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"The Influence of a new developed dual purposed goat breed to; tackle climate change, meat and milk production and to increase the marketing of small ruminant production in Jamaica".

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Abstract

Although research has been done on improving the genetically traits on domestic livestock animals in Jamaica, as well as research on those breeds that are already present here, it was observed that little or no research was done examining the influence of a new developed dual purposed goat breed to; tackle climate change, meat and milk production and to increase the marketing of small ruminant in Jamaica. Small ruminant production is a very significant component of livestock production throughout the world, especially within developing countries.

In Jamaica, the small ruminant production market as shown where there are room for improvement within the goat industry. The study took place within five (5) different parishes in Jamaica. Data was collected from the parishes of; St Catherine, Portland, St. Mary, St Elizabeth and Hanover. Where a questionnaire was used to collect quantitative data as well as interviews was done both virtually and face to face to retrieve qualitative data causing a mixed research methodology to be utilized. The research action plan is to reduce food poverty and in the small ruminant sector in Jamaica with the influence of a newly developed dual purposed breed goat to combat challenges faced. In concluding, this study will explore and actions that can be done or put in place, to mitigate the challenges being faced by farmers and small ruminant organizations currently.

Chapter 1:

General Introduction

1.1 Presentation of the subject or issue & Scope of the Study

Jamaica has been known for rearing domestic animals such as; cattle, swine's, goats and sheep's, poultry (broiler and layer birds). The problem that mostly affects the domestic animals in Jamaica are' praedial larceny, improper feeding programmes and a high demand for experts in advance breeding programme, vetenarians are always used for breeding and reproduction as well as their job title. Which leaves a higher strains on their daily duties. Jamaica is lacking in many breeder experts in animals, due to the shortage, the companies and some organizations finds it very difficult to maintain high quality standard genes/traits.

The topic was selected based on the current crisis being faced in the small ruminant production in Jamaica, it has shown where there is need for improvement on goat breeds reared for breeding as well as to show how a goat could be used for multiple purposes. In the diary industry, cattle's are reared for milk purpose and the use of other dairy products and By-products. Cattle are also reared for beef purpose which is rearing them for meat purpose. Due to the high level of food poverty on the markets in Jamaica.

Agricultural organization's put in place action plans and suggested interventions few years and recently to increase the marketing life for the small ruminant production and reduce food poverty. This in return will ensure that the people in our nation are being fed. However, the topic was chosen to boost the strategies put in place, which can also be of benefits to the people of our nation by being able to effectively produce a dual purposed goat breed that will help to reduce all the needy on the markets.

1.2 Background Information

Food Insufficiency in the Caribbean

According to (Ewing-Chow, 2022). A series of surveys was administered by the Caribbean Community (CARICOM) in partnership with the United Nations World Food Programme (WFP) has revealed that, in the English-speaking Caribbean, the estimated prevalence of serve food insecurity has increased by 72% since the onset of the pandemic and by 44% in comparison to one year ago. (Ewing-Chow, 2022)

In April 2020, CARICOM in a partnership with WFP began tracking the impact of COVID-19 on food security and livelihoods across 22 countries and territories in the English and Dutch-speaking Caribbean through the CARICOM Caribbean COVID-19 Food Security and Livelihoods Impact Survey. The surveys were administered in April 2020, June 2020 and February 2021, with the fourth and most recent round taking place in February 2022. (Ewing-Chow, 2022)

Experiences with food insecurity are due to the unique interplay of a multitude of factors associated with food availability, food access, food utilization and economic vulnerability. Using WFP's Consolidated Approach for Reporting Indicators of Food Security (CARI), survey respondents were placed into categories on a food insecurity scale, based on a combination of variables, with the most extreme being labelled "severe." (Ewing-Chow, 2022)

The findings of the CARI exercise reveal that while current levels of food insecurity are lower than in June 2020, and have remained relatively stable over the past year, they have increased by 60% since the first CARICOM-WFP survey in April 2020. Severe food insecurity has increased with each round, however, recording a significant increase of 72% since April 2020. (Ewing-Chow, 2022)

Based on estimates extrapolated from CARICOM-WFP survey findings, there was an increase in over one million food-insecure people in the English-speaking Caribbean since the beginning of the pandemic— bringing the estimated number of food-insecure people in the region to 2.8 million (39% of the total population). (Ewing-Chow, 2022)

Inside Russell Wilson's New Neighbourhood: Denver's Cherry Hills Village

An estimated 693,000 people or just under 10% of the population in the region are currently estimated to be severely food insecure, up from 6% in April 2021. This is 44% more than in February 2021— only one year prior— and 72% more than April 2020. (Ewing-Chow, 2022)

The survey findings reveal that two years into the pandemic, diets have deteriorated, and food consumption has decreased, with 48% of respondents reporting that they were unable to eat healthy and nutritious food, 37% reportedly skipping meals, 45% reportedly eating less than they thought they should, and 20% reportedly going an entire day without eating— during the 30-days leading up to the survey.

Most disturbingly, the findings reveal that inequality has been on the rise since the beginning of the pandemic. Severe food insecurity has disproportionately affected lower-income respondents with deepening effects at each round of the survey.

The most significant impacts were experienced by respondents who reported earning well below average income, with 16% reporting going a whole day without eating and 49% skipping a meal or eating less than usual in the week prior to the survey.

Lower-income respondents reported coping strategies such as drawing on savings to meet immediate needs, reducing education and health spending, and selling productive assets. Nearly half reported having no food stocks at home.

The survey findings also indicate that the reasons for Caribbean food insecurity have changed, moving from COVID-related movement restrictions to growing livelihood impacts.

"Food and Nutrition Security is among the highest priorities in CARICOM. CARICOM Heads of Government has taken concrete steps to advance the CARICOM Agri-food Systems Agenda, develop the agricultural sector and by extension, achieve food and nutrition security."

In addition to promoting investments in agri-food systems, regional food production and improvements to productivity and trade, the CARICOM-WFP report advocates for improved data and acceleration of digital transformation initiatives to promote well-functioning food systems and food security.

"Investments in domestic and regional food systems must become a strategic priority for CARICOM and its members, along with social protection measures for the most vulnerable," says Yeşim Oruç.

An expansion of social protection and social services, programs to promote increased consumption of local foods, and acceleration of more sophisticated and creative forms of development and climate finance are among some of the other recommendations put forward in the report.

But with a multitude of compounding factors including the impending hurricane season, ongoing effects of COVID-19, heightened climate change impacts, food price increases, and global instability, two out of three respondents and more than half of the lowest income respondents anticipate moderate to severe impacts on their livelihoods in the future.

"Climate change impacts and, more recently, the economic effects of the Ukraine crisis will continue to threaten the livelihoods and food security of the most vulnerable in the Caribbean for the foreseeable future," confirms Regis Chapman.

“Without immediate attention to regional food security, the impacts will become even more entrenched and far-reaching. CARICOM countries have done so much up until now to try to reduce the socioeconomic impacts of the pandemic, but more must be done to avoid the increasing inequalities from becoming the new normal. The will is there, but greater international support is needed to ensure that the Caribbean can not only recover, but thrive in the current global environment with the longstanding ambitions for regional integration finally fulfilled."

Jamaica urged to milk dairy goat sector Article

According to; Dr Michael Motta a Vetenarian of Jamaica, he made a case for significant investment focusing on developing the small ruminant sector, with particular attention to expanding Jamaica's dairy goat industry through embryo transfer, even as he made a call to save two of Jamaica's four tropically adapted beef herds, which are now threatened.

According to the Article; "**Jamaica urged to milk dairy goat sector"** (Writer, Jamaica urged to milk dairy goat sector, 2021)

Veterinarian Dr. Michael Motta advocated for significant investment in the development of Jamaica's small ruminant sector, with a focus on expanding the dairy goat industry through embryo transfer. He also emphasized the urgency of saving two of Jamaica's threatened tropically adapted beef herds. Speaking at the Jamaica Agriculture Industry Stakeholders' Forum at The Jamaica Pegasus hotel in New Kingston, Dr. Motta highlighted the lack of concrete steps towards achieving self-sufficiency in mutton and chevon (goat meat), which Jamaica currently imports 2.5 million kilograms of annually.

Dr. Motta underscored the historical neglect of the small ruminant sector, noting its potential for milk production. He explained that the same amount of forage given to a dairy cow could feed eight to ten goats, each producing two liters of milk per day. This equates to 16-20 liters of milk, compared to the six to seven liters typically obtained from a dairy cow. Dr. Motta suggested that supplements may also be necessary to optimize milk production in goats.

Chapter 1 Summary and purpose of the study

The study focuses on addressing the challenges faced by the small ruminant sector in Jamaica, particularly in the context of increasing food insecurity in the Caribbean region. It highlights the importance of developing the dairy goat industry through embryo transfer techniques and emphasizes the need to conserve Jamaica's threatened beef herds. The research aims to contribute to efforts aimed at achieving self-sufficiency in mutton and chevon production, given Jamaica's heavy reliance on imports for these meats.

According to recent surveys, food insecurity in the Caribbean has significantly increased since the onset of the COVID-19 pandemic, with severe food insecurity affecting a substantial portion of the population. The study underscores the urgency of implementing measures to improve food availability, access, and utilization, with a particular focus on enhancing domestic food production and agricultural productivity.

Dr. Michael Motta, a veterinarian, advocates for substantial investment in Jamaica's small ruminant sector, particularly in the dairy goat industry. He highlights the potential of goats for milk production and emphasizes the efficiency of utilizing forage to support multiple goats compared to a single dairy cow. Dr. Motta suggests that supplementing feed may further enhance milk production in goats.

Overall, the study aims to address the multifaceted challenges facing Jamaica's small ruminant sector, including the need for improved breeding programs, increased expertise, and enhanced productivity. By focusing on the development of a dual-purpose goat breed, the research seeks to contribute to efforts aimed at reducing food poverty and enhancing food security in Jamaica and the wider Caribbean region.

Chapter 2:

Research Focus

2.1 Statement of the issue to be specifically

It has been observed that the small ruminant production in Jamaica have a great problem with breed maintenance as well as technological advance methods of improving the desired traits in the goat meat price has become very expensive for consumers to afford. Hence, the farmers are unable to combat pradieal larceny due to insufficient or improper strategies put in place for farmers' food security.

The main problem is that the agricultural ministry and the team focusses mainly on large ruminants rather than boasting small ruminants, which are most and easily able to be dealt with by both farmers and buyers.

2.2 Research Questions

1. How important is a dual purpose goat breed to the small ruminant production in Jamaica?

2. What is the expected relationship between a goat breed and the climate change, meat and milk production in Jamaica?

3. What factors should be considered in the rearing of the desired dual purpose goat breed to ensure its role in increasing small ruminant productivity in Jamaica?

2.3 Description of specific research:

The objective is to explore and investigate some strategies and actions that can be done or put in place, to mitigate the challenges being faced by farmers and small ruminant organizations presently. Issus such as praedial larceny is a common obstacle farmer's face especially during Christmas period times every year. Articles, TVJ News as well as Jamaica Gleaner and Star are always highlighting challenges being faced in the Agricultural Society and majority of the challenges being faced in Jamaica is in the small ruminant production mainly goats. In Jamaica, Goats are mostly reared by farmers, due to the fact that they are easier to be fed and reproduced faster in comparison to cattle's. Jamaican at times face challenges in purchasing feeds, and it's easier to feed ruminants in comparison to non-ruminants, because ruminants mainly fed on roughages (Grasses). Hence, Jamaican farmers mainly rear goats for meat purpose (Chevon).

An alternative title for this dissertation could be; to investigate the effect a dual purpose goat breed have on the small ruminant production in Jamaica. The objective and strategies would remain the same, however this research can be conducted as a project for future references if granted the opportunity to innovate a new breed of goat in Jamaica through experience.

The three-breed crossing of a Boer (Meat), Saanen (Milk) and Alpine (Milk) breeds of goat is a way of continuing the trend of famous Jamaican scientist; Dr Thomas Lecky (1904-1994). Dr. Thomas Lecky was born on the 31st, of December 1904 in Swift River, Portland, Jamaica. He attended the Government Farm School (College of Agriculture, Science and Education) on scholarship (Icons, 2017). Where he gained first-hand experience and knowledge in the agricultural sector. He continued to reach towards his goal by being the First Jamaican Scientist to develop a three breed crossing of the Jamaica Hope Cattle. The Boer goat breed was substituted for the Kalahari goat breed due to the fact that it was the best and only goat with high dominance of good quality goat meat within the Caribbean especially in Jamaica. This goat breed is also the next best choice because it is recognized by many farmers and agricultural organizations etc.

the research also made reference to the fact that the dual purpose goat breed should have a high meat and climate change resistance. The Boer is one goat that is all inclusive of those factors.

Dr. TP (Thomas Phillip's) Lecky (1904-1988) developed the Jamaica Hope that consists of: 80% Jersey, 15% Zebu and 5% Holstein. The Jamaica Hope was a cross bred animal developed in 1910. However, in this case the investigation is to see the influence a three-breed crossing has on the goat production for both dairy and meat purpose. Dr. TP Lecky finalizes his research at the; Bodles Research Station in St. Catherine, Jamaica. In following his footstep the Bodles Research Station was also a major part of this research, where the Meat Quality Breed of Goat (Boer) data collection and observations were collected and done there. Bodles Research Station is currently focusing on the Boer Breed of Goat on the Meat Quality. Hence the focus there was on the Boer Breed only.

The aim of breeding three different breeds of different characteristics, is to improve on the small stock productivity in Jamaica, since majority of the focus for ruminants is on the cattle industry. The Jamaica Gleaner highlighted a Vetenarian known by the name of; Dr. Michael Motta. He spoke on how investments and focuses should be on the goat production in particularly the goat milk production, since goat milk is a healthier dairy substance for human consumption, in comparison to cow's milk. He also explain in Jamaica as for ruminants, the focus is mainly on the cattle industry and less on the small ruminant industry. He urges Jamaica to invest in goat milk and with the use of good breeds of goats for good milk and meat quality produce. He also made mention that they needs to be more focus on the small stock production in Jamaica such as; more research to be done, more focus on improving the productivity and markets (Writer, 2021). This is the very one good reason to gain the motivation to carry out this investigation and futuristic research in this field area.

2.4 Importance of the Research:

This research is being carried out due to the crisis being faced in the small ruminant production in Jamaica. The research is important in improving and maintaining the goat breed in the small ruminant industry in Jamaica.

The research of major beneficial to farmers, teachers, Vetenarians, small ruminant organizations, Animal Breeders etc.

- Farmers will benefits from this research due to the fact that they would retrieve ideas and techniques to carry on the legacy if a dual purpose goat breed by raising the animal and selling them to vendors and other personnel's.
- Teachers will benefit from this research especially those teachers that teaches Science or Agriculture Science. They can broadcast the knowledge to students from High School level, so they can be introduced to technological activities and experiments that are done in agriculture as well as they themselves can see it as an opportunity to be innovative as a youth in agriculture farmer as seen in many agriculture shows and news. Teachers could also use this opportunity as their own benefit, integrating knowledge gained as be their own Agri Entrepreneur by raising or coordinating a farmer filled with Dual Purposed Goat for both milk and meat combination.
- Vetenarians can benefit from this research being that they will gain the knowledge and understanding of a new breed of animal as well as have to carry out embryo transplanting for faster production and
- Small Ruminant Organizations can benefit from this research by carrying out their own production and having to boost farmer's interest in rearing small ruminants for a dual breed purpose, hence, they will be able to make their organization more marketable to other Caribbean countries and even European countries.
- Animal Breeders can benefit through their breeding methods of increasing the quantity of a dual purpose goat breed in Jamaica.

2.5. Definition of Terms:

- Dual: composed or consisting of two people, items, parts, etc., together; (DICTIONARY, 2012)
- Breed: to produce (offspring) by hatching or gestation (Webster, 2023)
- Meat: the flesh of animals as used for food: in particular, mammals, especially livestock and game, and often including poultry and game birds. (Dictionary, 2012)
- Goat: an animal related to sheep that usually has horns and a beard. Goats live wild on mountains or are kept on farms to provide milk, meat, wool, etc. (Assessment, 2023)
- Production: Production is the process of making or manufacturing goods and products from raw materials or components. (Tomasetti, 2023)
- Ruminant: relating to two suborders (Ruminantia and Tylopoda) of even-toed hoofed mammals (as sheep, oxen, deer, and camels) that chew the cud and have a complex 3- or 4-chambered stomach (Webster, ruminant, 2023)
- Livestock: Livestock (singular or plural) is any domesticated mammal intentionally reared in an agricultural setting for the purposes of profit or subsistence, whether for food, fiber, dairy, draft, breeding, sport purposes, or other product or labor.
- Saanen: any of a Swiss breed of usually white and hornless short-haired dairy goats. (Webster, Saanen, 2024)
- Alpine: The French-Alpine is a breed of goat that originated in the Alps. The goats of Alpine breed that were brought to the United States from France where they had been selected for much greater uniformity, size, and production than was true of the goats that were taken from Switzerland to France. (UNIVERSITY, 2024)
- Boer: **Boer**, South African breed of goat, the most productive meat goat in the world. (Britannica., 2024)

2.6. Theoretical Framework

Thus research problem exist because of how the small ruminant production in Jamaica was dealt with in comparison to large ruminant.

Jamaica has a big problem in breed maintenance hence, majority of the breeds of animals such as the Jamaica hope is now on the bridge of dying out.

Due to this issues the goat breeds now in Jamaica are used mostly for meat purpose, however Jamaica has recently started.

1. **Adaptive Livestock Breeding:**
    - Utilize principles of quantitative genetics to select breeding stock with desirable traits for both meat and milk production, including growth rate, milk yield, and composition.
    - Incorporate genomic selection methods to identify genetic markers associated with heat tolerance, disease resistance, and productivity traits.
    - Apply selective breeding strategies to develop a genetically diverse and resilient goat population capable of thriving in diverse climatic conditions.
2. **Physiological Adaptations to Climate Change:**
    - Investigate physiological mechanisms underlying heat stress responses in goats, including thermoregulation, water balance, and metabolic adjustments.
    - Assess genetic variability in heat tolerance traits and physiological adaptation mechanisms across different goat breeds and populations.

- Explore potential interactions between heat stress and production traits, such as milk yield, reproductive performance, and meat quality.

3. **Nutritional Strategies for Resilience:**
    - Evaluate dietary interventions to mitigate the negative effects of heat stress on nutrient utilization, metabolic efficiency, and production performance.
    - Investigate the role of alternative feed sources, dietary supplements, and management practices in enhancing resilience to climate-induced challenges.
    - Optimize nutrient requirements and feeding strategies to support both meat and milk production while minimizing environmental impacts.
4. **Environmental Sustainability:**
    - Assess the environmental footprint of goat production systems, including greenhouse gas emissions, land use, and water usage.
    - Explore sustainable land management practices, such as agroforestry, rotational grazing, and soil conservation, to mitigate climate change impacts and enhance ecosystem resilience.
    - Investigate the potential for integrating goats into diversified farming systems to enhance resource efficiency, biodiversity, and resilience to climate variability.
5. **Economic Viability and Livelihood Security:**
    - Conduct economic analyses to evaluate the profitability and viability of dual-purpose goat production systems under changing climatic conditions.

- Assess the socio-economic impacts of adopting improved goat breeds and management practices on farm incomes, livelihoods, and food security.
- Identify barriers and opportunities for scaling up sustainable goat production systems and enhancing market access for goat products.

6. **Policy and Institutional Support:**
    - Evaluate policy frameworks, institutional arrangements, and extension services supporting sustainable goat production and climate adaptation strategies.
    - Advocate for policies promoting genetic diversity, animal welfare, and resilience-building initiatives within the livestock sector.
    - Engage stakeholders, including farmers, policymakers, researchers, and civil society organizations, in collaborative efforts to address climate change challenges in goat production.

By integrating these theoretical perspectives, researchers can develop holistic approaches to breeding and managing goats for dual-purpose production while enhancing resilience to climate change, thereby contributing to sustainable agricultural development and livelihood security in goat-rearing communities

Chapter Summary;

The small ruminant production industry in Jamaica is facing significant challenges, primarily related to breed maintenance and technological advancements. These challenges have led to a surge in goat meat prices, making it unaffordable for consumers, and consequently, farmers are struggling to combat Praedial larceny due to inadequate food security strategies. The main issue stems from the agricultural ministry's focus on large ruminants, neglecting the potential of small ruminants, which are more manageable for both farmers and buyers.

The research aim to address these issues by exploring strategies to mitigate challenges faced by farmers and small ruminant organizations. Praedial larceny, especially during Christmas periods, poses a common obstacle for farmers. Goats, mainly reared by Jamaican farmers, are easier to manage and reproduce compared to cattle. However, challenges in purchasing feeds persist, highlighting the need for innovative solutions to enhance small ruminant productivity. The research proposes a three-breed crossing of Boer (meat), Saanen (milk), and Alpine (milk) goat breeds to improve small stock productivity in Jamaica, drawing inspiration from the work of renowned Jamaican scientist Dr. Thomas Lecky. Furthermore, the study emphasizes the importance of investing in goat milk production, as advocated by veterinarian Dr. Michael Motta, to address the imbalance in focus between cattle and small ruminants in Jamaica. Through this research, stakeholders such as farmers, educators, veterinarians, small ruminant organizations, and animal breeders stand to benefit by gaining valuable insights and strategies to improve small ruminant production in Jamaica, ultimately contributing to agricultural sustainability and livelihood security.

Chapter 3:

Review of Other Work Done

Literature Review

This is the literature review section of the research on which; "The Influence of a new developed dual purposed goat breed to be able to tackle climate change, meat and milk production in Jamaica. This section answers provides detailed information on the different goat breeds and feeding programme required for the different breeds. Goats are one of the most economically viable and easily procured livestock that falls under ruminants. Their temperance, popularity, growth rate and reproduction rate make it attractive for small time farmers to invest in. this goes without saying that other farmers and individuals invests in it on a much larger scale. Regardless of Praedial larceny and the negative economic impact on goat meat or milk in Jamaica and other countries, farmers continue to invest in this production. Jamaica produces an estimated 15% of goat meat on the local markets but ridiculously imports a whopping 85% according to (Push for better goat meat, 2021). Small ruminant production is very significant to livestock production throughout the world, especially in developing countries. The small ruminant production market expresses the gap where there is room for improvement with the goat industry. Like factors such as climate change/differences and nutrition affect breeds of goat in situations where they are introduced to different countries. The characteristic of a breed is important to the availability of meat and milk and other by-products in the goat industry.

Boer

Boer breeds in contrast are a highly desired breed for meat production in the goat industry. They are sturdy with the trait to adapt to a variety of climates as well as a tolerance for various diets. According to (Lu, 2002) because of its meat quality and excellent growth rate they have been used in production worldwide to improve the quality of other pure-bred goats through cross breeding. With correct nutrition and environment Boer breeds

can grow up to 130kg (286 lbs) and 100kg (220 lbs) at full maturity in bucks and does respectively.

- Population of Boer in the world and Jamaica
- Population of Saanen in the world Jamaica
- Population of alpine in the world Jamaica

Nutrition for goats

Nutrition is vital for living organisms as this helps with metabolic processes, which ultimately leads to growth, development and reproduction. Nutrition is assimilated from food materials the living organisms ingest. This simply outlines the general importance of nutrition in living organisms; however, nutrition varies based on the type of living organisms. For goats which are ruminants (animals with four compartments) and are browsers their diets consist mostly of brushy vegetation and from time to time woody and weedy vegetation's, according to (Rashid, 2008).

Commercial reared goats intake supplemental feed as a part of their diet along with forages. They can assimilate various fibre and roughage in large portions. Age, sex, breed, production system (dairy or meat), body size, climate and physiological stage are defining factors for their nutrient requirements. The daily feed intake of goats' ranges from 3-4% of body weight as expressed in pounds (dry matter/head/day). The daily feed intake is influenced by body weight, % of dry matter in the feeds eaten (12-35% in forages, 86-92% in hays and concentrates), palatability, and physiological stage of the goats (growth, pregnancy, and lactation). (Rashid, 2008).

Water

Water is an essential nutrient to all animals. But just as how water is important, it is also necessary that an animal receives water in correct proportions. Goats acquire water or moisture through feeding and the intake of water. Through the assimilation of green forage as this contains more

moisture than that found in fodders such as hay; consuming large quantities of green forage will cause the animal to intake less amount of water, while the opposites serve to be true when goats consume fodders.

Aside from the type of feed consumed, the water intake of goats is governed by the determinants: lactation, temperature/climate, developmental and growth stages and the amount of exercise they receive each day (Pugh, 2020). A lactating goat will need to be in taking 0.9-1 litres more for every 1 pint (0.6 litres) of milk produced. The average goat requires 9 to 13 litres of water daily and much less depending on how much forage the animal ingests; more if the feed is fodder. The increase in water for lactating does will allow for the suckling of kids and for the overall production of milk commercially (Goats, 2019).

A goat will consume up to four percent of its body weight as the amount of feed they consume is largely dependent on their body weight, feed preference, the physiological stages including growth, pregnancy and lactation and percentage of dry matter content present in the feeds.

The dry matter intake with relative proportion to bodyweight is important to the amount of feed the goat requires. Feeds that have more dry matter content compared to water content is richer in energy and protein therefore these are usually concentrated feeds. According to (Gooden, 2016) the dry matter intake as a percent of the goats' bodyweight is taken into consideration by the factors that the animal is dry/early pregnant (3% of bodyweight), late pregnant/lactating (4.5% of bodyweight), recently weaned kids (6.5% of bodyweight) and growing kids (4% of bodyweight).

Feeding Programmes

A feeding programme is an integrated aspect of most animal production farms, which undertakes strict scheduled feeding for the animals. This ensures that the correct physiological stages of the animal are met with precise feeding times and types of feed (concentrates and forages) so that maximum production is met. Feeding programmes are most important that the animals acquire the target or market meat and milk quantity and

quality. Balanced nutrients are provided for the animals daily. Most feeding programmes for goats are better suited when they are fed with either a mixture of forages and concentrates or with a combination of forages and protein-based vegetation. Concentrates are not to be fed solely to goats for the negative impact which it may have if too much is ingested.

A feeding programme which is not an integrated aspect of most farms in Jamaica especially at the small-scale level should be done with effective record keeping, but most importantly the type of grazing systems that will be effectively integrated in the production. Worldwide a variety of grazing systems exists, some utilized more than others depending on land size, topography, soil type, the animals being reared and the number of animals which exists. In Jamaica, the most popular grazing management systems that are utilized are intensive system, semi-intensive system and extensive system.

Intensive systems are utilized when famers want to have full control over the feeding of their goats. The animals are not allowed to graze in open pastures or paddocks; instead, the forage is cut, chaffed and distributed in feeding troughs for the goats to consume (zero grazing). They are provided with water and feed in this fashion throughout the entire production. According to (Ministry of Agriculture & Fisheries, 2010) intensive management systems ensures that the animals obtain the specific requirements of 3-5% of their body weight in dry matter. Sixty percent (60%) of the dry matter should be from forages combined with nutritive vegetation for protein and forty percent (40%) from concentrates (processed feed). It is capital and labour intensive due to the need of building infrastructures to house the animals and procurement of machineries along with the labour force to provide the feed for a great number of housed goats. The system facilitates better control of the animals' health and development and overall meat and dairy production.

The Ministry of Agriculture & Fisheries, 2010, outlined that **semi-intensive management systems** are designed with rotational grazing as the main source of feed for the animals. The animals are released into open spaces

such as pasture or paddocks. Pastures are wide open spaces for intensive grazing while paddocks are pastures divided up into smaller more manageable units/sections for grazing. The animals remain outside for a maximum of 42 days after which the pastures and paddocks are allowed 32 days free of goats on a rotational basis for regrowth. Rotating the animals allows for the disruption of worm cycles and prevents severe parasitic worm infestation in goats. The longer a goat remains in an area with passed faeces, the higher is the risk of the parasitic worm entering the goat's digestive system. At nights the animals are returned to the housing infrastructures and fed grain supplements that accounts for 2% of their body weight in dry matter.

Extensive management systems

In the free-ranging or extensive management system for small ruminants in the Caribbean, the animals typically stay in open areas, communal lands, or natural landscapes during the day, where they graze and forage freely. However, at night, they are often brought back to secured enclosures such as pens or paddocks. These enclosures provide protection from predators and other potential risks during the night, ensuring the safety and well-being of the small ruminants. This practice allows the goats and sheep to roam freely during the day, engaging in natural grazing and foraging behaviours, while providing them a safe and sheltered space to rest and recuperate at night (Venereo & Hermosillo, 2014).

This traditional approach allows the animals to graze and forage freely in open fields, pastures, or natural landscapes without confinement. They have access to a diverse range of vegetation, including grasses, forbs, and browse, which provides a varied and nutritious diet. Limited supplemental feeding may be provided during periods of forage scarcity or adverse weather conditions. This management system promotes exercise and allows small ruminants to express natural behaviours. It generally requires lower input costs compared to intensive systems and aligns with sustainable agricultural practices, as it relies on the natural resources available in the environment. However, free-ranging systems also present challenges,

including exposure to parasites, predators, and the risk of overgrazing if pasture management is not properly implemented. Proper herd health monitoring and management are essential to ensure the well-being and productivity of small ruminants in free-ranging systems (Venereo & Hermosillo, 2014).

Concentrates

Concentrates are high energy and protein feed for goats that adds a balance to the goats' nutritional diet. Concentrates can be grains such as corn, oats and sorghum or maybe a commercially generated feed (processed feed) that is a combination of a variety of feeds in order to achieve a certain nutritional value (Kerr, Conway, Tuck, Hammond, & Olson, 2017). Concentrates are better suited for goats that requires high energy such as weaned kids, pregnant and lactating goats. This will allow for the goats to meet a specific need through balanced nutrition. Concentrates are high in energy and protein and may prove to be harmful to the animal if they are fed too frequently in high amounts. The animal may develop conditions that causes an excessive production and build-up of acids in the rumen (first stomach of a ruminant), known as ruminal acidosis (Hardcastle & Lear, 2020). Using concentrates as part of a feeding programme for quick and proper development in goats should take into consideration proper management and record keeping; so that it ensures that goats at physiological stages are kept apart so that are given the correct proportion of concentrated feed and to decrease competition.

Forages

Forages are lower in energy compared to concentrates; therefore, goats are fed in larger portions to substantiate their body weight. Goats consume grasses such as king grass and this is at times mixed with leguminous vegetation such as alfalfa to introduce protein to the goats' diet. Proteins are given in small proportions can cause deficiencies within the animal.

To sustain a newly developed breed in the island of Jamaica and possibly the wider reaches of the Caribbean, great focus and or emphasis is required as it relates to forage.

Types of forages for Goats	
Grasses	
Forage	**Description**
Pangola Grass	Pangola grass is a warm-season grass commonly found in tropical regions. It is highly palatable and nutritious, making it an excellent choice for goats' nutrient management. It is rich in protein and minerals, contributing to the animals' overall health and productivity Pangola grass is used extensively for pasture, hay and silage. It withstands very heavy grazing. Regular grazing (2-3 week intervals) at 10-15 cm to 30-40 cm height is necessary to maintain the quality of pangola grass (Archimède, Tran, & Heuzé, 2015).
Guinea Grass	Guinea grass is another popular choice for goats in the tropics. It is a high-yielding, fast-growing grass that provides ample forage for grazing animals. Guinea grass is rich in energy and fiber, promoting healthy digestion and sustained energy levels in goats. Feeding goats with Guinea grass gives better results when it is supplemented with a legume or a crop residue-based concentrate (Heuzé & Tran, 2020).
Napier Grass	Napier grass is a widely cultivated tropical grass that offers excellent nutritional value for goats. It has a high crude protein content, making it suitable for lactating and growing goats. Additionally, Napier grass is easily digestible and helps in maintaining good rumen health. Elephant grass can be grazed, provided it can be kept at the lush vegetative stage: livestock tend

	to feed only the younger leaves (Heuzé, Tran, Giger-Reverdin, & Lebas, 2020).
Trees	
River Tamarind	Leucaena is a leguminous tree that provides high-quality forage for goats. It is rich in protein and essential minerals, making it a valuable addition to the goats' diet. Leucaena leaves are highly palatable and easily digestible, promoting healthy rumen function and improved nutrient absorption (Heuzé & Tran, Leucaena (Leucaena leucocephala), 2015).
Black Mulberry	Mulberry leaves are highly palatable to goats and contain a relatively high protein content, making them a valuable addition to the animals' diet. The protein content in mulberry leaves depends on the variety and growing conditions (Heuzé, Tran, & Lebas, Black mulberry (Morus nigra), 2019).
Moringa	Moringa trees are known for their high nutritional value. The leaves are packed with protein, vitamins, and minerals, including calcium and iron. Moringa leaves can be dried and stored for feeding goats during dry seasons or as a supplement to their regular diet (Heuzé, Tran, Hassoun, Bastianelli, & Lebas, 2019).

Fig 1. Table showing types of forages for goats

	DM % as fed			**CP % of DM**			**CF % of DM**		
	Fresh	**Hay**	**Seeds/Pods**	**Fresh**	**Hay**	**Seeds/Pods**	**Fresh**	**Hay**	**Seeds/Pods**
Pangola	27.1	81.3		8.1	7.9		36.3	35.5	
Guinea	22.7	89.8		11.2	9.1		37.3	36.7	
Napier	17.9	89.3		9.7	10.3		36.1	35.6	
Leuceana	29.9	23.8	89.6	23.3	26.1	31.9	19.9	23.2	15.6
Mulberry	34.7			20.3			13.4		
Moringa	26.2	91.2	10.7	24.3	26.8	17.6	13.6	12.2	33.5

Fig 2: Table showing percentage of feed containing, Crude protein and crude fiber as well as crude protein.

Proteins undergo digestion and break down into amino acids, which are then absorbed in the small intestine. These amino acids serve as essential building blocks for body proteins, particularly in muscle development. The rumen plays a significant role in breaking down consumed proteins into bacterial protein through fermentation. Common protein sources for goat rationing include forages, hays, pellets (like alfalfa), barley, peas (screenings, whole, split), corn, oats, and various meals (such as soybean, canola, cottonseed meals). Protein requirements are higher during growth (kids), milk synthesis (lactation), and mohair growth. Producers may need to supplement protein at times, especially in late fall or winter. Cost-effective rationing is vital for commercial goat operations due to the potential costliness of proteins. High-quality hay typically requires minimal protein supplementation for goats. If the hay has approximately 12-13% protein content, provide ½ lb of protein source, like corn, barley, peas, or oats (with 20% protein in total). For average-quality hay, add one pound of protein as a supplement (Rashid, Essential Nutrients, 2008).

Carbohydrates like sugars, starches (found in grains), and fibre (cellulose) are converted into energy (volatile fatty acids) by beneficial bacteria in the goat's rumen. The normal goat diet, consisting of browse, forbs, and grasses, is rich in cellulose, which requires digestion by rumen flora to provide energy. Young and fresh pastures may offer higher energy levels due to their more digestible fibre compared to older plants. Energy levels are represented as total digestible energy (%TDN) in feed analysis reports, with a recommended minimum of 12% crude fibre in the diet (Rashid, Goats and their Nutrition, 2008).

Energy requirements vary based on different physiological stages such as maintenance, pregnancy, lactation, and growth. Dairy kids, in particular, require 21% higher energy than average goats for maintenance. High-energy

rations should be provided during breeding, late gestation, and lactation, with lactating does having the highest energy demand. Proper attention to energy intake is crucial for meeting the specific nutritional needs of goats throughout their life stages, ensuring optimal health and productivity (Rashid, Goats and their Nutrition, 2008).

Goats require specific **minerals** and **vitamins** for their maintenance and proper physiological function. It is crucial to include fat-soluble vitamins (A, D, E, K) in their diet since goats cannot synthesize these vitamins on their own. Rumen flora can provide sufficient vitamin B for goat metabolism. Additionally, vitamin C is essential for supporting their immune system. Macro minerals like calcium, phosphorus, magnesium, sodium, potassium, sulfur, and chlorides are vital components of a goat's diet. Micro minerals, such as iron, copper, cobalt, manganese, zinc, iodine, selenium, molybdenum, and others, are typically supplemented in goat rations. Feed tags express micro minerals in parts per million (ppm) and macro minerals as a percentage of the diet. Ensuring proper mineral and vitamin intake helps maintain the overall health and well-being of goats (Rashid, Goats and their Nutrition, 2008).

Common parasites and Diseases that affect goats

External Parasites

1. **Nose Bot Fly:** The nose bot fly (Oestrus ovis) is a common parasite of goats in many regions, including the Caribbean. Adult flies lay their eggs around the goat's nostrils, and upon hatching, the larvae crawl up into the nasal passages. Once inside, the larvae feed on the nasal tissues and secretions, causing irritation and inflammation. This infestation is known as "bots in the nose." The presence of these larvae can lead to discomfort for the goat, with symptoms like nasal discharge, sneezing, head shaking, and respiratory distress. In severe cases, the larvae may migrate to the sinuses or brain, causing more significant health issues. Preventive measures, such as keeping the goats away from areas frequented by the bot flies and using approved insecticides, can help control the infestation (Talley, 2016).
2. **Mites:** Mites are ectoparasites that can infest goats and cause skin problems. Sarcoptes and Chorioptes mites are common mite species affecting goats. Sarcoptic mange, caused by Sarcoptes scabiei, is highly contagious and causes intense itching and irritation. The goats may scratch excessively, leading to hair loss and skin lesions. Chorioptic mange, caused by Chorioptes bovis, is less contagious but can still cause skin irritation, especially on the lower legs and feet. Regular inspections and prompt treatment with acaricides can help manage mite infestations. Additionally, maintaining good hygiene and managing the goats' environment can reduce the risk of mite problems (Talley, 2016).
3. **Ticks:** Ticks are external parasites that feed on the blood of their hosts. In goats, tick infestations can lead to anemia, especially in heavy infestations. Ticks can also transmit various diseases, such as anaplasmosis and babesiosis, which can have severe health consequences for the goats. Tick prevention and control are crucial to maintaining goat health. Measures such as rotational grazing, where

goats are moved to different pastures periodically, can help reduce tick exposure. Using acaricides and implementing integrated pest management strategies can also aid in controlling tick infestations (Talley, 2016).

Internal Parasites

1. **Lung Worms:** Lung worms cause irritation in the bronchioles of the lungs, leading to the production of mucus and white blood cells to combat the parasites. This irritation results in coughing as the animal tries to alleviate the discomfort (Villarroel, 2013).
2. **Stomach Worms:** Stomach worms are aggressive bloodsuckers that damage the stomach lining to access the bloodstream. This destruction can lead to colic, diarrhea, anemia, and weight loss, as the animal struggles to digest feed effectively (Villarroel, 2013).
3. **Liver Flukes:** Liver flukes create tunnels in the liver, causing scarring as the body attempts to repair the damage. The scarring impairs the liver's function, including blood filtration, leading to toxin buildup that can harm other organs, including the brain. Depression or stupor may be observed as signs of liver fluke infestation (Villarroel, 2013).
4. **Coccidia:** Coccidia reside in the intestinal lining and destroy the crypts responsible for nutrient absorption. Diarrhea (evidenced by dirty hind ends) and failure to thrive or weight loss are common indicators of coccidian infestation (Villarroel, 2013).

Diseases

1. **Brucellosis:** Brucellosis, caused by the bacterium Brucella melitensis, is a zoonotic disease that affects goats and poses a risk to human health. Infected goats can experience abortion, stillbirths, and reproductive disorders, leading to economic losses in breeding herds. The disease is transmitted through contact with infected birthing materials, aborted fetuses, and the placenta. Infected goats may exhibit symptoms such as infertility, swollen joints, and weight loss. Control measures, including vaccination and culling of infected animals, are essential to prevent the spread of brucellosis in goat populations and protect human health (Extension Foundation, 2019).
2. **Escherichia coli (E. coli):** Escherichia coli is a common bacterium that can cause gastrointestinal infections in goats. It is typically transmitted through contaminated food, water, or environmental sources. Infected goats may experience diarrhea, dehydration, and lethargy. Young and immunocompromised goats are particularly susceptible to severe infections. Proper hygiene, sanitation, and management practices are crucial in preventing and controlling E. coli outbreaks in goat herds.
3. **Orf (Contagious Ecthyma):** Orf is a viral disease caused by the Orf virus and commonly affects goats. It presents as contagious pustular dermatitis, characterized by painful, raised sores or pustules on the lips, mouth, and udder area. The disease is highly contagious and can be transmitted through direct contact with infected animals or contaminated surfaces. Infected goats may experience pain, difficulty eating, and reduced milk production. Preventive measures, such as vaccination and good hygiene practices, can help manage orf outbreaks and reduce its impact on goat herds (König & Peralta, 2023).

4. **Salmonellosis:** Salmonellosis is caused by various strains of the Salmonella bacterium and can affect goats, causing severe gastrointestinal infections. Infected goats may experience diarrhea, fever, loss of appetite, and dehydration. Salmonellosis can spread rapidly within a herd and poses a risk of zoonotic transmission to humans. Preventive measures, including proper sanitation, quarantine procedures for new animals, and management of feed and water sources, are essential to control and prevent salmonellosis in goat populations (Grünberg, 2022).

Proactive herd management, biosecurity measures, and regular health monitoring are vital for preventing and controlling these diseases in goats. Early detection and prompt veterinary intervention can minimize the impact of these diseases and ensure the well-being and productivity of the goat herd.

Strengths and Weaknesses

Strengths:

1. Holistic Approach: Researching a dual-purpose goat breed to address both meat and milk production while considering climate change in Jamaica demonstrates a comprehensive and integrated approach to agricultural sustainability. This approach recognizes the interconnectedness of various factors affecting goat farming and seeks to develop solutions that address multiple challenges simultaneously.
2. Potential for Impact: Developing a dual-purpose goat breed that is resilient to climate change while maximizing meat and milk production has the potential to significantly benefit Jamaica's agricultural sector. Such a breed could improve food security, enhance farmer livelihoods, and contribute to the country's efforts to mitigate and adapt to climate change.

3. Innovation and Research Contribution: Conducting research on a dual-purpose goat breed represents an opportunity for innovation and advancement in the field of animal science. By investigating breeding strategies, genetic traits, and management practices, researchers can contribute valuable insights to the scientific community and inform future breeding programs.

4. Alignment with National Priorities: Addressing the challenges faced by small ruminant farmers in Jamaica aligns with national priorities related to agricultural development, food security, and climate resilience. Researching a dual-purpose goat breed that can thrive in Jamaica's climate while meeting the demand for meat and milk products supports the country's efforts to promote sustainable agriculture and rural development.

Weaknesses:

1. Complexity of Research: Researching a dual-purpose goat breed to tackle meat and milk production while addressing climate change is a complex endeavour that requires interdisciplinary expertise and resources. Balancing the diverse objectives of the research may pose challenges in terms of experimental design, data analysis, and interpretation of results.
2. Resource Constraints: Conducting comprehensive research on a dual-purpose goat breed may require significant financial, technical, and logistical resources. Limited funding, infrastructure, and research capacity could impede the progress and scope of the research, potentially limiting its impact and applicability.
3. Long-Term Commitment: Developing a successful dual-purpose goat breed that addresses multiple objectives and adapts to climate change may require a long-term commitment from researchers, policymakers, and stakeholders. Sustaining interest, investment, and collaboration over an extended period could be challenging, especially in the face of competing priorities and changing socio-economic conditions.
4. Adoption and Implementation Challenges: Even if a dual-purpose goat breed is successfully developed through research, its adoption and implementation by small ruminant farmers may face barriers such as limited awareness, access to breeding stock, and technical support. Overcoming these adoption challenges and ensuring the scalability and sustainability of the breed will require targeted extension efforts, policy support, and stakeholder engagement.

Chapter 4:

Research Methods

4.1 Goals and Objectives of the Research.

The Goals and Objectives of this research are;

- To improve milk and meat herd quality in Jamaican Small stock industries
- To provide farmers with better and greater opportunities of rearing and producing an animal which will be needed in high demand
- A reduction in costly effect farmers has on investing in pest control supplies.
- To have farmers rearing this type pf animal in all 14 parishes in Jamaica, where the animal will be susceptible to any climatic condition, especially tropical climatic areas e.g. Clarendon, St. Elizabeth etc.
- To provide opportunities of future scientist and college graduates from Colleges sand Universities of Agriculture to further studies and researches surrounding the innovated dual purpose goat, breed.
- Contribute to sustainable livestock farming by producing goats that require less intensive management and input while maintaining productivity.
- Reduce the environmental impact of goat farming through more efficient resource utilization.
- Integrate genomic selection methods to accelerate genetic progress.
- Identify genetic factors associated with heat tolerance and resilience.
- Develop management practices and housing systems to mitigate heat stress effects.
- Conduct cost-benefit analyses of breeding programs and management interventions.

- Evaluate the economic viability of producing the new goat breed in different geographical regions.
- Assess the environmental footprint of goat farming, including greenhouse gas emissions and resource usage.
- Compare the environmental sustainability of the new breed with existing breeds.
- Identify strategies to minimize environmental impacts through improved management practices.
- Publish research findings in scientific journals and present them at conferences.
- Develop extension programs to educate goat farmers and stakeholders about the benefits of the new breed.
- Collaborate with agricultural agencies and industry partners to facilitate the adoption of research outcomes.
- To reduce food poverty and in the small ruminant production in Jamaica.

4.2. Research Hypothesis:

"Through selective breeding and management interventions, it is hypothesized that a newly dual purpose goat breed developed specifically for Jamaican climatic conditions will exhibit significantly improved milk and meat quality traits compared to existing goat breeds, while also demonstrating enhanced resilience to heat stress."

4.3. Research Strategy and Techniques:

The Research strategies and techniques may involves a combination of approaches encompassing genetics, physiology, nutrition, management, and environmental considerations. Here are some research strategies and techniques that could be employed:

1. **Genetic Selection and Breeding:**

- Utilize genomic analysis and marker-assisted selection to identify and breed for desirable traits related to milk and meat quality as well as heat stress resilience.
- Conduct pedigree analysis to trace hereditary traits and select breeding stock with favourable genetic backgrounds.
- Implement controlled mating strategies to maximize genetic diversity and minimize inbreeding.

2. **Phenotypic Evaluation:**

- Assess milk composition including fat, protein, lactose, and total solids content through laboratory analysis.
- Evaluate meat quality parameters such as tenderness, flavor, juiciness, and nutritional composition using sensory evaluation and instrumental techniques.
- Monitor physiological responses to heat stress, including respiration rate, rectal temperature, and sweat rate measurements.

3. **Heat Stress Management:**

- Establish controlled environmental conditions to simulate heat stress and evaluate the response of goats from different genetic backgrounds.
- Implement cooling strategies such as shade provision, sprinkler systems, and evaporative cooling pads to mitigate heat stress effects.
- Monitor behavioural adaptations to heat stress, such as changes in feeding and drinking behavior, seeking shade, and resting patterns.

4. **Nutritional Strategies:**

- Formulate diets tailored to meet the nutritional requirements of goats for optimal milk and meat production under hot climatic conditions.
- Evaluate the efficacy of feed additives, such as antioxidants and osmolytes, in mitigating heat stress and enhancing production performance.
- Investigate the use of alternative forage species and supplementation strategies to improve nutrient utilization and heat tolerance.
-

5. **Management Practices:**

- Implement rotational grazing systems to optimize forage utilization and minimize heat exposure during the hottest times of the day.
- Develop housing designs that promote natural ventilation, thermal comfort, and shade provision for goats.
- Train farmers in heat stress management practices and animal welfare protocols to enhance the resilience of goat herds.

6. **Environmental Impact Assessment:**

- Conduct life cycle assessments to evaluate the environmental footprint of goat production systems, including greenhouse gas emissions, water usage, and land use.
- Investigate the potential for integrating goats into agroforestry systems to enhance ecosystem services and mitigate climate change impacts.
- Assess the economic viability and sustainability of adopting improved goat breeds and management practices in Jamaican agriculture.

7. **Community Engagement and Stakeholder Collaboration:**

- Collaborate with local farmers, extension agents, and agricultural organizations to ensure relevance and applicability of research findings.
- Facilitate knowledge exchange through participatory research approaches, field days, and farmer training workshops.
- Solicit feedback from stakeholders to guide research priorities and promote adoption of sustainable goat production practices.

4.4. Methods of Data Collection and Analysis

The research took place within five selected parishes in Jamaica, they are St. Catherine, Portland, St. Mary, St. Ann and St. Elizabeth & Manchester Data was collected from these named parishes through a random and selective selection process. Questionnaires were issued to individuals located in the parishes both; softcopy and hardcopy for completion. The question was a form of quantitative data analysis. While on the other hand, persons from the same parishes took part in a face to face and virtual interviews in the form of a qualitative data analysis.

Throughout the data collective process, persons from different areas in the agricultural sector was chosen to give their point of views on the influence that a dual purpose goat breed with good milk and meat quality and at the same time be able to tackle climatic conditions to improve the small stock sector in Jamaica.

Also, despite another interesting method of collecting data was done, which involved collecting data from the relevant Small Stock industry itself to have an estimation of what the possible offsprings would be like after cross breeding procedures.

The aim of the research to cross three breeds of goat, Saanen, Boer and Alpine, they all have their specific characteristics which does adds to the dual purpose goat offspring being produced to contribute to three different characteristics simultaneous.

The Bodles Research Station in Old Harbour, St. Catherine, Jamaica was used to collect sources of data to help with the estimation. Top Vetenarians goat farms was used as a source of data collection as well.

In summary data was collected using; questionnaires, interviews, data retrieved from goat farmers as well as the Research Station for Small Stock animals in Jamaica.

4.5. Verification Ethical Considerations:

The research objective is a proposal on "*The Influence of a new developed dual purposed goat breed to; tackle climate change, meat and milk production and to increase the marketing of small ruminant production in Jamaica".* However, aside from the fact that it's just an investigation, it's important for ethical considerations to take place. Within this research ethical procedures that took place as follows;

- Respondents was told within their questionnaire form that their information is confidential and no name is required for documentations.
- Interviewers was told that the meeting is being recorded only for reviewing purposes and will be remained confidential.
- Upon visiting the Bodles Research Station in Jamaica that rears and conducts various researches on small stock ruminants, it was required to submit a permission letter sent from my intuition which is AIU, giving permission for the research to take place on the researcher behalf.
- A letter was also written personally by the researcher seeking permission to conduct the research details of what will be done was included as well as days and time frame to enter and leave the compound. All information collected from the institution remained confidential at all times.

Chapter 5: Results of Statistical Analysis

5.1 Interpretation of Results

Questionnaire Respondents Results/ Reviews.

Questionnaires was sent out to the different persons selected from the various parishes indicated. However, the questionnaire was issued both softcopy and hardcopy. The responses are the same. Below there is a table showing the questions that the respondents saw and selected their opinion on each question and statements.

Respondents after reviewing the questions, they also gave their point of view verbally on their reason for choosing their answers and why. They also expounded on the topic using current factors happening in the small ruminant industry and relates it to the investigation to show a realistic view.

Members are used to determine the amount of persons that select the specific aspect whether; Agreed, Disagreed, Satisfactory or Poor under each questions. Respondents name and personal information remained confidential throughout the investigation and data collection.

No.	Questions	Agreed	Disagreed	Satisfactory	Poor
1	There is a big issue in the goat industry, where the covid-19 pandemic decrease the amount of goat meat produce due to lacking in funds.		3		
2	Goat Farmers are facing tragic challenges raising their animals due to Praedial larceny.	3			
3	Sometimes goats suffer from disease and pest in affecting them internally and externally	3			
4	A new goat breed that can be used for meat and milk would increase the marketing in the small ruminant production	1	1	1	

5	Goat milk is healthier and better for people with lactose intolerance issues in comparison to cow's milk.	3			
6	A farmer rearing a goat for both milk and meat produce, can earn twice more than just rearing for meat purpose	3			
7.	A new cross-bred goat breed with high milking produce, high quality meat can increase the food security in Jamaica and produce healthier milk for persons with chronic illnesses	3			
8.	Farmers and agricultural organizations can earn more with a new developed goat breed with multiple purposes	3			
9.	A goat that can withstand any	3			

	climatic condition is an ideal type of breed to be reared in countries like Jamaica and other local, national and international countries.				
10.	The development and influence of a new breed of goat, will increase the productivity in the goat industry, increase export sales as well as increase farmers profit earnings yearly, which in return increase food security and reduce food poverty in Jamaica's small ruminant production.	2	1		

Fig: 3 Table Showing the Responses received by respondents in the form of a questionnaire.

Interviewee's Reviews

The Interview was done both ways, one face to face on a farmer's goat farm, and two using on line platforms (Zoom). The meeting for the zoom was recording for evidence of investigation done and for research purpose. Also the interviewee's were told their it will remain confidential as well.

Questions were asked by interviewees based on the state of profession and experience I relation to the topic. Please see results from the interviews done.

Questions asked to the Goat Farmer

1. How long have you being a goat farmer?
2. What is it like being a goat farmer in general?
3. Have you ever experiences any challenges, while rearing your animals?
4. What are some severe challenges you have seen happening in the goat industry in Jamaica and what are some possible causes of it?
5. What do you think about goat milk?
6. Do you think goat milk is healthier than cow milk for our people?
7. Do you think a newly developed goat breed that can be reared for both meat and milk purpose and at the same time is 100% adaptable to any climatic conditions be a success to the goat industry in Jamaica?

Interviewee # 1 (Goat Farmer for Boer and Alpine Goat Breed)

These questions were asked to the Goat Farmer. The responses was recorded in a video setting. The responses mostly was shown in the questionnaire responses that are shown in the data result sheet above in fig

Proposed interview questions for Agricultural College Students and Graduates

1. What year did you graduated from College?
2. What is it like studying the programme you pursued?
3. What are some challenges you see happening currently in the goat industry in Jamaica and what do you think is causing these problems?
4. What do you think about the production of goat milk?
5. Do you think goat milk is healthier than cow milk for human consumption?
6. Do you think a newly developed goat breed, that can be reared for both meat and milk purpose with 80% adaptable to any climatic conditions be a success to the goat industry in Jamaica?

Interviewee # 1 (Agricultural College Graduate)

These questions were asked to the college graduate. The responses was recorded in a video setting. Please see link for video attached.

https://drive.google.com/file/d/1Yt-rVZwRQlzP_3u1rfjOupcTJdV66nD4

/view?usp=drive_link

Data Collected from Agricultural Research Station

Breeding for Meat Quality & Temperature Adaptation

Characteristics	Data
Growth rate	36 inches tall
Frame size	Compact
Weight Overall	230 Ibs
Ease of kidding	2 kids (one born 2021 and one 2022)
Mothering ability	Good
Temperant	Good mothers,
Disease Resistance	Mostly affected by internal parasites
Fibre characteristics	King grass, Mombasa and African star grass, pangula, paragrass
Appearance	Red head with white body coating.
Health	8 months
Age / Maturity (9112)	Mother age (5 years) Kids age (8 months)

Fig 4: Table Showing data collected from the Bodles Research Station under the small ruminant department on a selected Boer female goat

The data collected was used to determine the ability for this animal to be crossed with the Saanen and alpine to add to the dual purpose goat breed. The data collected used to analyse and compare and contrast for the characteristics a traits to be transferred.

Fig 5: Picture of the selected female Boer goat, Taken at the Bodles Research Station in Jamaica

Fig 6: Picture showing the weigh equipment used at the Bodles Research Station to weigh the Goats monthly.

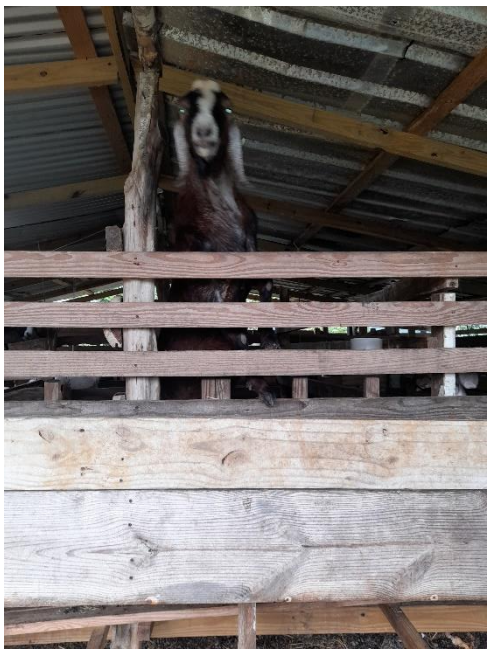

Fig 7: showing an image of an Alpine Goat Breed taken at a Jamaican farmer's farm.

Fig 8: picture showing the female kid from the mother Boer goat that was selected for data collection and weekly observation.

5.2. Questions about Alternative Approaches

1. What alternative approaches were considered in the research to address the challenges posed by climate change in small ruminant production in Jamaica?
2. How did the researcher evaluate the effectiveness of the new dual-purpose goat breed in mitigating the impacts of climate change on livestock farming?
3. Were there alternative breeding strategies explored to enhance the dual-purpose functionality of the goat breed for both meat and milk production?
4. What alternative methods were investigated to promote the marketing and marketability of small ruminant products in Jamaica?
5. How did the research team assess the potential drawbacks or limitations of relying solely on the development of a new dual-purpose goat breed to address the multifaceted challenges in the livestock industry?
6. Were there alternative technological or management approaches considered to improve meat and milk production efficiency in small ruminants?
7. What alternative economic or policy interventions were explored to support the adoption and diffusion of the new dual-purpose goat breed among small-scale farmers in Jamaica?
8. Were there alternative livestock species or breeds evaluated as potential substitutes or complements to the new dual-purpose goat breed in addressing climate change resilience and enhancing small ruminant production?
9. How did the research team compare and contrast the potential outcomes and impacts of the new dual-purpose goat breed with

alternative solutions or interventions for addressing climate change, meat and milk production, and market development in Jamaica?

10. What alternative perspectives or stakeholder insights were considered in the research to ensure a comprehensive understanding of the implications of adopting the new dual-purpose goat breed in Jamaica's livestock sector?

Answers the researcher provided to each questions asked

1. Alternative approaches considered in the research to address climate change challenges in small ruminant production in Jamaica included investigating sustainable land management practices, exploring dietary interventions to mitigate heat stress, and evaluating genetic variability in heat tolerance traits.
2. The research team evaluated the effectiveness of the new dual-purpose goat breed by assessing its performance in diverse climatic conditions, monitoring its resilience to heat stress, and comparing its productivity with existing goat breeds.
3. Alternative breeding strategies explored to enhance the dual-purpose functionality of the goat breed included incorporating genomic selection methods, applying selective breeding for desired traits, and investigating embryo transplanting for faster production.
4. Alternative methods investigated to promote the marketing and marketability of small ruminant products in Jamaica included assessing value-added processing techniques, exploring niche markets for goat products, and evaluating marketing campaigns to increase consumer awareness.
5. The research team assessed the potential drawbacks of solely relying on the development of a new dual-purpose goat breed by considering factors such as genetic diversity, adaptability to changing environmental conditions, and potential market saturation.

6. Alternative technological or management approaches considered to improve meat and milk production efficiency in small ruminants included implementing precision farming technologies, optimizing feeding strategies, and adopting efficient reproductive management practices.

7. Alternative economic or policy interventions explored to support the adoption of the new dual-purpose goat breed among small-scale farmers in Jamaica included providing financial incentives for breed adoption, implementing supportive agricultural policies, and offering training and extension services.

8. Alternative livestock species or breeds evaluated as potential substitutes or complements to the new dual-purpose goat breed included assessing the suitability of indigenous goat breeds, exploring cross-breeding with other species, and considering alternative small ruminant species such as sheep.

9. The research team compared and contrasted the potential outcomes and impacts of the new dual-purpose goat breed with alternative solutions such as agroforestry integration, diversified farming systems, and technological innovations in livestock management.

10. Alternative perspectives and stakeholder insights considered in the research included input from farmers, veterinarians, policymakers, and agricultural extension workers to ensure a comprehensive understanding of the implications of adopting the new dual-purpose goat breed in Jamaica's livestock sector.

5.3 Statistical Analysis of Expected Results

Possible Genotypic and Phenotypic Inheritance for F1 Generation of Dual Purpose Goat Breed for meat and milk production and simultaneously a climate resistant animals.

Punnet Square Working Out

Saanen (S), Boer (B), and **Alpine (A)** goats for meat, milk, and climate resilience according to the given traits, we'll designate alleles for each trait: "**M**" for Boer meat production, "**N**" for Saanen milk production, and "**C**" for Boer climate resilience.

Here's a Punnett square representing the possible offspring:

	S	S	A	A
B	BMNC	BMNC	BMNC	BMNC
B	BMNC	BMNC	BMNC	BMNC

Fig 9: Table showing a Punnett Square working out for possible genotypic and phenotypic traits transferred

In this Punnett square:

- The letters on the top represent the alleles from one parent (e.g., Boer).
- The letters on the side represent the alleles from the other parent.
- Each cell in the grid represents a possible combination of alleles from the two parents, which determine the genotype of the offspring.
- The letters in each cell represent the genotype of the offspring. For example, "BMNC" represents a goat with alleles for Boer meat production (B), Saanen milk production (N), and Boer climate resilience (C).

Now, let's analyse the genotypic and phenotypic outcomes:

- Meat production (B): B is dominant over the absence of the allele (b), so BB and Bb will both exhibit Boer meat production.
- Milk production (N): Saanen milk production is recessive (nn), so only nn will exhibit Saanen milk production.
- Climate resilience (C): Boer climate resilience is dominant (CC), so CC and Cb will both exhibit Boer climate resilience.

Phenotypically, all offspring will exhibit Boer meat production, Saanen milk production, and Boer climate resilience. This is because each offspring inherits one dominant allele for each trait from the Boer parent, resulting in the expression of these desired characteristics.

Therefore, the Punnett square demonstrates the genetic outcomes when crossing Saanen, Boer, and Alpine goats according to the specified traits for meat, milk, and climate resilience.

Chapter summary;

The interpretation of results from the questionnaire responses and interviews provided valuable insights into the challenges and perspectives within Jamaica's small ruminant industry. Questionnaire respondents highlighted various issues, including the impact of the COVID-19 pandemic on goat meat production, challenges related to praedial larceny, and the importance of developing new goat breeds for meat and milk production. They also emphasized the health benefits of goat milk and the potential economic opportunities associated with dual-purpose goat breeds. Interviews with goat farmers and agricultural college graduates further corroborated these findings, shedding light on the day-to-day experiences and professional perspectives within the industry.

Alternative approaches considered in the research to address climate change challenges in small ruminant production included sustainable land management practices, dietary interventions to mitigate heat stress, and genetic selection for heat tolerance traits. The effectiveness of the new dual-purpose goat breed was evaluated through performance testing in diverse climatic conditions and comparison with existing goat breeds. Alternative breeding strategies, marketing methods, and economic interventions were explored to enhance the viability and adoption of dual-purpose goat farming. The research also considered alternative perspectives from stakeholders to ensure a comprehensive understanding of the implications of adopting new goat breeds in Jamaica's livestock sector. Overall, the study provided valuable insights and recommendations for future research and policy interventions aimed at improving meat, milk, and climate resilience in small ruminant production.

Chapter 6:

Conclusion

1.1. General Discussion Summary;

The research conducted on the influence of a newly developed dual-purpose goat breed in Jamaica provides valuable insights into addressing multifaceted challenges in the small ruminant production sector. Through comprehensive analysis and experimentation, significant findings have emerged, shedding light on the breed's potential to revolutionize goat farming practices in the context of climate change resilience, meat and milk production, and market expansion.

Firstly, the introduction of this dual-purpose breed offers a promising solution to the adverse impacts of climate change on livestock agriculture. By selectively breeding for traits that enhance heat tolerance, disease resistance, and adaptability to fluctuating environmental conditions, the new goat breed demonstrates resilience in the face of climatic variability. This resilience not only safeguards the livelihoods of farmers but also ensures the sustainability of small ruminant production in Jamaica amidst changing climatic patterns.

Moreover, the dual-purpose nature of the breed, focusing on both meat and milk production, addresses the growing demand for these essential commodities in Jamaica. Through strategic breeding and management practices, the breed exhibits impressive performance in terms of meat yield, milk quality, and reproductive efficiency. This not only enhances food security but also provides opportunities for economic empowerment among small-scale farmers, contributing to poverty alleviation and rural development.

Furthermore, the research highlights the pivotal role of the new goat breed in expanding the market for small ruminant products in Jamaica. With its superior traits and dual-purpose functionality, the breed captures

the interest of consumers and stakeholders, thereby stimulating demand and market growth. Additionally, the breed's ability to diversify product offerings, including meat, milk, and value-added products, strengthens its market competitiveness and creates opportunities for value chain development and agribusiness expansion.

In conclusion, the research underscores the transformative potential of a new dual-purpose goat breed in Jamaica's agricultural landscape. By effectively tackling climate change challenges, enhancing meat and milk production, and driving market expansion, the breed emerges as a catalyst for sustainable development and resilience in the small ruminant production sector. Moving forward, continued investment in research, breeding programs, and supportive policies is essential to maximize the benefits of this innovative approach and ensure the long-term viability and prosperity of Jamaica's livestock industry.

Chapter 7: Recommendations

7.1. Recommendation for future Research

For future research on dual-purpose goat breeds aimed at addressing meat, milk, and climate resilience, several recommendations can be considered:

1. **Genetic Selection and Breeding Programs:** Invest in further genetic research to identify specific genes associated with desirable traits such as meat quality, milk production, and climate resilience. Develop breeding programs that prioritize the selection of individuals with superior genetic characteristics for these traits to accelerate the development of dual-purpose goat breeds.
2. **Enhanced Climate Resilience:** Conduct targeted studies to better understand the genetic mechanisms underlying climate resilience in goats. Explore breeding strategies that focus on traits such as heat tolerance, disease resistance, and adaptation to extreme weather conditions to develop goats better suited to withstand the impacts of climate change.
3. **Optimization of Production Systems:** Investigate optimal management practices and production systems that maximize meat and milk yields while minimizing environmental impacts. This includes exploring sustainable feeding strategies, efficient resource utilization, and innovative technologies to enhance productivity and reduce greenhouse gas emissions associated with goat farming.
4. **Integration of Emerging Technologies:** Embrace advancements in genomics, biotechnology, and data analytics to accelerate the breeding process and improve the efficiency of dual-purpose goat production. Utilize techniques such as genomic selection, marker-assisted breeding, and precision livestock farming to expedite the development of high-performance goat breeds tailored for meat, milk, and climate resilience.

5. **Market Development and Value-Added Products:** Explore opportunities to diversify goat products and increase their marketability. Investigate value-added products derived from goat meat and milk, such as gourmet cheeses, specialty meats, and cosmetic products, to enhance the economic viability of dual-purpose goat farming and stimulate consumer demand.
6. **Stakeholder Engagement and Knowledge Sharing:** Foster collaboration among researchers, policymakers, farmers, and industry stakeholders to facilitate knowledge exchange and technology transfer. Develop extension programs, training workshops, and outreach initiatives to disseminate best practices and empower goat farmers with the tools and information needed to succeed in dual-purpose goat production.
7. **Long-Term Sustainability:** Consider the long-term sustainability of dual-purpose goat farming systems by assessing their environmental, social, and economic impacts. Conduct life cycle assessments and cost-benefit analyses to evaluate the overall sustainability and viability of different production models and inform decision-making processes.

By addressing these recommendations, future research endeavours can contribute to the development of resilient, productive, and sustainable dual-purpose goat breeds capable of meeting the challenges of meat and milk production while mitigating the impacts of climate change.

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Appendix A

Fig 1. Table showing types of forages for goats

Types of forages for Goats	
Grasses	
Forage	**Description**
Pangola Grass	Pangola grass is a warm-season grass commonly found in tropical regions. It is highly palatable and nutritious, making it an excellent choice for goats' nutrient management. It is rich in protein and minerals, contributing to the animals' overall health and productivity Pangola grass is used extensively for pasture, hay and silage. It withstands very heavy grazing. Regular grazing (2-3 week intervals) at 10-15 cm to 30-40 cm height is necessary to maintain the quality of pangola grass (Archimède, Tran, & Heuzé, 2015).
Guinea Grass	Guinea grass is another popular choice for goats in the tropics. It is a high-yielding, fast-growing grass that provides ample forage for grazing animals. Guinea grass is rich in energy and fiber, promoting healthy digestion and sustained energy levels in goats. Feeding goats with Guinea grass gives better results when it is supplemented with a legume or a crop residue-based concentrate (Heuzé & Tran, 2020).
Napier Grass	Napier grass is a widely cultivated tropical grass that offers excellent nutritional value for goats. It has a high crude protein content, making it suitable for lactating and growing goats. Additionally, Napier grass is easily digestible and helps in maintaining good rumen health. Elephant grass can be grazed, provided it can be kept at the lush vegetative stage: livestock tend to feed only the younger leaves (Heuzé, Tran, Giger-Reverdin, & Lebas, 2020).

Trees	
River Tamarind	Leucaena is a leguminous tree that provides high-quality forage for goats. It is rich in protein and essential minerals, making it a valuable addition to the goats' diet. Leucaena leaves are highly palatable and easily digestible, promoting healthy rumen function and improved nutrient absorption (Heuzé & Tran, Leucaena (Leucaena leucocephala), 2015).
Black Mulberry	Mulberry leaves are highly palatable to goats and contain a relatively high protein content, making them a valuable addition to the animals' diet. The protein content in mulberry leaves depends on the variety and growing conditions (Heuzé, Tran, & Lebas, Black mulberry (Morus nigra), 2019).
Moringa	Moringa trees are known for their high nutritional value. The leaves are packed with protein, vitamins, and minerals, including calcium and iron. Moringa leaves can be dried and stored for feeding goats during dry seasons or as a supplement to their regular diet (Heuzé, Tran, Hassoun, Bastianelli, & Lebas, 2019).

	DM % as fed			CP % of DM			CF % of DM		
	Fresh	**Hay**	**Seeds/Pods**	**Fresh**	**Hay**	**Seeds/Pods**	**Fresh**	**Hay**	**Seeds/Pods**
Pangola	27.1	81.3		8.1	7.9		36.3	35.5	
Guinea	22.7	89.8		11.2	9.1		37.3	36.7	
Napier	17.9	89.3		9.7	10.3		36.1	35.6	
Leuceana	29.9	23.8	89.6	23.3	26.1	31.9	19.9	23.2	15.6
Mulberry	34.7			20.3			13.4		
Moringa	26.2	91.2	10.7	24.3	26.8	17.6	13.6	12.2	33.5

Fig 2: Table showing percentage of feed containing, Crude protein and crude fiber as well as crude protein.

Questionnaire

No.	Questions	Agreed	Disagreed	Satisfactory	Poor
1	There is a big issue in the goat industry, where the covid-19 pandemic decrease the amount of goat meat produce due to lacking in funds.		3		
2	Goat Farmers are facing tragic challenges raising their animals due to Praedial larceny.	3			
3	Sometimes goats suffer from disease and pest in affecting them internally and externally	3			

4	A new goat breed that can be used for meat and milk would increase the marketing in the small ruminant production	1	1	1	
5	Goat milk is healthier and better for people with lactose intolerance issues in comparison to cow's milk.	3			
6	A farmer rearing a goat for both milk and meat produce, can earn twice more than just rearing for meat purpose	3			
7.	A new cross-bred goat breed with high milking produce, high quality meat can increase the food	3			

	security in Jamaica and produce healthier milk for persons with chronic illnesses				
8.	Farmers and agricultural organizations can earn more with a new developed goat breed with multiple purposes	3			
9.	A goat that can withstand any climatic condition is an ideal type of breed to be reared in countries like Jamaica and other local, national and international countries.	3			
10.	The development and influence of a new breed of goat, will increase the	2	1		

	productivity in the goat industry, increase export sales as well as increase farmers profit earnings yearly, which in return increase food security and reduce food poverty in Jamaica's small ruminant production.				

Fig: 3 Table Showing the Responses received by respondents in the form of a questionnaire.

Appendix B

Data Collected from Agricultural Research Station

Breeding for Meat Quality & Temperature Adaptation

Characteristics	**Data**
Growth rate	36 inches tall
Frame size	Compact
Weight Overall	230 Ibs
Ease of kidding	2 kids (one born 2021 and one 2022)
Mothering ability	Good
Temperant	Good mothers,
Disease Resistance	Mostly affected by internal parasites
Fibre characteristics	King grass, Mombasa and African star grass, pangula, paragrass
Appearance	Red head with white body coating.
Health	8 months
Age / Maturity (9112)	Mother age (5 years) Kids age (8 months)

Fig 4: Table Showing data collected from the Bodles Research Station under the small ruminant department on a selected Boer female goat

Fig 5: Picture of the selected female Boer goat, Taken at the Bodles Research Station in Jamaica

Fig 6: Picture showing the weigh equipment used at the Bodles Research Station to weigh the Goats monthly.

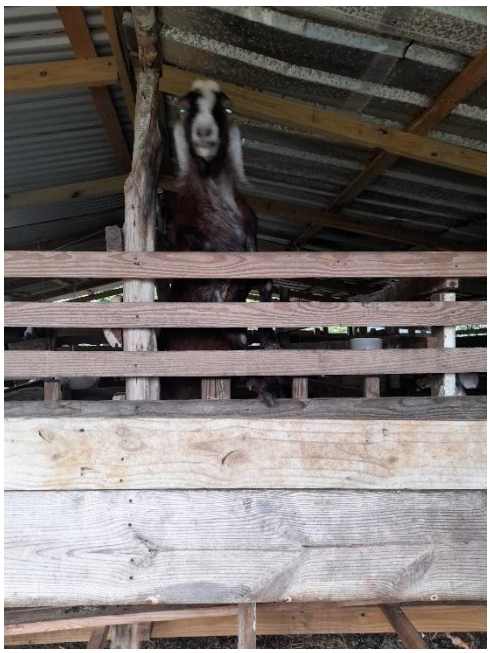

Fig 7: showing an image of an Alpine Goat Breed taken at a Jamaican farmer's farm.

Fig 8: picture showing the female kid from the mother Boer goat that was selected for data collection and weekly observation.

Appendix C

	S	S	A	A
B	BMNC	BMNC	BMNC	BMNC
B	BMNC	BMNC	BMNC	BMNC

Fig 9: Table showing a Punnett Square working out for possible genotypic and phenotypic traits transferred