia, few farmers implemented the biosecurity measures described in the literature review. Some said they changed the area in which the goats were grazing regularly, only one did so to keep the goats from getting sick whilst the others did so to ensure food availability. One farmer kept new animals or sick animals in quarantine for an adequate amount of time (3 weeks or more), no farmers dewormed or treated the new goats against ectoparasites before allowing them to interact with the rest of the herd, and many farmers reported that their goats often interacted with goats of other herds when on pasture. Goats were often, and casually, treated with deworming (often ivermectin and/or albendazole) when sick, but no other anthelmintic measurements were taken. Several farmers, however, regularly treated the goats with a spray against ectoparasites to protect them from ticks and lice. A few farmers never allowed visitors to interact with the goats.

The three Swedish farms that participated in the CAE control program were the farms with the highest levels of biosecurity measures adopted in this study. All three farms implemented quarantine routines, where a new animal was kept in isolation in a separate stable for 3-6 weeks (although one of them only had the new goat in isolation for two weeks the last time they got a new goat, but 4-5 weeks the time before that), either alone or with a castrated male or goat intended for slaughter. If

the new goat carried any infections, the goat for company could be euthanised without any big impact on the economy of the farm. None of them wanted to keep the new goat alone as they said it gets so sad and depressed.

The new goats were purchased from a CAE free herd. All three farmers examined the new goat upon arrival. Two farmers used foot baths or sprayed the hoofs with zinc solutions when the goats arrived, one of the two also sprayed the hoofs with zinc solution when the goat was to exit the quarantine stable. This was to prevent foot rot. One of these farmers also treated the new goat against mange, lice and intestinal worms on arrival. The other farmer sheared the coat of the new goat and examined for lice first and only treated if necessary, or if the new goat came from a herd with a known problem with mange or lice, the new arrival was dewormed straight away. The third farmer closely examined the new animal for signs of illness, trimmed the hoofs and sent faeces samples for parasitic analysis. Only if necessary did they treat the new goat with any medication.

All these farms regularly had visitors on the farm, but none of these farmers allowed visitors to interact with their goats if they had recently interacted with goats of other herds. If visitors were to enter the stable or paddock, they were required to have clean shoes or wear shoe caps. The main reason stated for this was to prevent the introduction of endo parasites.

More measures taken to prevent endo parasites were deworming, which two of the three did on a regular basis before the goats went to summer pasture, in connection to faeces samples analysed for worms or eggs. The third farmer did not regularly deworm the goats but did regularly analyse the faeces and dewormed if necessary (if the egg count reached a certain level or eggs from *Haemonchus contortus* were detected). All three farms regularly changed the pasture locations during summer and interchanged pasture with cattle and/or horses.

None of these three farmers had problems with rats, mice or small birds contaminating the goats' feed and stored grain and concentrate in such ways that pests could not access it and never allowed residues of feed to remain on the floor.

4.3. How does the farmers in both countries know what to do and how to manage their goats?

On the question on how the farmers know how to manage goats, five farmers in Zambia said they got some kind of training provided by the veterinary office, community facilitators or others. One had no formal training, but sometimes

attended seminars on goat reproduction and three farmers said they had no education at all related to goat management and one farmer lacked education but had friends who have goats that provided information and advice.

Swedish goat farmers responded to the question on how they know what to do with their goats as follows: three of five had done their own research by reading books and searching on the internet, two had received education in livestock management and worked with cattle on other farms before, one of which regularly attended seminars in goat management, health and production. One of the farmers who learned by own research stated that "being able to read and being curious enough to do so is highly important when you plan on taking care of animals".

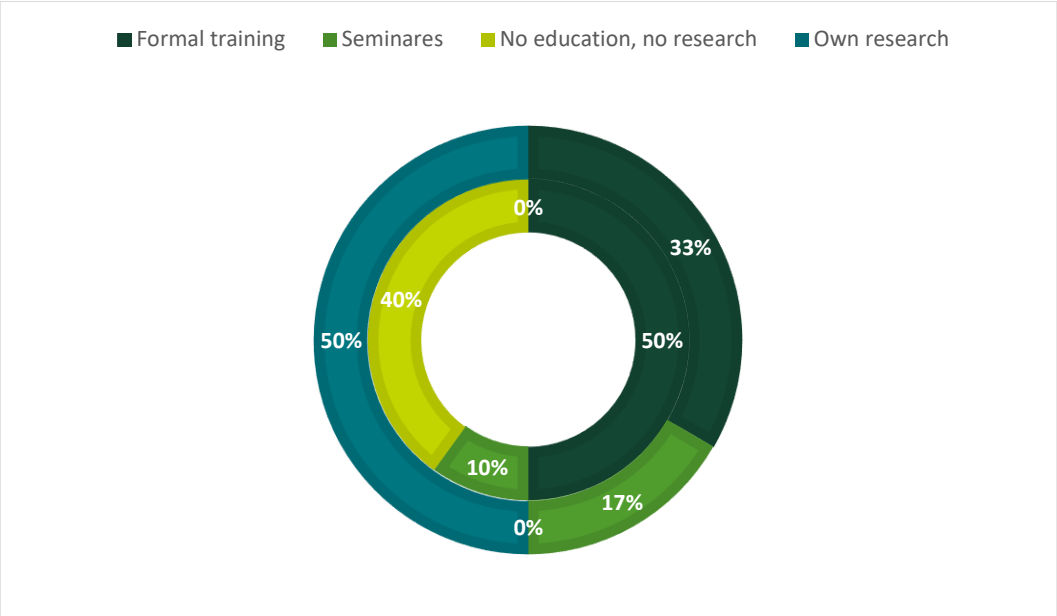

Figure 6. How does the farmers in both countries know what to do and how to manage their goats? The outer circle represents Sweden, and the inner circle represents Zambia.

In Zambia, seven farmers said they regularly had contact with the veterinary office. Both for regular treatments, like deworming, and advise but also for more acute matters, like when an animal showing signs of clinical illness. The other three interviewees never called out a veterinarian to the farm, because it was too expensive.

Farmers in Sweden appeared more reluctant to bring out a veterinarian to the farm if goats got sick than those in Zambia. Three farmers did it only as a last resort. The other two only had contact with a specific veterinarian that they trusted. The main reason stated was the cost, it was simply too expensive to consult a veterinarian to help a single animal. The lack of goat-specific knowledge among the "common" veterinarians was stated as the second most important reason. One of the more

experienced farmers said the following during the interview: “I only call out a veterinarian to my farm if I already know what the goat is sick from, and I know the veterinarian can help. If I don’t know, and can’t find out myself, I rather kill the goat. Why should I pay to educate veterinarians?”.

5. Discussion

The goat husbandry in Zambia versus Sweden shared many similarities, like the differences in housing and feeding routines depending on the season. During the rainy season in Zambia goats were often fed with cut grass, vegetables and maize bran – which are all high in starch and low in fibres compared to branches, bark and small trees which the goat needs to maintain a healthy gastro- intestinal function. As previously described, feed with high starch and low fibres can lead to clostridiosis, which often has a fatal outcome for the animal affected (Hammarberg & Persson 2020; SVA 2021b). But feed high in fibres might be hard to provide for the goats in Zambia during the rainy season when the goats are enclosed, as herbs and grass are especially low in fibre content and the availability of fibre rich fodder therefore depends on the availability of trees in the vicinity. As trees take much longer to grow than grass and herbs, any forests or groves from which trees and branches are harvested for the goats might soon be devoid of harvestable fibre rich greenery. Since most of Sweden is composed of forests, providing branches or small trees for the goats is easier, which might be a part of the explanation why the Swedish farmers interviewed provided such fodder and the Zambian farmers did not.

In Sweden, most farmers interviewed for this study provided supplements of minerals, salt and concentrates to their goats as a way of ensuring healthy strong animals. This, however, was not the case in Zambia – where none of the ten farmers provided their goats with minerals and salt. The study previously mentioned by Ogebe *et al.* (1996) described how mineral supplement dissolved in the goats drinking water improved their health, and how a deficiency in blood sodium levels made the goats lick the pen walls, sniffing and licking of urine and the bodies of other animals – actions which increase the risk of transmitting infectious pathogens present in the herd. Providing minerals and salt could thereby help decrease spread of infections and increase the health and wellbeing of the goats in Zambia, and by that, increase the productivity.

Mineral supplements for the goats might however be another product hard to access for Zambian goat farmers, as many live in rural areas – often with long travel distances to cities where such things can be found and bought. A lack of monetary

funds might pose another challenge in the procuring of minerals, as they rarely come for free. It can be discussed that since minerals likely would help to improve their goats' health, and thereby production, goat farmers would ultimately gain from such an investment – but that does little to fill their wallets in the short term.

Regarding maintaining hygiene in the stables/goat houses and pens, Zambian goat houses were cleaned out by hand by the farmers or employees. The Zambian goat houses were cleaned out more frequently than those in Sweden and could as such be cleaner and more hygienic for the goats – but to draw any such conclusion, further investigation is required, preferably on site. As the outside temperatures in Zambia is generally higher than those in Sweden, having bedding in the stable is not as necessary in ways of temperature regulation, and out of the Zambian interviewees who had a house for their goats, no one had any bedding material for the goats. This saves the farmers from having to procure bedding material as well as makes cleaning of the stable far easier and emptying the stables of manure was done far more often in Zambia than in Sweden. Whether or not this ensured better hygiene in the stable is unclear, but it could be possible. However, no bedding means for a harder surface, which could increase the risk for injuries to skin and joints – and could thereby cause stress and increased risk for secondary infections due to lower immune defence.

Hygiene in the Swedish stables were mainly maintained by continuously, through-out the winter, providing new fresh straw for bedding. It was cleaned out once a year or less and whether or not the interior was more thoroughly washed at this time varied. This is a method that, according to studies by Källström (2008) and Waldemarsson (2021), ensures sufficient hygiene as well as an additional heat source during the winter, which can help prevent stress based production loss and disease due to hypothermia. As a deep litter bed is based on a thick layer of straw, it also provides a soft ground for the goats to stand and lay on and can thereby help increase their general well-being and prevent damages to the hoofs and skin. However, with a deep litter bed comes less wear on the hoofs, which might increase the risk of the hoofs growing too long and increases the importance of regular inspection and trimming of the hoofs.

As many hoof-related infectious pathogens survive longer and spread faster in wet environments (Waldemarsson 2021), the goats urine is an important factor to take into consideration when discussing the stable hygiene. With a thick layer of straw, the urine can pass down and be absorbed by the straw close to the floor and the goat would still have a dry bedding on top. On a hard packed dirt floor, the urine would likely collect in puddles until the liquid evaporates, forcing the goats to walk and lay in the urine-soaked dirt for some time, increasing the risk of hoof-related

diseases and could possibly increase the risk of skin infections as well. Having a slatted floor (raised floor with spaces in between boards to allows the refuse to pass), providing a dry and somewhat clean space for the goats to stand and lay on. Both of these solutions however have the downside of being rather hard, and a hard floor might increase the risk of pressure injuries and damages to the goats' skin, increasing stress and the risk of infection.

5.1. Are there any measures or routines from one country that could be implemented to help improve the general health and wellbeing of goats in the other country?

In words of biosecurity, most Zambian farmers included in this study did not implement many or any of the measures described as important in literature, and disease in the herd was common amongst the farms interviewed for this master thesis. Few had any sort of quarantine of newly precured or sick animals and therefore did not treat the new goats to prevent introduction of new diseases (like *H. contortus,* lungworm, lice, mange, *etc*.), and many allowed their goats to interact with goats of other herds. One farmer said their goats sometimes hypersalivate, "run mad" and then die, symptoms affiliated with diseases like rabies. Whether that was the case in this situation cannot be said, and the owner themselves thought the goats had ingested some kind of poison. It could also be symptoms of acidosis or clostridiosis. But as they did not recognise it as potential rabies, and therefore did not isolate the animal, they risked the rest of the herd being affected by the same disease.

Some of the Swedish farmers included in the study had quarantine routines in place, but only two kept the new goat isolated for an adequate amount of time (>3 weeks). By implementing proper quarantine routines of new and sick animals it is likely that farmers could help prevent the introduction of new diseases to the herd and prevent disease from spreading within the herd, increasing the health and production of their animals. This is an important biosecurity measure and the one probably most easily implemented by farmers of both countries without too much of an investment from the farmer.

In most Zambian farms, and some of the Swedish farms, there were no routines or special demands on visitors who were allowed to interact with the goats of the farms. Since many infectious pathogens can spread with clothes, shoes, and equipment (Hammarberg 2015), making sure visitors do not interact with one's

goats if they have recently been with goats from other herds, or change or wash their clothes, shoes and equipment between the herds could help keep one's goats protected against diseases.

Most farmers in both countries appeared to have problems with intestinal parasites in their herds. The main solution used was antiparasitic drugs, and only one Zambian farmer actively changed grazing area for the goats as a protective measure. It was more common in Sweden, where only one of the interviewees did not regularly move the goats to new areas, this same farm also had known occurrence of helminths, but did not act against it unless the goats showed clinical signs from the infection.

Some of the Swedish farmers also took faeces samples before and after deworming, to control whether the animal carried any intestinal parasites and to ensure the deworming had done its job. One farmer continuously sent faeces for analysis during the grazing period and moved the goats every four weeks. Their goats hardly ever had enough parasites to need deworming, proving that changing pastures is an important measure in parasite control.

Of course, the parasitic burden varies between areas and countries, and providing a parasite free grazing area might be difficult for farmers all around the world. Intestinal parasites can also spread with wild animals, other animals grazing in the same area and with humans. Having your own, private land, which you can put a fence around to keep out other animals, help. This can be an important factor in why Zambian farmers seemed to have more problems with intestinal parasites in their herds and used deworming medicines more often and often as treatments against many different illnesses – since they in less extent had their own land but instead had to use communal lands, where the prevalence of intestinal parasites might be high and can spread from one herd to another.

Moreover, in Zambia, several farmers reported on having problems with pests, mainly rats, accessing the goats feed. This was not as common in Sweden, as most farmers stores the feed in rat proof containers. As infectious pathogens often can spread via contaminated feed and water, ensuring good hygiene around feeding/ drinking places and around feed storage is important. Therefore, keeping away pests from the goats' feed could be an important factor in ensuring good goat health in the herd, as these animals can carry pathogens on their feet or in their faeces. The quality of the fodder itself is also important, as mould and bacterial growth can make the goats sick as well or decrease their immune defence and thereby increasing the risk disease.

Most Zambian farmers fetched water from communal wells or nearby streams or rivers or took the goats to these water sources, where they could intermingle with other animals who also gathered there to drink. Water hygiene can thus be difficult to ensure. The respondents were not asked how much water the goats received per day, but in the cases where the farmers fetched water by buckets, one could suspect they were not provided with sufficient volumes to fulfil their daily need. To battle this problem, a stable, private, water source would likely help. This however is nothing that the farmers can build or install for themselves but require more funds and means than most farmers have. The supply of hygienic drinking water is a question for governments, as it is important for all the population.

In general, one can state that biosecurity was implemented in a higher degree amongst the Swedish farms included in the study compared to the Zambian ones. What the lack of biosecurity in Zambian goat farms is caused by is hard to say. It could be argued to be a lack of knowledge regarding infections, their way of transmission and their importance to the production of the herd that is behind it. Most likely, it is multifactorial and the lack of funds and means to implement certain measures is probably just as important. Not having stable internet connections and/or access to computers or smartphones, as was the case for all but two Zambian farmers interviewed, makes a search for information a lot harder. It is possible that the climate and available finances affects which biosecurity measures are possible to implement. For example, keeping one's goats away from other animals whilst grazing often require a fence or a very vigilant herder, having a private water source for the goats require a private well, and being able to sort out feed which has gone bad requires that the farmer has enough feed left to give the goats. Farmers with lots of land, with streams filled with water all year round and no problem procuring extra feed if a batch goes bad might have it a lot easier, as is often the case in Sweden. However, more education regarding goat health, biosecurity and common pathogens would probably not hurt. The same goes for Swedish farmers, even though biosecurity measures were implemented in a much higher degree in the five herds included in the study.

5.2. Limitations

The biggest limitation, as well as the most difficult to overcome, was spreading information of the project and the gathering of farmers interested in participating in the study. Because of the Covid-19 pandemic, it was not possible for the author to physically travel to and visit farms and ask in person if they would participate, but instead had to rely on others to do this task in Zambia and rely on Facebook pages for farmers in Sweden. As it is most often easier to get a reply when asking someone

in person, the number of interviewees, and the quality of the answers, are lower than expected and desired.

Despite the low number of interviewees from Sweden, a large spectra of goat farms were included: everything between a small farm with just a few goats for hobby to big farms with many animals and a financial business based on the animals. Also, not only dairy farms were included, but also one farm who based their income on mohair, providing different aspects of goat farming in Sweden to the study. This likely allowed for a more nuanced depiction of Swedish goat farming and gives more weight to the result.

Another limitation was the lack of stable internet connection – most noticeable during the interviews with Zambian goat farmers. Seeing as all interviews happened online, having functional mobile internet connections was very important and the lack of such resulted in some time lag, glitching and frame freezing, which influenced the interviews negatively. The Zambian interviews had to take place where people had access to Wi-Fi, which complicated matters for them, or be done without video feed (as it uses more data). This allows for oral conversation, but much of the communication via body language and facial expressions were lost.

It would of course have been more desirable to conduct the interviews in person, also giving the possibility to see the farms in person, but there would still be certain difficulties with language barriers as well as those that stem from coming from different cultures. Having an interpreter is always a source of potential errors: there is the risk of miscommunications, even without a person in the middle, but the risk of misunderstandings and information loss increase when information is exchanged via an interpreter. The loss of information during interpretations of Zambian interviews in this study was apparent, as the answers translated to English was far shorter than those given in the original language. This, however, would have likely not been different even if the interviews took place in person, but could possibly have been decreased if the translator had been asked to translate the entire answer and not just the conclusion of the answer.

Further on, it should be discussed that while the average herd size in Zambia is between 1-5 goats (MFL 2019), the herds in this study were larger, most had between 10 and 35 goats each. As there were no limitations or "rules" set up for what farms were to be recruited, one can presume the veterinarian chose bigger farms in their district. It would have been interesting to also discuss biosecurity with farmers of more "normal" sizes, as their answers could vary from the ones from the larger farms.

Another question which could be relevant is one about education. For this project, farmers were asked about goat specific education only, but their general level of education could be highly relevant in understanding their means of gathering information. If a farmer has received higher levels of scientific education, where information gathering and processing is a big part, this can help them greatly to collect, analyse and understand the existing literature regarding biosecurity and goat husbandry. Contrary, having received no education, or only a little general education, and thus not being able to read or not understanding English (which a big part of the available literature is written in), can have a huge negative impact on the possibility to conduct research.

Furthermore, when conducting personal interviews in the role of an authority (as one might regard a 6th year student of veterinary medicine in the field of animal husbandry and biosecurity), there is the risk of so called "will to please"-bias. This is when people give answers, they think are correct or sought after, even if it is not the complete truth, or even true at all. This bias is suspected mainly in the answers of one of the Zambian farms, where the farmer in the end of the interview expressed the notion that they would receive funds or goats for their participation, a mis-understanding of unknown source but with a probable impact on the interview.

The risk for this sort of bias could be minimized by being on site and conducting the interviews face-to-face, so that one could see for oneself how the farm, stables and enclosures look, if the animals appear to be in good health, feed and water hygiene and any other detail relevant to the study. This was unfortunately not possible in the current situation and the word of the interviewees would have to suffice. This "will to please"-bias can also be reduced by clearly stating, in the beginning of the interview, that the participation is voluntary and will not bring any advantages or disadvantages to the farm, that there is no reward or reimbursement offered. Which was done with the rest of the interviews. It is however important to take this bias into consideration when interpreting and drawing conclusions from the results.

6. Conclusion

In Sweden, farmers were overall more likely to implement biosecurity measures than in farmers in Zambia. The reason for this could be discussed to be lack of knowledge and understanding of how infectious pathogens spread and the impact they might have on one's herd, lack of funds or means to implement necessary changes or the lack of will to do so. Proper quarantine routines, proper feeding routines and supplement of minerals, pasture changing, and stable hygiene are all areas vital for the health and wellbeing of goats in goat herds in both countries and could likely help improve goat and animal health and welfare, as well as help fight poverty and starvation in Zambia.

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To healthy goats and knowledgeable farmers!

Popular science summary

Biosecurity means protecting one's animals from disease. The diseases in question are mainly those that can spread from one individual to another by bodily fluids, (like saliva, milk, blood, or mucus), skin contact (external parasites, like mange, lice or other insects) or via faeces or faeces contaminated feed or water. When infected, the animals often lose their appetite, lose weight, drop in production of milk or stop growing, and might even die. As many of the disease inducing organisms exist naturally in the goat or its environment, making sure the goats are strong and healthy enough to not fall ill is as vital as trying to reduce the goats' exposure to them.

Studies have shown that goats need a fibre rich diet as well as supplements of minerals and salt to remain healthy. During pregnancy and lactation, they also need more energy than mere grass and trees can offer, and supplements of grains or peas can be necessary. Wrong feed can have a negative impact on the goats' innate ability to protect themselves from infections and can have fatal outcomes.

Further on, isolation of new or sick animals is an important measure to prevent disease from spreading in one's herd. It is a measure that can relatively easily be implemented and could mean the difference between having a herd riddled with disease or a healthy one. Isolation must be complete, when infectious diseases are concerned, and the isolated animal must not be allowed any contact with the herd for a minimum of 3 weeks (for a new animal) or until such time that the risk of disease transmission is no longer present. This can however make the isolated animal very stressed, which is not good for their health either, so keeping one goat from the herd as company for the isolated goat might be appropriate.

This also makes it directly inappropriate to allow ones' goats to interact with goats of other herds, or wild cloven-hoofed animals – as they pose a great risk of spreading diseases to one's goats.

Intestinal worms can lead to decreased body weight and a decreased resistance against other diseases – in severe cases the infected animal can even die. By changing pastures regularly, possibly coupled with treatment of deworming drugs,

one can protect the goats from being infected with intestinal worms. Different strategies can be necessary depending on how big a problem there is in the specific herd, but reducing the use of anthelmintic drugs is vital to prevent resistance against such medications.

Lastly, hygiene is a very important factor to take into account. Hygiene of the stable, hygiene of the feed and water and hygiene of the people who might interact with the goats are vital to protect against disease.

This study was based on interviews with Swedish and Zambian goat farmers to map how farmers from these countries take care of their goats, how the goat industry differs and if there are any likenesses between them. The author also wished to examine how much the farmers from both countries knew about biosecurity and from where they got this knowledge, as well as what biosecurity measurements were taken in farms from each country.

All interviews were conducted over video fee or voice call from the authors computer, in Zambia the interviews also required a translator and help reaching the farmers as many of them do not have their own computers or access to Wi-Fi or internet.

The interviews showed that Swedish farmers in higher extent adopted biosecurity measures in their herds and the health of the goats were overall better.

In both countries, the climate played a significant role in how the goats were managed at different times of the year: during Swedish summer and Zambian dry season, goats are mainly kept outside, grazing – living of what they can find for themselves. During Swedish winter and Zambian rain season, goats are often kept indoors or in enclosures/pens with access to houses. At this time, they are fed with grass/hay mainly. Swedish farmers did in a greater extent supplement goats with branches and minerals, whilst Zambian farmer often provided maize bran or vegetables for feed – which might be high in carbohydrates, risking overgrowth of harmful bacteria.

Farmers in both Sweden and Zambia reported reluctancy to contact veterinarians for assistance, mainly for the cost. The prize for the veterinarian to help one goat is more than the one goat's individual value. Farmers instead relied on their own experience or advice from friends or acquaintances. Swedish farmers often did their own research in literature or on the internet.

If the lack of biosecurity in Zambia (and in a few Swedish farms) is due to the lack of knowledge and education, funds and means or both cannot be concluded in this study. However, with education in biosecurity and proper goat management, the farmers would at least have the knowledge and choice of implementing necessary measurements to maintain a healthy herd. The author of this paper strongly believe that the wellbeing and health of goats and humans could be greatly improved by the thorough spread of proper information. How this is to be accompliced, this author leaves unsaid – however, she hopes this study might be helpful in reaching that goal.

Appendix 1: Interview guide

Presentation:
Hello! My name is Gry Martineau, I am a Swedish veterinary student who are currently working on my masters thesis in infection control in goat herds in Zambia and Sweden. I was supposed to go to Zambia to conduct interviews in person, but the current pandemic prevented this. Therefor I will be conducting them over video link over the internet instead.

Do you agree to me recording this interview? So that I can go back and watch/listen to it again when I need to?

In the interview I will ask some questions, you may choose to answer them or not as you will. If you do not wish to answer a certain question, just say so and we will move on. If you no longer wish to participate in the study, say so and we will stop the interview and all recordings and information I have gathered of you will be deleted.

All information from these interviews I use in my project will be published without your name or information.

Is this okay with you?

Questions:
What is your role on the farm (e.g. owner, manager, employee etc)? For how long have you kept (or worked) with goats on this farm or another? Have you worked with goats previously to working on this farm? How did you learn to manage goats? Do you have any education related to working with goats? What are your responsibilities on the farm?

Why do you keep goats? What is their main purpose for you (meat, milk, manure for crops, use as payment etc)?

Do you have any other sources of income? Do you grow crops? Do you have any other types of animals? Do you have any occupations other than farming? If so; what is your main occupation?

Could you describe the farm?

How many goats do you have? How are the animals kept/managed? Are they kept in indoors (zero grazing), in an enclosure, on free range pasture (with or without herding), kept tethered or something else? Are all your goats kept together or are they kept in groups/go on separate pastures/sheds? Are the goats managed differently at specific seasons/time of year/month/week? If so, why?

Do you allow your goats to interact with animals of other herds (other goats or other species of livestock)? Do you sometimes interact with goats from another herd? If so, how often? Do you change clothes or wash your shoes or hands after interacting with goats from other herds, before interacting with your own herd?

Change pasture and switch between enclosures?

How often, if ever, do you remove feces from the stable and enclosures? How often, if ever, do you clean the stables with water and/or disinfectant?

What do your goats eat? Do they get any supplements? How is the feed stored?

How do you water your animals? Do they drink from a tank/bucket etc or nearby water hole? If water hole; is it a place where many animals drink? If a tank/bucket; do you change the water regularly? If so, how often? Do you clean the tank/bucket before adding new water? If so; how do you clean the tank/bucket?

Do you have a problem with rats of mice in your farm? Do rats and/or mice ever get into the goats feed? Do you use traps or poison to get rid of them?

Do you have any health problems in your herd that you are aware of? What is the biggest health problem or challenge, according to you, in your goat herd? Why is this important to you and your herd? Why do you think you have them?

Do you have any other diseases in your herd? What symptoms do you see when your animals are sick? Do you often see animals in your herd that exhibit listed symptoms and why do you think they have them?

- Ocular or nasal discharge (runny eyes or runny nose)
- Coughing

- Diarrhoea
- Itching, matt coat, loss of fur
- Abortions or kid death
- Natural death (not slaughter or euthanasia), with or without previous symptoms

If you have an animal with the symptoms listed, do you do anything about it? If so; what do you do? Is it separated from the rest of the herd? If so; how is it separated from the herd? Is there a special enclosure for sick animals? How far away is it from the rest of the herd? How long is the sick animal separated from the herd? Are sick animals given any special treatment: feed, medication or other apart from separation from the herd? If so; what kind of treatment does it get? How do you know what do give the sick animal?

Do you use separate clothes and equipment for working with sick animals?

Do you ever call out a veterinarian to your herd? If so, how often? If not, why not? Do you ask anyone else for help with medical problems in your herd? If so, who and why?

Do you get your goats treated with any medications regularly? If so; what kind of medications? For what are they medicated? How often are they medicated? Does anyone advise you to do so? How do you get these medications? Do you treat your goats with any of the following: dewormer, vaccination and/or treatment against tics and other external parasites? If so; how often and with what?

Do you sometimes introduce new goats to your herd? If so; how often? How do you get the new goats; do you buy them yourself, someone else buys them for you or do you get them without payment (as gifts etc)? How do you normally introduce a new animal to your herd? How long after you got it do you normally introduce it to your herd? Do you normally give the new animal any kind of special treatment; feed, medication, vaccinations or other? If so; what kind of treatment does it get? Are you advised by anyone to do so? If so; who gave you the advise?

Do you sometimes buy a new animal to your herd that exhibit any of the symptoms of illness (like coughing, itching, diarrhoea etc)?

Do you breed your goats? Are kids born throughout the year (continuous) or in a restricted period? Do you have any special selection of which animals will be allowed to reproduce? If so, how do you select which animals to breed?

When are animals slaughtered? Do you have any special selection for which animals are going to be slaughtered? If so, how do you select these animals? What happens with the body after slaughter (sell it to restaurants, sell it directly to people, keep it yourself etc.)? How old are your oldest goats?

Do you have any routines with visitors? Are visitors allowed to interact with your animals? Do they need to do something special to be allowed to interact with your animals (wash their hands, change clothes, wear protective clothes etc)?

That was all my questions. Is there anything else you would like to ad that I have not asked? Or do you have any questions for me? If not, I thank you for your time and help with my project.