Effects of water availability on physiological status of Nguni does and weaners

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By

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Dedication

This *Thesis* is dedicated to the entire Dlamini-Mseleku clan, to my late father Mandlenkosi Timothy Mseleku, to my mother Tshengisile Eunice Mseleku, and to all the hard workers.

"You cannot prevent the birds of sorrow from flying all over your head, but you can prevent them from building nests on your head".

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List of Abbreviations

BCS	Body condition score
FAMACHA	FAffa MAlan CHArt
GLM	General linear model
GPE	Goat production efficiency
H	hour
IK	Indigenous knowledge
Km	Kilometre
LCI	Lower confidence interval
MT	Metric tonnes
Na-EDTA	Sodium-ethylene diaminetetra acetic acid
PCV	Packed cell volume
PDIFF	Probability of difference
rpm	Revolutions per minute
RT	Rectal temperature
SAS	Statistical Analysis System
SEM	Standard error of means
UCI	Upper confidence interval

Thesis output

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Abstract

Physiological status of goats is mainly affected by the availability of feed and water. Factors such as frequency of droughts and low rainfalls are main contributors to water scarcity. Understanding perceptions of goat farmers about water availability in the aspect of climate change is vital for sustainable and improved livelihoods. The objectives of the study were to: (1) determine the factors influencing water availability for Nguni goat flocks in wet and dry areas; and (2) compare responses in physiological status of Nguni weaners and does to distance from water source. Farmer perceptions were captured from 300 goat farmers using structured questionnaires. Water shortage was among the major constraints to goat production. The odds ratio estimates of households experiencing goat drinking water shortage were high for temperature and rainfall patterns ($P<0.001$). Goat flock size and distance from water sources highly predisposed the household to experience water shortage. Farmers who did not provide additional drinking water for goats were 3.7 times more likely to have goats experiencing water shortage as compared to farmers who provided additional drinking water for goats ($P<0.01$). Goats that were owned by farmers situated (≥1 km) away from the water source were 1.89 times more likely to experience water shortage compared to goats owned by farmers situated (<1 km) from the water source. Farmers who had large goat flock size were 1.64 times more likely to experience water shortage as compared to the farmers who had small goat flock size ($P<0.05$). A trial was conducted to compare physiological status responses of Nguni weaners and does to distance from water sources. A negative linear regression was recorded between body condition score and distance from water source. A positive linear regression was recorded between FAMACHA scores and distance from water source across weaners and does. The rate of reduction in body condition scores were lower in does (-0.45 ± 0.292) as compared to weaners (-0.55 ± 0.374). The FAMACHA scores increased as distance to water source increased in both classes of goats. The slope was, however steeper ($P<0.05$) for does (0.56 ±

0.403) than for weaners (0.44 ± 0.432). There was a negative linear relationship between packed cell volume and distance from water source. Reduction in packed cell volume was lower ($P<0.05$) in does (-0.62 ± 2.57) as compared to weaners (-11.21 ± 2.196). The rectal temperature and distance from water source were positively related. The increase in rectal temperature was lower ($P<0.05$) in does (0.05 ± 0.280) than in weaners (0.07 ± 0.432). It was concluded that although both classes of goats were affected by the distance to water source, the effects were more adverse in does than in weaners.

Keywords: Body condition score; FAMACHA; Goat productivity; Packed cell volume; Rectal temperature; Water availability

Chapter 1

General Introduction

1.1 Background

Africa and Asia comprise of 88 % of the world's goat population (Alexandre and Mandonnet, 2005). In Southern Africa, for example, there is over four million goats (Botha and Roux, 2008). Goats provide human food mostly during times of drought (Lebbie, 2004; Van Niekerk and Pimentel, 2004). Threats about decline in feed and water availability, and land degradation are not highly pronounced in goat production (Aune *et al*., 2001). This is due to their small body size and hardiness with selective browsing skills that enables them to utilize low quality feeds (Webb and Mamabolo, 2004; Alexandre and Mandonnet, 2005).

Climate change is one of the main challenges affecting livestock and the challenge is severe in the African developing countries (Abate, 2016). Global temperatures have noticeably got warmer by approximately 0.6℃ since 1910 (Walther *et al*., 2002). Such increase in ambient temperatures are usually associated with low amounts of rainfall, increased frequencies of droughts and evaporation (Araújo *et al*., 2010; Abate, 2016). The decline in rainfall adversely affects both feed and water availability and feed intake for goats (Alamer, 2009). The low rainfall and increase in the frequency of droughts further causes a decline in water levels and river flows. Some perennial rivers may turn into seasonal rivers. The quality of drinking water is also reduced. This poses a serious challenge for goats reared in communal production systems where fresh water supplementation is seldom.

Limited water availability or contaminated water supply interferes with goat physiological status and productivity (Alamer, 2006). The common water sources for goats are in the form of rivers, lakes and rain water (Tyagi *et al*., 2013). Unavailability of water make goats walk for long distances searching for drinking water to meet their nutritional and physiological requirements (Alamer, 2006). The distance walked by goats to drinking water was reported to be 1.25 km or even greater (Hendricks *et al*., 2005). This increases their maintenance requirements for energy, reduces time for feeding and, therefore, reduces the body weight and body condition of goats and, consequently impair physiological status and increases their susceptibility to endemic diseases and parasites (Nsoso *et al*., 2003).

In arid environments, gastro-intestinal nematodes contribute greatly to impairment of physiological status of goats (Berrag and Cabaret, 1998). They also interfere with the nutritional status of goats as they cause anaemia (Burke *et al*., 2007). Using both the FAMACHA scores and determining packed cell volume, farmers can now assess anaemia in goats (Burke *et al*., 2007). The FAMACHA technique enables farmers to investigate anaemia (Mohammed *et al*., 2016). To date, nearest water sources are drying out due to climate change and this has contributed to impaired nutritional status of goats, since goats have to walk long distance for drinking water and compromise some of their browsing and grazing time. Impaired nutritional status of goats could increase food insecurity (Maurya and Singh, 2015) mainly in women and children due to gender and age prioritization.

1.2 Justification

Climate change is posing additional pressure on water availability (Arnell, 1999). This increases the competition for water between humans and livestock. Goats can live up to five days without drinking water, and can walk up to 4 km in search for water. Utilizing such knowledge can be useful in reserving the nearest water sources for human use. The understanding will also help in minimising labour for farmers who are transporting water for their use personal use and for goats from distant water sources. The study focusses on does and weaners because does have higher energy requirements and they are more important in reproduction. Weaners are replacers and they contribute to goat production efficiency. In communal production systems, indigenous goats are a valued genetic resource. This is due to their natural resistance to several endemic diseases (i.e. gall sickness, internal parasites, and pulpy kidney) and adaptation to harsh climatic conditions (Webb and Mamabolo, 2004). The abundance, tolerance and better adaptation of goats will sustain communal farmers during severe climatic changes. Putting more effort on understanding the influence of water availability on growth performance and nutritional status of goats can sustain agriculture, improve the livelihoods of rural households, and protect the environment from degradation (Devendra, 1999). Walking long distances to water source have limits productivity due to lack of endurance and dehydration tolerance. Nguni goats have the ability of walking long distances since they possess dehydration tolerance. Such ability aids in not compromising goat's productivity, however improves it. Improved nutritional status of goats is important in counteracting hunger and poverty, and it can also improve nutrient intake (i.e. protein) especially in communal households. Goats are useful in controlling invasive species and their milk is good for patients and also for patients with lactose intolerance.

1.3 Objectives

The broad objective of the study was to determine the influence of water availability on the physiological status of Nguni goats. The specific objectives of the study are to:

1. Determine the factors influencing water availability for Nguni goat flocks in wet and dry environments; and
2. Compare responses in physiological status of Nguni weaners and does to distance from water source.

1.4 Hypotheses

The hypotheses tested will be that:

1. Factors influencing water availability for Nguni goat flocks differs with an environment; and
2. Responses in physiological status of Nguni weaners and does to distance from water source are linear.

1.5 References

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Chapter 2

Review of Literature

2.1 Introduction

In Southern African countries, livestock farming is one of the most essential agricultural activities (Webb and Mamabolo, 2004). Farmers as well as developing goat producing industries are constrained by the change in climate for maximal goat productivity. Such change in climate has interfered not only with maximal goat productivity, but also with the welfare of goats as well as both human health and rights (McMichael *et al*., 1996). The production of goats is often done under unfavourable production conditions. These conditions are continuously threatened by both bush encroachment and desertification (Webb and Mamabolo, 2004).

Throughout the world, goats are of social and economic importance (Araújo *et al*., 2010). Traditionally, goats are source of fibre, leather, meat and milk (Casey and Webb, 2010). These products from goats play a role in fighting hunger and poverty. In the past decade, Provincial government of the Eastern Cape marked goat production as the rural area strategy to address socio-economic development (Botha and Roux, 2008). Currently, drought is the main challenge to goat productivity. In Mozambique, for example, goat flocks decreased in the previous two decades and this was due to drought (Van Niekerk and Pimentel, 2004). This literature review discusses about the indigenous knowledge on climate change, goat productivity and climate change adaptation and mitigation strategies on the production of goats.

2.2 Importance of goats

A number of nations around the world have noticed goats as an important part of economic and social life to them (NRC, 2007). Numerous countries, especially developing countries have considered goats to be of high importance. Their provision of cash, cashmere, manure, meat, milk, mohair and skins has contributed to human living (Haenlein and Ramirez, 2007). Goat farming is profitable due to their early maturity ability, prolificacy, and less effort requirement for adequate production level (Devendra and Burns, 1970; Webb and Mamabolo, 2004). Abdul-Aziz (2010) reported that goats are important due to their productivity and non-competitiveness with humans for food. Mahanjana and Cronje (2000) indicated that bush encroachment is the major issue to manage in grazing systems, thus introducing browsers such as goats helps to control it. Goats are the most abundant livestock species in Africa and Asia. Goats are mainly kept for traditional rituals, income generation, for meat and for emergencies (Table 2.1 and 2.2).

2.3 Effects of climate change on goat productivity

Climate change is a phenomenon mainly due to emission of gases (i.e. carbon dioxide, methane and nitrous oxide) from anthropogenic practices especially agriculture, deforestation, industrialization and urbanization (Malla, 2009). These gases are released and, therefore, accumulate the atmosphere resulting into changes in precipitation, temperature and solar energy (Awuor *et al*., 2008). Changes in climate have direct and indirect effects on goats. Direct effects include humidity, wind speed and high temperatures for example heat stress and indirect effects include soil infertility and water scarcity (Thornton *et al*., 2009). These climatic effects adversely affect goat performance, feedstuff quality and quantity, and also contribute to increase distribution of goat diseases and disease vectors (Seo and Mendelsohn, 2008).

Table 2. 1: Importance of goats among continents on meat and milk production

Continent	Number of goats (million)	%	Meat (million MT)	%	Milk (million MT)	%
Africa	224	29	825	20	2,793	23
Americas	36	5	138	3	357	3
Asia	489	64	3098	74	6,404	53
Europe	18	2	122	3	2,433	21
Worldwide	768	100	4199	100	11,987	100

Source: FAO (2004); Haenlein and Ramirez (2007).

Table 2. 2: Reasons for goat keeping farmers in the Eastern Cape Province

Reason	**Proportion (%)**
Milk	2
No reason	4
Status	5
Meat	15
Emergencies	16
Cash sale	23
Rituals	35

Source: Mahanjana and Cronje (2000).

Climate is the most determining factor for goat productivity and change in climate has grown more concern to human welfare due to its effects on agricultural productivity (Aydinalp and Cresser, 2008). Exposure of goats to high temperature evokes extreme changes in biological functions, such functions include reduced feed intake efficiency and utilization, disruptions in blood metabolites and water, energy, protein and mineral balance metabolism. These changes lead to reduced live body weight and impaired reproduction (Marai *et al*., 2008). Climate is an imperative factor of goat productivity. Higher temperatures results in a reduced goat’s body weight due to adverse impact of climate change on feed and water availability (Aydinalp and Cresser, 2008). The changes in climate affect both quality and quantity of feedstuffs, consequently influence goat performance such as growth and nutritional status (Seo and Mendelsohn, 2008).

2.3.1 Quantity and quality of feedstuffs

Consequences from climate change include increased temperatures, precipitation changes and increased atmospheric carbon dioxide concentration. These changes adversely affect plants in terms of photosynthesis, transpiration and growth rate, and quality and quantity of the yield (Mahato, 2014). There are several feed sources for goats, however, grasslands and shrubs are the most common feed sources. Goats derive some of their nutrition from grasslands (O'Mara, 2012). Climate change is expected to directly impact crops and vegetation, and this compromises goat’s health, such impacts differs with rainfall patterns (Wheeler and Reynolds, 2013). In communal production systems, most people hardly supplement goat feed (Rumosa Gwaze *et al*., 2009) and there are cases whereby bushes or grazing areas are burnt, therefore, this causes a decline in feed quality and quantity, resulting in declined goat production.

Climate change affects distribution, phenology, and physiology of plants (Thuiller *et al*., 2005). Climate change has been associated with increased number of plants dying off. Changes in climate potentially alter the grazed ecological units (Easterling *et al*., 2007). A change in climate adversely impacts the growth and quality of vegetation (Lenart *et al*., 2002; Goetz *et al*., 2005). Poor vegetation growth and quality is a major element of feed intake and thus affect the body condition of goats (Estrada-Cortés *et al*., 2009).

2.3.2 Reduced water availability

Goats form a fundamental part of farming systems in arid areas globally. These areas are characterized by poor rainfall, limited water availability and inaccessible water due to climate change (Jaber *et al*., 2013). Goats grazing in arid areas are limited by drinking water. During dry seasons, goats must tolerate heat stress, low feed, and poor availability of water (Casamassima *et al*., 2008). Climatic changes have impacted both quality and quantity of water and this has consequently affected plants and goats (Gurung and Bhandari, 2009). Access to adequate water is key to normal life maintenance as it is an important constituent of living cells (Aganga, 1992).

Access to available water is important for survival and adaptation of goats under non-conducive climatic conditions and to obtain thermal balance (Araújo *et al*., 2010). Molecules within the animal organism are covered by approximately 98 % of water (NRC, 2001). Water can be given to goats in three ways, namely; drinking water, water within feed and water produced during nutrient catabolism (Araújo *et al*., 2010). In arid and semi-arid areas throughout the world, available water is scarce for goat flocks. During times of drought, goats ingest low quality forages with low humidity level and uneven limited water (Araújo *et al*., 2010). Goats had a decreased feed intake, average daily weight gain and body weight as the water deprivation hours increase (Table 2.3).

2.3.3 Frequency, duration and severity of droughts

Drought is a recurring phenomenon commonly in arid regions of Africa (Scoones, 1992). It is a condition relative to long-term average condition of balance between rainfall and evapotranspiration within an area, this condition is perceived normal. Drought can occur both in high and low rainfall areas (Wilhite and Glantz, 1985). Drought events are induced by prolonged absence of rainfall and this result into declined pasture production and goat dynamics, and increase goat mortalities (Nandintsetseg and Shinoda, 2013). Droughts are one of the main factors that control the number of goats (Begzsuren *et al*, 2004).

Table 2. 3: Effects of water deprivation on growth performance and nutritional status of goats

	Watering intervals (hours)			
	Ad libitum	24	48	72
Feed intake (g DM/ day)	762	743	742	758
Total water intake (litres/day)	1.960	1.847	1.321	1.111
Body weight (kg)	36.1	34.7	31.3	31.3
Average daily gain (g/day)	85.5	81.9	64.3	65.6
Feed conversion efficiency (g feed/g gain)	9.3	9.3	12.1	12.1
Haemoglobin (%)	9.6	9.8	10.5	10.6
Packed cell volume (%)	24.5	25.1	25.9	26.5

Source: Adogla-Bessa and Aganga (2000).

2.3.4 Heat stress

Heat stress is highly noticed during dry seasons when the ecological temperature and relative humidity are high with long disclosure to direct sunlight (Okoruwa, 2014). Heat stress causes hyperthermia and potentially affect physiology and economy of livestock industry, as a result aberrations such as reduced animal performance and increased mortalities are pronounced (Hahn and Mader, 1997; Al-Tamimi, 2007). Environmental heat adversely affect goat performance by increasing body temperature and panting rate, such increments denote heat stress, thus results into declined goat productivity (Alam *et al*., 2013). Furthermore, heat stress is detrimental to goats in terms of physiological equilibriums and systems such as endocrine, immune and nervous system (Castanheira *et al*., 2010). The eating behavior of goats changed with time of exposure to heat stress. The eating time of goats increased with increasing time intervals of heat stress (Table 2.4).

Goats are homeotherms, as they are able to regulate a balanced metabolic and environmental heat and this makes them less susceptible to heat stress compared to any other domesticated ruminants (Lu, 1989). Goats have a comfort zone whereby their energy expense is at minimal and this is correlated with their physiological state. Outside this zone, goats are unable to regulate homeothermy and this results in thermal stress (Nardone *et al*., 2006).

Rectal temperature increased with increase in exposure time to heat stress (Table 2.5 and 2.6). Al-Haidary (2004) showed an increase in rectal temperature due to heat stress. Alam *et al*. (2011) showed an increase in PCV due to heat stress. Sejian *et al*. (2012) added that PCV increases due walking stress, hence heat stress is in association with walking stress.

2.3.5 Goat diseases and disease vectors

Climatic variations change the balance of ecology and context within the disease vectors and therefore transmit diseases (Patz *et al*., 2000). Vector-borne diseases have increased due to climate change and some have already occurred, for example the blue tongue virus (Gale *et al*., 2009). Diseases have become a major challenge and reduce goat productivity, especially in tropical areas (Kochapakdee *et al*., 1994).

Table 2. 4: Effects of heat stress on eating behaviour of goats subjected under three different time intervals

	Time intervals (hours)		
Eating behaviour	**0**	**4**	**8**
Eating time/minute	300.00 ± 15.1	366.70 ± 6.0	380.00 ± 5.0
Chewing rate/ minute	90.30 ± 2.3	92.30 ± 2.2	92.10 ± 1.1

Source: Alam *et al*. (2013).

2.3.6 Systems and livelihoods vulnerability

More than 40 % of the earth's lands are dry regions (i.e. arid and semi-arid) due to environmental changes. Changes within the regions are associated with climate change and have contributed to unsustainable livelihoods (Fraser *et al*., 2011). Changes in climate severely impact on populations that relies more on subsistence agriculture, especially populations from developing countries (Morton, 2007). Nevertheless, keeping goats creates livelihoods for people living in poverty by counteracting hunger (Gaughan *et al*., 2009).

In the Eastern Cape region of South Africa, malnutrition is reported to exceed its normal level in all rural areas among people and this is due to inadequate protein intake (DBSA, 1994; Mahanjana and Cronje, 2000). Simela and Merkel (2008) reported that goat meat is classified as staple red meat and can compete with beef and mutton. According to Devendra (2005), goats are the main contributors of animal protein and food security to poor people from rural areas all over the developing countries. Masika and Mafu (2004), concluded that keeping goats is the main rural area practice done to chase away both hunger and food insecurity. Goats have been contributing to human nutrition since ancient times of human civilization (Webb *et al*., 2005).

Table 2. 5: Effects of heat stress on thermoregulatory and body weight of dwarf goats in southern Nigeria

Parameters	Treatments		
	T1	**T2**	**T3**
Thermoregulatory			
Rectal temperature (°C)	37.98	39.07	41.02
Skin temperature (°C)	36.63	38.99	40.68
Respiratory rate (breaths/minute)	16.04	18.98	23.01
Pulse rate (heartbeats/minute)	78.38	82.01	91.04
Body weight (kg)			
Initial body weight (kg)	8.62	8.54	8.42
Final body weight (kg)	8.66	7.80	6.40
Change in body weight (kg)	0.04	-0.74	-2.02

T1 = penned throughout the study; T2 = on the yard between 0800 and 1300 h daily; T3 = on the yard between 1300 and 1800 h daily)

Source: Okoruwa (2014).

Table 2. 6: Effects of heat stress on physiological parameters of goats subjected to three time intervals

Physiological parameters	Time intervals (hours)		
	0	**4**	**8**
Skin temperature (°C)	37.56 ± 16.6	39.06 ± 17.1	39.44 ± 16.7
Rectal temperature (°C)	37.83 ± 16.7	39.39 ± 16.6	40.17 ± 17.1
Panting rate / minute	32.70 ± 2.2	111.0 ± 2.0	119.30 ± 0.8
Pulse rate/minute	74.30 ± 1.2	82.30 ± 2.3	87.30 ± 0.8

Source: Alam *et al*. (2013).

2.4 Indigenous knowledge on climate change

Rural communities possess indigenous knowledge on climate change mitigation and adaptation, and they are aware of the changes in available water. Indigenous knowledge is slowly getting extinct and needs to be passed on. Integrating indigenous knowledge together with conventional knowledge is of interest in improving goat productivity. Indigenous knowledge refers to locally established knowledge that has been constructed and passed on through generations by word of mouth. Indigenous knowledge forms the base in decision-making for local-level of rural communities (Ajani *et al*., 2013). Indigenous knowledge is based on culture, place, and time (Speranza *et al*., 2010). In arid and semi-arid areas, indigenous knowledge have been used for over centuries to avail water for human consumption, crops and livestock production through rainwater harvesting (Mbilinyi *et al*., 2005).

Combined value of western science and indigenous knowledge is recognised, although these paradigms sometimes contrast (Gearheard *et al*., 2010). Integrating indigenous knowledge and observations of ecological processes can create solid responses to climate change (Green and Raygorodetsky, 2010). According to Gearheard *et al*. (2010), combining these patterns of understanding is not for comparison, however to be certain when drawing conclusions. According to Egeru (2012), indigenous knowledge is the knowledge that gather together generations of a particular environment and pass over, the knowledge is useful in counteracting climate change.

Indigenous knowledge is valuable to climate change by creating moral economy. Alexander *et al*. (2011) reported that indigenous knowledge is useful in matching information that has actual value in determining climate change patterns for regions constrained by instrumental records. Nyong *et al*. (2007) postulated that combining indigenous knowledge into climate change strategies can potentially advance sustainable climate change mitigation and adaptation strategies. Nyong *et al*. (2007) highlighted that observations and experiments from previous generations are influential to indigenous knowledge set. They intrinsically connect people's surroundings and the environment.

2.5 Goat productivity in communal production systems

In communal production systems, farmers keep livestock species such as cattle, goats, sheep and chickens (Mapiye *et al*., 2009). Nevertheless, more attention is paid to cattle compared to other species, however goats play much similar role to cattle in people's livelihoods and indigenous goats are abundant in communal farming systems (Webb and Mamabolo, 2004). In communal systems, goats are herded during the day and kept inside the kraal at night. Mating is not controlled, therefore inbreeding is highly pronounced resulting into not improved goat production.

Masika and Mafu (2004) reported that a decline in goat productivity is due to environmental factors. Goat productivity is adversely influenced by disclosure to harsh climatic conditions, feed and water scarcity, and by walking long distances in search of feed and water (Sejian *et al*., 2012). Webb and Mamabolo (2004) concluded that communal female goats have low reproductive status. Increased kid mortalities and herd inbreeding are mainly pronounced as the basis of declined reproductive status (Webb and Mamabolo, 2004).

Combining productive and reproductive traits can be an indicator of total productivity (Abdul-Aziz, 2010). Goats can withstand the changing climate and its adverse effect on feed and water availability, however, such restricts their productivity (Baraza *et al*., 2009). Peacock (1987) argued that goat productivity can be measured by describing the individual production traits, reproductive performance, reproductive performance and the growth of kids, and flock production indices. Tolera *et al*. (2000) indicated that goat productivity can be measured using feed and water intake, and also by using growth performance and nutritional status.

2.5.1 Reproductive performance of goats

Goat reproductive performance is determined by environmental factors and genetic interactions, however the performance is primarily susceptible to seasonality (Moaeen-ud-Din *et al*., 2008). Goat reproductive performance is influenced by reproductive traits, such as age at puberty, age at conception, age at first kidding and gestation period (Zeshmarani *et al*., 2007). Reproductive performance can be determined by evaluating the following parameters; conception and kidding rate, kidding intervals, birth and weaned weight of kids, survival rate and the rate at which kids are weaned (Moaeen-ud-Din *et al*., 2008; Sejian *et al*., 2012).

2.5.2 Growth performance of goats

Drinking water and feed are often constraining factors for optimum growth performance in goats grazing and browsing in semi-arid areas (Casamassima *et al*., 2008). Climate change potentially compromise the reproductive efficiency of goats by adversely impact milk yield (Nardone *et al*., 2010). Insufficient water intake adversely impact milk composition by creating imbalances among milk constituents (Casamassima *et al*., 2008). Does with low milk production at lactation period and kids with low birth weight are known reduce growth performance (Mege *et al*., 2007; Andriyanto and Manalu, 2011).

2.5.3 Physiological status of goats

Physiological status of goats can be assessed traditionally (i.e. body condition scoring and body weight) or by determining the packed cell volume (PCV) through animal's blood (Ndlovu *et* *al*., 2007). Physiological status can also be determined using FAMACHA system. FAMACHA and PCV are complements; however, FAMACHA is a practical, designed on-farm system that aids goat farmers or producers to improve the control of internal parasites (Burke *et al*., 2007). Packed cell volume is a volume of red blood cells (erythrocytes) given as a percentage of the total blood volume in a sample. Packed cell volume is an indicator of anaemia, values of PCV greater than the reference values also indicate dehydration (Ndlovu *et al*., 2007).

2.6 Adaptation of goats to climate change

Goats are the most adaptable animals compared to other domesticated livestock (Abdul-Aziz, 2010). Goats are well adapted to wide-ranging climatic environments (Alexandre and Mandonnet, 2005). Generally, goats tolerate drought better compared to cattle (Campbell, 1978; Lebbie, 2004). During dry summer seasons, goats can cope well due to their hardiness and selective grazing skill (Alexandre and Mandonnet, 2005). They can graze and utilize low quality feeds and browse (Webb and Mamabolo, 2004). Goats are better adaptable to climate change than other domesticated livestock ruminants. Cattle and sheep had large numbers of herds died due to changes in climate (Table 2.7 and 2.8).

In Ethiopia and the Sahel for example, during 1980s over 80% cattle died and less than 50% goats died due to drought (Lebbie, 2004). Goat body size, ability to decrease metabolism, efficient nitrogen economy and use of water, low metabolic needs and highest digestive efficiency adds to drought tolerance (Alexandre and Mandonnet, 2005). Small body size and low metabolic requirements enables goats to have reduced maintenance and water requirements (Assan, 2014). Furthermore, their respiratory system is structured to improve heat dissipation through respiratory water vaporization using adequate panting (Shafie, 1992; Lebbie, 2004). The knowledge about successful adaptation to climate change can be acquired from indigenous or traditional people (Egeru, 2012). Adogla-Bessa and Aganga (2000), concluded that goats live for up 3 three days without drinking water and this is due to their ability of limiting urine and faecal water excretion.

2.7 Climate change mitigation

Throughout the world, applications of indigenous knowledge in climate change mitigation and adaptation have long been neglected, however, the use of this knowledge is of interest (Egeru, 2012). Climate change can be mitigated by adopting and diversifying herd composition with dehydration tolerance specie such as goats (Abate, 2016). Goats can mitigate climate change due to their adaptation to non-conducive environmental conditions and their physiological mechanisms that support their adaptation (Araújo *et al*., 2010). Goats can contribute to climate change mitigation by sequestering soil carbon and by their nature of emitting reduced methane gas (Mottet *et al*., 2017). According to Egeru (2012), Sahel local populations for example have managed to develop and implement successful climate change mitigation strategies.

Table 2.7: Comparison of susceptibility of ruminant livestock species to climate change in the year 2010/2011 drought

Species	No. of exposed herds	No. of died herds	Mortality rate (%)
Cattle	242	193	26.4
Goats	229	76	9.1
Sheep	207	68	10.5

Source: Megersa *et al*. (2014).

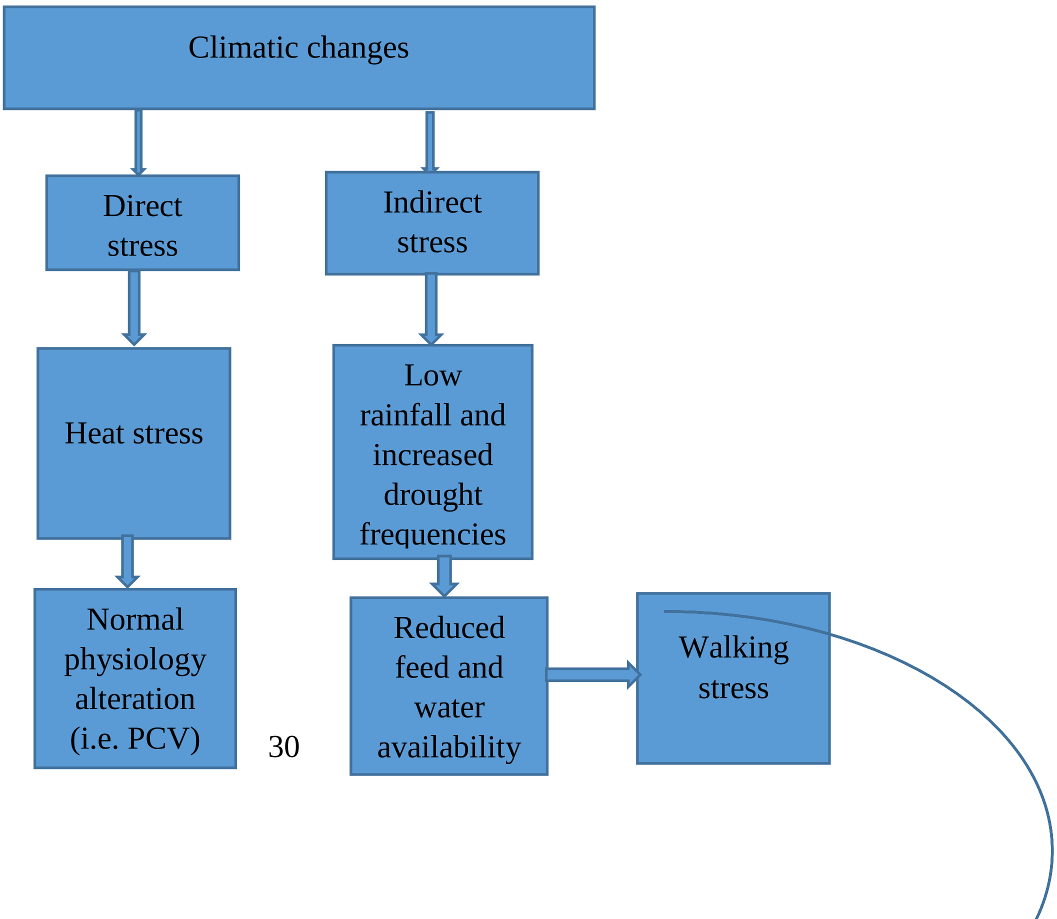
Table 2.8: Comparison of adaptation to climate change between Madari goat and Yankasa sheep

Item	Goat	Sheep
Average body weight (kg)	20.16	25.56
Metabolic body weight (kgBW$^{0.75}$)	8.96	10.95
Water intake (mL/kgBW0$^{.75}$/day)	152.40	202.53
Water intake by ration (mL/kgBW$^{0.75}$/day)	2.75	3.17
Metabolic water (mL/kgBW$^{0.75}$/day)	16.95	19.02
Water lost by faeces (mL/kgBW$^{0.75}$/day)	9.32	16.08
Water lost by urine (mL/kgBW$^{0.75}$/day)	42.00	45.60
Water lost by transpiration (mL/kgBW$^{0.75}$/day)	120.40	162.40
Average daily urine production (mL)	382.9	501.10
Daily water intake (mL)	1364.00	2218.00
Average daily faeces production (g)	208.80	362.1

Source: Araújo *et al*. (2010).

2.8 Summary

Majority of resource-poor households rely on goats and their products for living. Climatic variations have, however, interfered with the optimum physiological status of goats. Physiological status of goats is mainly affected by drought frequencies (poor water availability), heat stress, disease incidents, and poor feed quality and quantity (see Figure 2.1). Such incidents do not affect goats only, however, also affect other livestock and people's livelihoods through food insecurity. Application of indigenous knowledge can be useful in mitigating climate change. This knowledge is being ignored and integrating it with conventional knowledge can be useful. Goats are the common livestock specie usually reared in communal areas. They are abundant and can feed the entire household. Goats can, therefore, play a major role in counteracting food insecurity. It is advantageous to consider keeping goats due to their adaptation to variable climatic conditions and due to their dehydration tolerance. The objective of the current study was, therefore, to determine the effects of water availability on the physiological status of goats in the Southern African region.



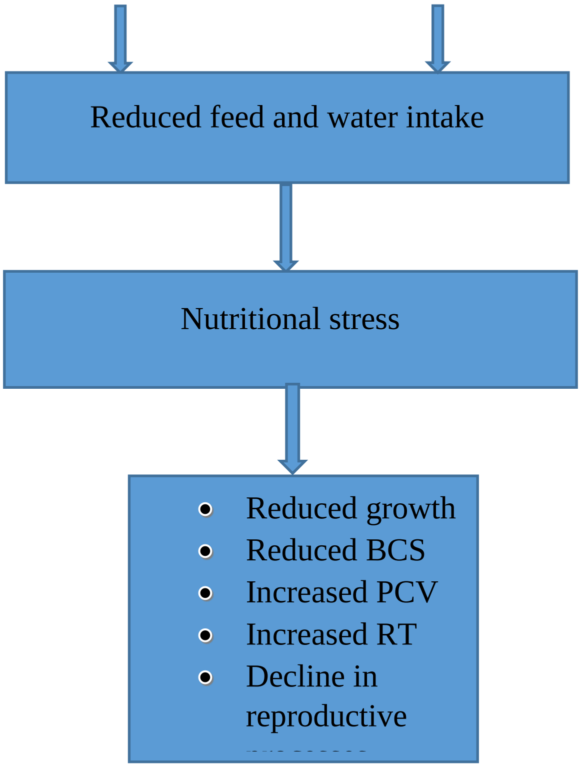


Figure 2.2: Effects of climate change on nutritional status of goats

Sources: Naqvi and Sejian (2011); Sejian (2013)

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Chapter 3

Farmer perceptions on the factors influencing water availability for Nguni goat flocks in wet and dry environments

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Abstract

Understanding perceptions of goat farmers about water availability in the aspect of climate change is vital for sustainable and improved livelihoods in communal production systems. The objective of the study was to determine the factors influencing water availability for Nguni goat flocks in wet and dry environments. Farmer perceptions were captured in 300 goat farmers using structured questionnaires. The major challenges to goat production were water shortage, disease prevalence, and feed shortage. Sales, ceremonies, and meat were the major reason for keeping goats. The odds ratio estimates of households experiencing goat drinking water shortage were high for temperature and rainfall patterns ($P<0.0001$). Distance from water sources ($P<0.05$) highly predisposed the household's likelihood to experience water shortage. Farmers who did not provide additional drinking water for goats were 3.7 times likely to have goats experiencing water shortage as compared to farmers who provided additional drinking water ($P<0.01$). Goats that were owned by farmers situated (≥1 km) away from the water source were 1.89 times likely to experience water shortages compared to goats owned by farmers situated (<1 km) from the water source ($P<0.05$). Farmers who had large goat flock size were 1.64 times likely to have goats experiencing water shortage compared to farmers who had small goat flock size ($P<0.05$). It was concluded that goat flock size, provision of additional drinking water and distance to water source were the main factors that influenced water shortage for goats in wet and dry environments.

Keywords: Flock size; Goat production; Livelihood; Water shortage; Water source

3.1 Introduction

The agricultural sector supplies up to 50 % of households with food and income in South Africa (Rust and Rust, 2013). Livestock farming is one of the main important components of African economy. In the Southern African humid tropics, goats are a valuable resource for livelihood security and development of economy for rural households (Salem and Smith, 2008). The production of goats is a feasible way to improve livelihoods for rural communities (Braker *et al*., 2002). In communal areas, goats have multiple functions (Mmbengwa *et al*., 2013). Goats are kept for meat, sales, and for performing traditional ceremonies (Slayi *et al*., 2014). In addition, goats mainly possess an important major role to cultural activities (Amole *et al*., 2017). Resource-poor households have been supported by goats and goat products for over 7 000 years for living (Peacock, 2005).

Goats are also important in controlling invasive species, however, there is major concern on their decline in numbers due to bush encroachment (Mahanjana and Cronje, 2000; Megersa *et al*., 2014). Goats are abundant mostly in drier regions of the world (Daramola and Adeloye, 2009). Most goats in communal areas are found in harsh environment with varying climate that adversely affect their productivity and production (Iñiguez, 2004). In arid areas, availability of water influences foraging activity of goats and therefore, reduce goats' nutrient uptake leading to decline in goat productivity (Shrader *et al*., 2008). Water is scarce and is among the major limiting factors in agricultural production (Raviv and Blom, 2001).

Water availability is a critical element for goat production in arid areas (Alamer, 2009). Goats require adequate drinking water for maintenance of feed intake (Reiber *et al*., 2015). Due to water scarcity, goats drink infrequently and therefore, do not meet their health requirements (Alamer, 2009). Water availability has not been investigated as a possible limiting factor for goat flocks. To improve goat flocks for farmers in communal production systems, better understanding about factors affecting drinking water availability for goats is required. Thus, the objective of the current study was, therefore, to compare the influence of water availability for Nguni goat flocks in wet and dry environments. It was hypothesized that the factors influencing water availability for Nguni goat flocks differs with region.

3.2 Materials and methods

3.2.1 Study site and ethical consideration

The study was conducted in Jozini municipality of uMkhanyakude district (27.4294° S, 32.0651° E) in the KwaZulu-Natal province of South Africa. The study complied with the standards required by the Human Social Science Ethics Committee of the University of KwaZulu-Natal (Protocol Reference Number: HSS/0852/017).

Jozini is located in the summer rainfall area where the wet months are from December to February. Jozini has a subtropical climate, with an average annual rainfall ranging from 671 to 1002 mm. Average daily maximum and minimum temperature is above 20 °C and 10 °C, with an infrequent variation of 12 °C between minimum and maximum temperature. The main vegetation type is bush veld, coastal sand veld and foothill woody grasslands (Morgenthal *et al*., 2006).

3.2.2 Farmer selection and research design

A list of farmers who keep goats was compiled from each village with the help from extension officers, veterinarians, and headmen of the villages. Eight villages were visited across Jozini namely; Biva, Gedleza, Bhanjana, Mamfene, Manyampisi, Mkhonjeni, Mkhayana and

Nyawushane. Villages were selected based on the farmer ownership of goats and willingness to participate in the study. Among these eight villages, four villages were from the wet environment and the other four villages were from the dry region. The wet environment was characterised by the frequency of rainfall, presence of natural permanent water sources such as rivers and wetlands, and by the soil type which was suitable for vegetation growth and agricultural activities. The dry environment was characterised by water scarcity due to infrequent rainfall and occurrence of droughts. In wet region, water is available and accessible at all the times, whereas in the dry region, water was not always available and accessible as most water sources dry out in dry seasons and during drought. In each site, 150 farmers were interviewed.

3.2.3 Data collection

Participatory rural evaluation approaches through group discussions with farmers and interviews with key informants were used to establish farmer perceptions on goat production. Key informants included livestock association members, officials from veterinary services at Makhathini Research station and village headmen. A structured questionnaire was also administered to 300 household heads with the assistance from trained enumerators. The aspects covered in the questionnaire included the household demography, goat flock sizes and composition, reasons for keeping goats, challenges to goat production, and water sources for goats. Personal observations were also made on the appearance and availability of the goats. Interviews were conducted in IsiZulu vernacular.

3.2.4 Statistical analyses

All the data were analysed using SAS (2010). Household socio-economic status was analysed using PROC FREQ of SAS (2010). The PROC GLM procedure was used to analyse reasons for keeping goats, challenges to goat production, and the effects of wet and dry environment on livestock herd size and goat flock composition. An ordinal logistic regression (PROC LOGISTIC) was used to predict the odds of a household that experience goat's drinking water shortages and farmer perceptions on water sources. The variables fitted in the logit model included age of the farmer, gender, marital status, feed supplement and provision of additional water, distance to water source and flock size. The model used was:

$$Ln [P/1-P] = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots \beta tXt + \varepsilon$$

Where: P is the probability of household experiencing goat's drinking water shortages;

[P 1−P] is the odds of the household to experiencing goat's drinking water shortages;

$\beta 0$ is the intercept;

$\beta 1 \ldots \beta t$ are the regression coefficients of predictors;

$X1 \ldots Xt$ are the predictor variables;

ε is the random residual error

When computed for each predictor ($\beta 1 \ldots \beta t$), the odds ratio for water shortages were interpreted as the proportion of households that experienced goat drinking water shortage versus those households that were not experiencing shortages.

3.3 Results

3.3.1 Household demography and socio-economic status

Household demographics and socio-economic status of farmers are shown in Table 3.1. Households were commonly headed by married males and females with an educational level below grade 8. Only less than 2 % of respondents received tertiary education, less than 29% had above seven years of formal education and the majority had received less than seven years of education. More than 51 % of household heads were of males and females over 50 years of age. Over 69 % of the respondents had no training on livestock production. The major sources of income for households in both areas were government grant followed by crops and livestock sales. The common livestock species that were kept in Jozini are shown in Table 3.3. Chicken and pig flock sizes were different ($P<0.05$).

3.3.2 Reasons for keeping goats

Goats were kept for various uses. They were, however, largely kept for sales ($P<0.05$), ceremonies ($P<0.05$), and meat in that descending order for both wet and dry environments (Table 3.2). Milk and Skins ($P<0.05$), gifts, and manure were the least reasons for keeping goats.

3.3.3 Challenges to goat production

Goats in the wet environment were mainly challenged by disease prevalence, feed shortage, and water scarcity in that descending order. The main challenges for goats in the dry environment were water scarcity, feed shortage, and disease prevalence in that descending order (Table 3.4). Inbreeding and theft were amongst the least challenges affecting goat production ($P<0.05$).

3.3.4 Water sources for goats

As shown in Table 3.5, rivers, tap water and canals in that descending order were the main water sources. In the wet environment, rivers, tap water, and wetlands were the main water sources. In the dry environment, tap water and canals were the main water sources. There were no boreholes in the wet area and there were no wetlands in dry area. Both areas contributed to water sources (P<0.01).

3.3.5 Goat supplementary feeding and drinking water

As shown in Table 3.6, farmers from both environments were providing additional drinking water for goats, however, provision of additional drinking water is more common in the wet area than the dry area (P<0.0001). Supplementary feeding is not prominent in the wet environment (P<0.01). In dry area, supplementary feeding is prominent (P>0.05).

3.3.6 Water shortages

The odds for the occurrence of water shortage in goats are shown in Table 3.7. The odds ratio estimates of households experiencing the shortage of drinking water for goats were high for temperature and rainfall patterns (P<0.0001). The flock size of goats, distance to water source (P<0.05), and provision of additional drinking water (P<0.01) highly predisposed the household’s likelihood to experience water shortages for goats. Farmers who did not provide additional drinking water for goats were 3.7 times likely to have goats experiencing water shortage as compared to farmers who provided additional drinking water for goats (P<0.01). Goats that were owned by farmers situated (≥1 km) away from the water source were 1.89 times likely to experience water shortage as compared to goats owned by farmers situated (<1 km) from the water source (P<0.05). Farmers who had large goat flock size were 1.64 likely to experience water shortage compared to farmers who had small goat flock size (P<0.05).

Table 3.1: Socio-economic status of the households in dry and wet environments

Status	**Wet region**	**Dry region**
Gender (%)		
Males	48.61	58.55
Females	51.39	41.45
Marital status (%)		
Married	50.00	40.71
Single	36.57	40.00
Divorced	0.75	5.00
Widowed	12.69	14.29
Age group (%)		
18 - 30 years	7.86	2.03
31 - 50 years	40.71	42.57
>50 years	51.43	55.41
Farmers residing on farm	1.11 ± 0.027	1.11 ± 0.026
Education level (%)		
No formal education	37.32	36.67
Grade 1 – 7	33.80	37.33
Grade 8 – 12	28.17	24.67
Tertiary education	0.70	1.33
Livestock production training (%)		
Yes	11.19	30.94
No	88.81	69.06
Sources of income (%)		
Crops and livestock sales	35.20	29.48
Salary	17.60	24.86
Government grant	43.2	38.15
Own Businesses	2.40	6.36
Family support	1.60	1.16

Table 3.2: Least square means and standard errors for reasons of keeping goats in Jozini

Use	Wet environment	Dry environment
Meat	(3) 2.24 ± 0.081^{a}	(3) 2.21 ± 0.082^{a}
Ceremonies	(1) 1.82 ± 0.095^{a}	(2) 1.93 ± 0.095^{b}
Sales	(2) 1.94 ± 0.074^{a}	(1) 1.75 ± 0.076^{b}
Skins	(5) 3.92 ± 0.149^{a}	(6) 3.35 ± 0.198^{b}
Gifts	(7) 4.30 ± 0.236^{a}	(8) 3.90 ± 0.267^{a}
Manure	(6) 4.19 ± 0.238^{a}	(7) 3.62 ± 0.243^{a}
Investments	(4) 3.52 ± 0.257^{a}	(4) 2.40 ± 0.330^{b}
Milk	(8) 4.86 ± 0.533^{a}	(5) 3.00 ± 1.411^{b}

Values in the same row with different superscripts are different ($P<0.05$). The lower the mean value, the more important the trait.

Table 3.3: Least square means and standard errors for livestock herd size and goat flock composition in two environments of Jozini

Livestock flock/herd size	Wet environment	Dry environment
Cattle	14.35 ± 1.16	16.08 ± 1.33
Goats	19.00 ± 1.12	18.82 ± 1.27
Sheep	21.75 ± 8.29	11.50 ± 16.57
Chickens	27.15 ± 1.12^{a}	21.83 ± 1.28^{b}
Pigs	11.50 ± 2.45^{a}	3.57 ± 1.85^{b}
Ducks	5.00 ± 9.94	7.60 ± 4.45
Gooses	5.00 ± 3.09	6.60 ± 1.95
Guinea fowls	3.00 ± 1.29	4.00 ± 1.05
Goat flock composition		
Bucks	2.98 ± 0.24	2.83 ± 0.26
Does	6.80 ± 0.50	7.74 ± 0.55
Male weaner	2.81 ± 0.20	3.29 ± 0.22
Female weaner	2.66 ± 0.18	3.08 ± 0.20
Male kids	3.22 ± 0.25	3.67 ± 0.28
Female kids	3.18 ± 0.20	3.21 ± 0.22

Values in the same row with different superscripts are different ($P<0.05$).

Table 3.4: Main challenges to goat production in two environment of Jozini

Challenges	Wet environment	Dry environment
Disease prevalence	(1) 2.15 ± 0.265[a]	(3) 2.44 ± 0.261[a]
Feed shortage	(2) 2.29 ± 0.121[a]	(2) 2.41 ± 0.119[a]
Internal parasites	(4) 3.01 ± 0.098[a]	(5) 2.91 ± 0.102[a]
Water shortage	(3) 2.62 ± 0.165[a]	(1) 2.27 ± 0.186[a]
Ecto-parasites	(5) 3.34 ± 0.146[a]	(6) 3.20 ± 0.128[a]
Thefts	(6) 3.37 ± 0.167[a]	(4) 2.67 ± 0.166[b]
Inbreeding	(7) 5.23 ± 0.322[a]	(7) 3.86 ± 0.404[b]

Means in the same row with different superscripts are significantly different at ($P<0.05$). The lower the mean value, the more important the trait.

Table 3.5: Water sources (%) used for drinking by goats in two environment of Jozini

Region	Water sources										Significance
	Dams	Rivers	Rainwater	Spring	Wetlands	Tap water	Boreholes	Greywater	Canals	Other sources	
Wet	3.93	44.10	8.30	0.87	17.47	22.71	0.00	1.75	0.44	0.44	**
Dry	8.11	9.19	8.56	6.76	0.00	34.68	10.90	0.45	20.45	0.90	**

**Significant difference between water sources at (P<0.01)

Table 3.6: Association of environment to provision of additional drinking water and supplementary feeding of goats in Jozini

Environment	Provision of additional water		Significance
	Yes	**No**	
Wet	95.62	4.38	****
Dry	78.57	21.43	****
	Supplementary feeding		
	Yes	**No**	
Wet	23.61	76.39	**
Dry	56.85	43.15	NS

NS: Not-significant (P>0.05); ** (P<0.01); **** (P<0.0001)

Table 3.7: Odds ratio estimates, lower (LCI) and upper (UCI) confidence interval of water shortage in the wet and dry environments of Jozini

Predictor	Water shortage			Significance
	Odds	LCI	UCI	
Sex (males versus females)	0.76	0.49	1.23	NS
Age (≤30 years versus ≥31 years)	1.38	0.72	2.66	NS
Training on livestock (yes versus no)	0.28	0.15	0.54	NS
Provision of additional drinking water (yes versus no)	0.27	0.12	0.59	**
Supplementary feeding (yes versus no)	0.73	0.46	1.17	NS
Temperature (increased versus decrease)	6.43	3.37	12.26	****
Rainfall pattern (decreased versus increased)	5.03	3.33	7.59	****
Distance from water sources (<1 km versus ≥1 km)	0.53	0.33	0.85	*
Cattle herd sizes (small versus large)	1.22	0.67	2.24	NS
Goat flock size (small versus large)	0.61	0.38	0.99	*
Farmers residing on farm (yes versus no)	1.01	0.47	2.16	NS

The higher the odds ratio estimates the greater the difference in occurrence between predictors.

^{NS} P>0.05; * P<0.05; ** P<0.01; P<0.0001.

3.4 Discussion

The finding that the government grant, crops plus livestock sales being the main sources of income in households concurs with Baiphethi *et al*. (2006) and Bahamondes (2003). This finding reveal that the majority of farmers are unemployed, and their lack of tertiary education further contributes to unemployment. The finding on the educational level of respondents concurs with the findings by Mahanjana and Cronje (2000), who found that only 4 % of respondents had post-matric education, 8 % had above eight years of education and 60 % received education for 5 years or less.

Resource-poor farmers usually own chickens and goats as due to lack of purchasing power for large stock, such as cattle. In the observed flock or herd size, chickens and goats have the largest compared to the herd size for the cattle in that order, which concurs with Dovie (2006). The mean flock size of goats per household is similar to the finding of Mapekula *et al*. (2009) and Mapiye *et al*. (2009). The finding about chicken and goat flock sizes being the largest denote that chickens and goats are of high importance for rituals compared to other livestock species. Chickens and goats are the common prerequisite for rituals in communal areas. Additionally, some households do not afford cattle but can afford small livestock species such as chickens and goats.

Rural households are mainly supported by goat meat for protein intake. Keeping goats have also contributed to income generation and performing traditional ceremonies (Rumosa Gwaze *et al*. 2009). The finding that goats are mainly kept for sales, ceremonies and for meat is in accordance with earlier reports (Masika and Mafu, 2004; Dovie *et al*., 2006; Legesse *et al*., 2008). Nguni goats secretes low amounts of milk, and milking them is not popular. The finding that the usage of goat milk is the least on the reasons for keeping goats agrees with the finding by Rumosa Gwaze *et al*. (2009). The findings that goat flock composition was dominated by does means farmers keep more does than bucks to avoid inbreeding and to maximise production. Van Niekerk and Pimentel (2004) reported that goat flocks are dominated by does. Webb and Mamabolo (2004) reported a low reproductive status in communal does due to inbreeding associated with traditional livestock management where does and bucks are kept together in the same flock for years. Majority of communal farmers keep wethers and one or two bucks in a flock and sell or slaughter bucks before mating with their offspring.

In communal production systems, goat production is challenged by a number of factors (Iñiguez, 2011). The observed prevalence of diseases, feed shortage, and water shortage being the main challenges to goat production concurs with Rumosa Gwaze *et al.* (2009). Mdletshe *et al*. (2018) found that diseases and water scarcity were the main challenges to goat production. Similar results were also reported by Mutibvu *et al*. (2012), who found that disease prevalence and feed shortages are common challenges to goat production. These results denote that farmers do not acquire adequate veterinary services and help from the agricultural extension officers. In addition, the finding on the livestock training highlights that farmers are not well-trained due to concealment from formal higher education where agricultural subject is introduced. Communal farmers usually apply treatment to goats when they observe signs and symptoms of diseases instead of preventing the disease.

Rivers normally do not dry-out due to their flowing water which contributes to water freshness and, therefore, reduces water evaporation. In the observed water sources, rivers are the major sources of water for goats which, therefore, concurs with the observation by Kassahun *et al*. (2008) who reported that rivers are the main drinking water source for goats. Wetlands were among major sources of water in wet region, and there were no wetlands in the dry region. This is attributed to drought frequencies that usually occur in the dry area. Drought frequencies and high temperatures are prominent in the dry areas, thus high temperatures contributes to an increased water evaporation especially in wetlands due to not flowing water.

Rivers are less affected by drought compared to standing waters such as wetlands (Bond *et al*., 2008). River flow contributes to the freshness of water and low evaporation, therefore, rivers remain as the most available water sources for goats. There is no observed use of boreholes as water sources for goats in the wet environment. This implies that water is not a scarce resource in wet areas. In the dry regions, boreholes are among the least water sources for goats. Cho *et al*. (2000) reported a decreased use of boreholes in communal areas due to bacterial and chemical contaminants in them.

The finding that the majority of respondents from wet area do not supplementary feed their goats could be attributed to high rainfall amount which influences the availability of fodder. Mapiye *et al*. (2009) reported that high rainfall improves the availability of feed. The majority of respondents from the dry area practice supplementary feeding and this is supported by previous assertion by Casamassima *et al*. (2008), who indicated that goats grazing in arid areas are affected by low feed availability. This, thus prompt farmers to supplementary feed their goats. The finding that the majority of respondents who provide additional drinking water for goats are from wet area denotes that there is little or no competition for water among humans and goats.

The finding that farmers who reported water shortage for goats were farmers that were not providing additional drinking water for goats denote that at some point water was barely available and accessible for them. This may be due to climatic changes such as low rainfall amount and drought frequencies. As a result, this created competition for drinking water among humans and goats, thus humans had to prioritise themselves over goats. The finding that the farmers who reported water shortage for goats were the farmers situated far from water sources denotes that the nearest water sources may had dried off, or there was insufficient water quantity, thus goats had to walk long distances due to low availability of drinking water. In contrast, Mdletshe *et al*. (2018), found that farmers situated near (≤ 3 km) to the water sources are more likely to experience water shortage for goats. The finding that farmers who reported water shortage for goats had large goat flock size denote that there was competition for water among goats.

3.5 Conclusions

Although the importance of challenges to goat production varied with an environment type, disease prevalence, feed shortage, and water scarcity were the most important challenges. Tap water was the primary water source for goats in both wet and dry environments. Farmers who were not providing additional drinking water for goats were likely to report water shortage. The odds ratio estimates for households experiencing water shortage for goat were the highest for temperature and rainfall patterns. Goat flock size, provision of additional drinking water, and distance to water source were main factors influenced water shortage for goats in wet and dry environments under communal production systems. The farmer perception on physiochemical properties of water should be considered for a clear understanding of water availability and, improved and sustained goat production in communal production systems.

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Chapter 4

Responses in physiological status of Nguni weaners and does to distance from water source

Abstract

The objective of the study was to compare responses in nutritional status of indigenous Nguni weaners and does to distance from water source. Thirty-five Nguni weaners and 35 does were used in this study. The goats were situated at 0.25, 0.75, 1.25, 1.75, 2.25, 2.75 and 3.25 km from the Ibalamhlanga and Pongola rivers, the nearest water sources for the goats and other livestock. A negative linear regression was recorded between body condition score (BCS) and distance from water source in both goat classes. The rate of reduction in BCS was significantly lower in does (-0.45 ± 0.292) as compared to weaners (-0.55 ± 0.374). The FAMACHA scores increased as distance to water source significantly increased in both classes of goats. The rate of change in FAMACHA score was, however steeper ($P<0.05$) for does (0.56 ± 0.403) than for weaners (0.44 ± 0.432). There was a negative linear relationship between packed cell volume (PCV) and distance from water source. Reduction rate in PCV was significantly lower ($P<0.05$) in does (-0.62 ± 2.57) as compared to weaners (-11.21 ± 2.196). The rectal temperature (RT) and distance from water source were positively related. The increase in RT was significantly lower in does (0.05 ± 0.280) than in weaners (0.07 ± 0.432). It was concluded that although both does and weaners were affected by the distance from water source, the effects were more adverse in weaners than in does.

Keywords: Body condition score; FAMACHA; Packed cell volume; Rectal temperature

4.1 Introduction

In Southern Africa, livestock systems are susceptible to climatic changes (Descheemaeker *et al*., 2016). These changes in climate affect goats and other livestock due to unavailable feed and water (Nardone *et al*., 2010). The assessment of physiological status of goats is useful (Maurya and Singh, 2015) when determining the effects of climate change. Body condition score is a common method used to assess nutritional status in animals. Due to drawbacks that this method has (Ndlovu *et al*., 2007), addition of other methods such as, FAMACHA, rectal temperature, and packed cell volume is becoming popular. These methods indicate the extent of metabolism of energy, protein, and other nutrients in goats (Marcotty *et al*., 2008; Papadopoulos *et al*., 2013)

In the arid and semi-arid regions, goats are widespread and they are important for smallholder farmers and social livelihoods (Kosgey, 2004). In the upcoming decades, a global decline of 25 % in goat production is expected, and food and water scarcity is predicted to mainly affect humankind (Nardone *et al*., 2010). Nutritional status and productivity of goats are hampered by a number of factors that varies with areas, countries and geographical locations (Kosgey, 2004). These factors include diseases, low feed supply and management, which leads to impairment of nutritional status, and poor productivity of goats mainly in the tropics (Kochapakdee *et al*., 1994). One of the most common factors is water scarcity which compromises nutritional and health status of goats. For efficient goat productivity, nutritional status of goats needs to be monitored. Humans are now competing for water with livestock and crops.

Water is a vital component and its availability is an important factor on agricultural goat productivity (Aydinalp and Cresser, 2008). Water has become scarce due to water sources drying out and this adversely affects livestock, therefore, the use of water in goat production must be revised. Goats walk long distances in search for drinking water (Sejian, 2013). Apart from water scarcity, in the tropical environments, goats in smallholder extensive production systems are exposed to heat stress. Goats experience unusual physical activity during walking long distances under such harsh environments (Maurya *et al*., 2012). The stress from walking alters homeostasis and metabolism processes (Sejian *et al*., 2012). Focusing on the classes of goats such as, weaners and does is vital. Weaners contribute to goat production efficiency (GPE), while fertility is from does. Improving nutritional status of weaners could be a key pathway to sustainable and growing flock sizes of goats (Hatcher *et al*. 2010). The adaptability of weaners to walk long distance to water source under arid environment is unknown and does have higher energy requirements compared to other classes of goats. Thus, this make both classes being highly prone to walking stress.

The impact of distance from water source and walking stress needs to be determined to in order to ascertain whether weaners and does affected, and intervention strategies need to be developed (Alamer, 2006). Knowledge about the impacts of distance from water source on the nutritional state of goats is required for sustainable goat improvement (Rumosa Gwaze *et al*., 2009). Combining body condition scores, FAMACHA, rectal temperatures, and packed cell volumes could increase the accuracy of assessing nutritional status of goats. The optimum nutritional status response of Nguni weaners and does to distance from water source is unknown. Thus, the objective of the current study was to compare nutritional status responses of Nguni weaners and does to distance from water source. It was hypothesized that nutritional status responses of Nguni weaners and does to distance from water source are different.

4.2 Materials and methods

4.2.1 Study site and ethical consideration

The study site is described in section 3.2.1. In relation to distance, Jozini experiences water scarcity and goats within Jozini walk long distances to water sources. The study complied with the standards required by the Animal Research Ethics Committee (Reference Number: AREC/043/017).

4.2.2 Goats and experimental design

A total of 70 indigenous Nguni goats (*Capra hircus*) were used. Thirty-five out of 70 goats were non-lactating and not heavily pregnant does, and the other 35 were weaners of mixed sex. Does aged between 18 and 36 months and weaners aged between four and six months were used. Goats were selected from eight villages based on a household location to Ibalamhlanga and Pongola rivers. Seventy goats were used in relation to household location to the water source with the preferred distance. All 70 goats were taken from eight households with fixed distances travelled to the water source and they were not provided with water at the homesteads. At each point, there were 10 goats, composed of five weaners and five does. Ten goats were selected based on household flock size and availability of the targeted classes of goats. Households with flock sizes of 20 goats and above were targeted in order to ensure the availability of weaners and does as the targeted classes. Goats were also selected based on the willingness of the owners to participate in the study and assurance of the availability of goats. All goats were free-ranging, browsing, and drinking water from Ibalamhlanga and Pongola rivers.

4.2.3 Blood collection

Blood samples were collected by jugular venipuncture from each selected goat into tubes with Na-EDTA as an anti-coagulant. After sampling, the tubes were immediately placed in a cooler box containing ice packs and transported to the laboratory within four hours of collection.

4.2.4 Distance from water source

The distance from water source was measured using "*goal-fitness application"* downloaded from a cell phone. The goal-fitness application is a motion sensor which counts the number of steps and travelled distance. The distances from households to water source were different in kilometres. Households with distance variation of 0.10 kilometres or less were summed up as one and mean distance was considered. All mean distance kilometres were rounded-off to the nearest tens to give means of 0.25, 0.75, 1.25, 1.75, 2.25, 2.75 and 3.25 km. The distances of 0.25, 0.75, 1.25, 1.75, 2.25 and 2.75 km were obtained between the households and Ibalamhlanga river, and the distance of 3.25 km was obtained between the household and Pongola river. The distance of 3.25 km was the longest distance obtained. Ibalamhlanga and Pongola rivers were the nearest water source for the goats, as indicated by the farmers and shepherds.

4.2.5 Measurements

4.2.5.1 Body condition scores

Body condition scores (BCS) were determined through physically feeling the level of muscling and fat deposition over and around the goat's vertebrae in the loin region, and also through visual assessment. A scale ranging from 1-5 was used (Suiter, 1994). Body condition scoring was done by four experienced personnel. The BCS and descriptions that were used are shown in Table 4.1.

4.2.5.2 FAMACHA scores

The FAMACHA scores were obtained by observing the colour of the lower eyelid of goats. Ocular mucous membrane colours were categorized into five categories as stated in FAMACHA eye chart. The FAMACHA eye colour chart scores and descriptions that were used are shown in Table 4.2.

4.2.5.3 Rectal temperature

Rectal temperature (RT) of goats was measured using a digital thermometer. Measurements were conducted at 0800 h. The thermometer was inserted in the rectum to full depth until stable automated reading was achieved.

4.2.5.4 Packed cell volume

Packed cell volume (PCV) was measured using a Hawksley micro-haematocrit centrifuge. The blood was centrifuged for 3 min at 3 000 rpm.

Table 4.1: Body condition scores and descriptions

Score	Description of body condition
1	Emaciated: abnormally thin (visible rib cage)
2	Thin: even fat cover (slightly visible rib cage)
3	Good condition: smooth even fat (invisible ribs, but can be felt)
4	Fat: thick fat (invisible ribs, only indents can be felt between ribs)
5	Obese: no individual vertebrae (invisible ribs and no indents between ribs)

Sources: Suiter (1994) and Mahieu *et al*. (2007)

Table 4.2: FAMACHA eye colour chart scores and description

Score	Description
1	Optimal: red colour (non-anaemic)
2	Standard: red-pink colour (non-anaemic)
3	Borderline: pink colour (mildly anaemic)
4	Risky: pink-white colour (anaemic)
5	Fatal: white colour (severely anaemic)

Source: Kaplan *et al*. (2004)

4.2.6 Statistical analyses

PROC REG (SAS, 2010) was used to determine the relationship between distance to water source against the BCS, FAMACHA, RT and PCV. Quadratic component was removed from the model because it was not significantly different. The model was;

$Y = \beta_o + \beta_1 A + \varepsilon$

Where: Y - is the response variable (BCS, FAMACHA, RT, and PCV);

β_o – is the intercept;

$\beta_1 A$ – is the linear regression component;

ε – is the residual error;

The test statement of regression procedure was used to compare differences in the slopes of Nguni weaners and does.

4.3 Results

4.3.1 Body condition scores

The relationship between BCS with distance to water source is shown in Table 4.3. There was a linear relationship between BCS with distance to water source ($P<0.001$). The smallest BCS was observed at 3.25 km of distance to water source and the highest BCS was observed at a distance of 0.25 km. Figure 4.1 illustrates the relationship between BCS with distance to water source in Nguni weaners and does. Body condition score of both weaners and does decreased with the increasing distance (in kilometres) to water source. Body condition scores dropped faster ($P<0.05$) in weaners (-0.55±0.374) than in does (-0.45±0.292).

4.3.2 FAMACHA scores

The relationship between FAMACHA with distance to water source is shown in Table 4.3. There was a linear relationship between FAMACHA scores with distance to water source ($P<0.001$). The smallest FAMACHA score was observed at a distance of 0.25 km and the highest FAMACHA score was observed at a distance of 3.25 km to water source. Figure 4.2 shows the relationship between FAMACHA scores with distance to water source in Nguni weaners and does. The increase in FAMACHA scores was higher ($P<0.05$) in does (0.56 ± 0.403) than in weaners (0.44 ± 0.432).

4.3.3 Packed cell volume

The relationship between PCV with distance to water source is shown in Table 4.3. There was a linear relationship between PCV with distance to water source ($P<0.001$). The highest PCV was observed at a distance of 0.25 km and the lowest PCV was observed at distance 3.25 km to water source. Figure 4.2 shows the relationship between PCV with distance to water source in Nguni weaners and does. Packed cell volume percentage for both Nguni weaners and does decreased with increasing distance to water source. Does had the lowest drop ($P<0.05$) in packed cell volume (-0.62 ± 2.57) compared to weaners (-11.21 ± 2.196).

4.3.4 Rectal temperature

The relationship between RT with distance to water source is shown in Table 4.3. There was a linear relationship between RT with distance to water source ($P<0.01$). The highest RT was observed at a distance of 3.25 km and the lowest RT was observed at distance 0.25 km to water source. Figure 4.1 shows the relationship between RT with distance to water source and age of Nguni goats. Rectal temperature for Nguni weaners and does increase with increasing distance km to water source. Rate of change in rectal temperature was higher ($P<0.05$) in weaners (0.07 ± 0.432) than does (0.05 ± 0.280).

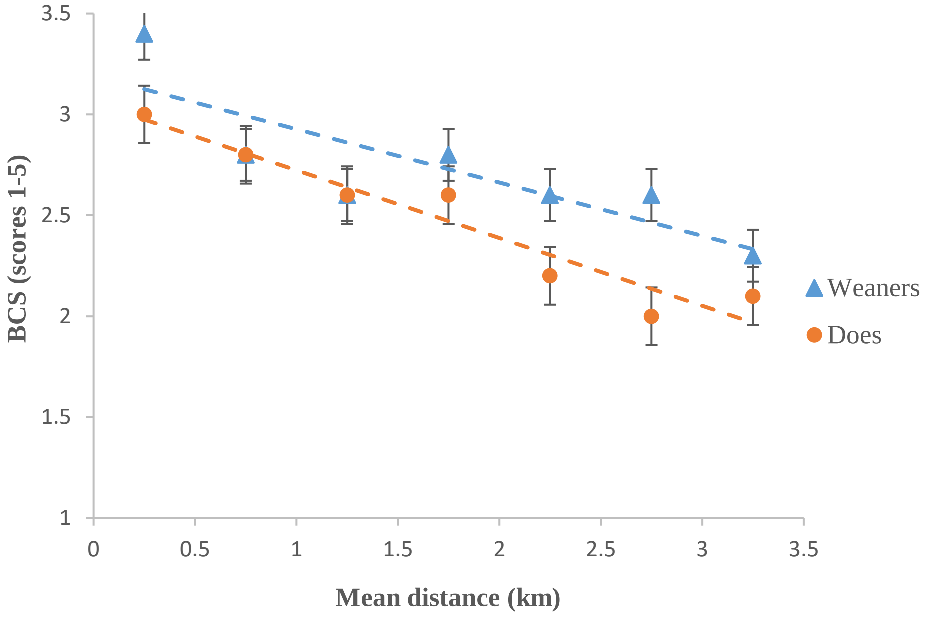
4.4 Discussion

Productivity of goats in arid environments is constrained by energy requirements and its unavailability affects the adaptation of goats. Walking to drinking water source requires energy (Lachica and Aguilera, 2005). The current study was designed to assess the extent at which Nguni weaners and does can tolerate walking stress to drinking water sources through measurements of BCS, FAMACHA, PCV and RT. Increased drought frequencies and reduced rainfall amount due to climatic changes cause water to be poorly available, thus prompt goats to live a number of days without drinking water and walk long distance in search for drinking water. Understanding of the extent at which Nguni goats can walk to drinking water is useful in maintaining the productivity of goats and conserving nearest water sources for human use without competing with goats.

Table 4.3: Relationship between distance from water and body condition score, FAMACHA scores, rectal temperature, and packed cell volume n Nguni weaners and does

Parameter	Mean distance to water source (km)							SEM	Regression coefficient	Sig
	0.25	0.75	1.25	1.75	2.25	2.75	3.25		Linear	
BCS	3.2	2.8	2.6	2.7	2.4	2.3	2.2	0.16	-0.50	***
FAMACHA	2.3	2.5	2.8	2.9	3.5	3.4	3.8	0.19	0.50	***
PCV (%)	32.5	26.4	24.9	24.1	26.1	23.8	21.2	1.15	-5.91	***
RT (°C)	38.4	38.5	38.8	38.7	38.8	38.8	39.3	0.16	0.06	**

Abbreviations: BCS = body condition score; PCV = packed cell volume; RT = rectal temperature; SEM = standard error of the means; ** (P<0.01); *** (P<0.001); n = 10; Sig = significance



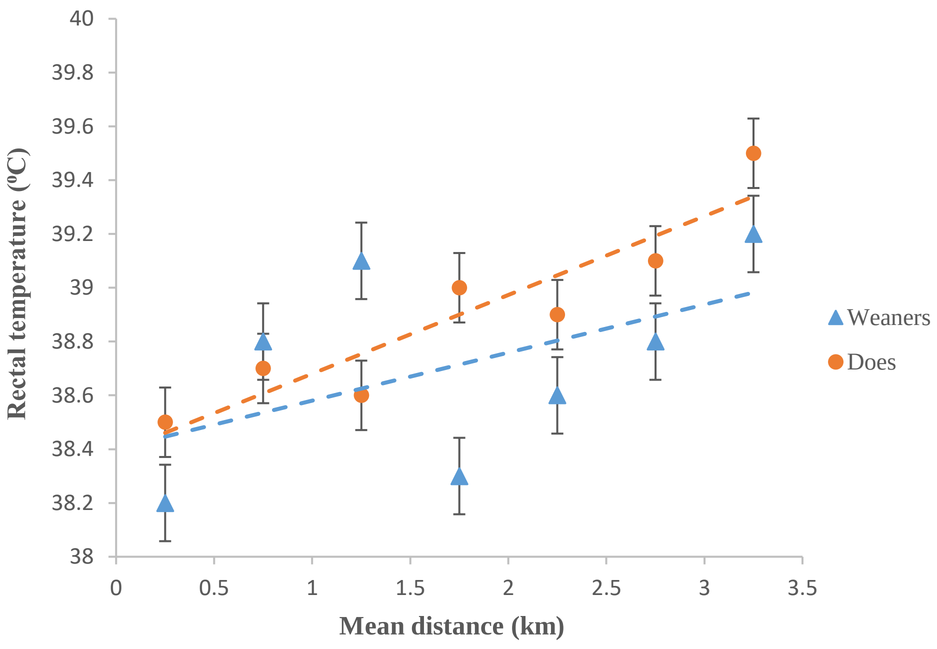


Figure 4. 1: Relationship between body condition score and rectal temperature with mean distance from water source in Nguni weaners and does

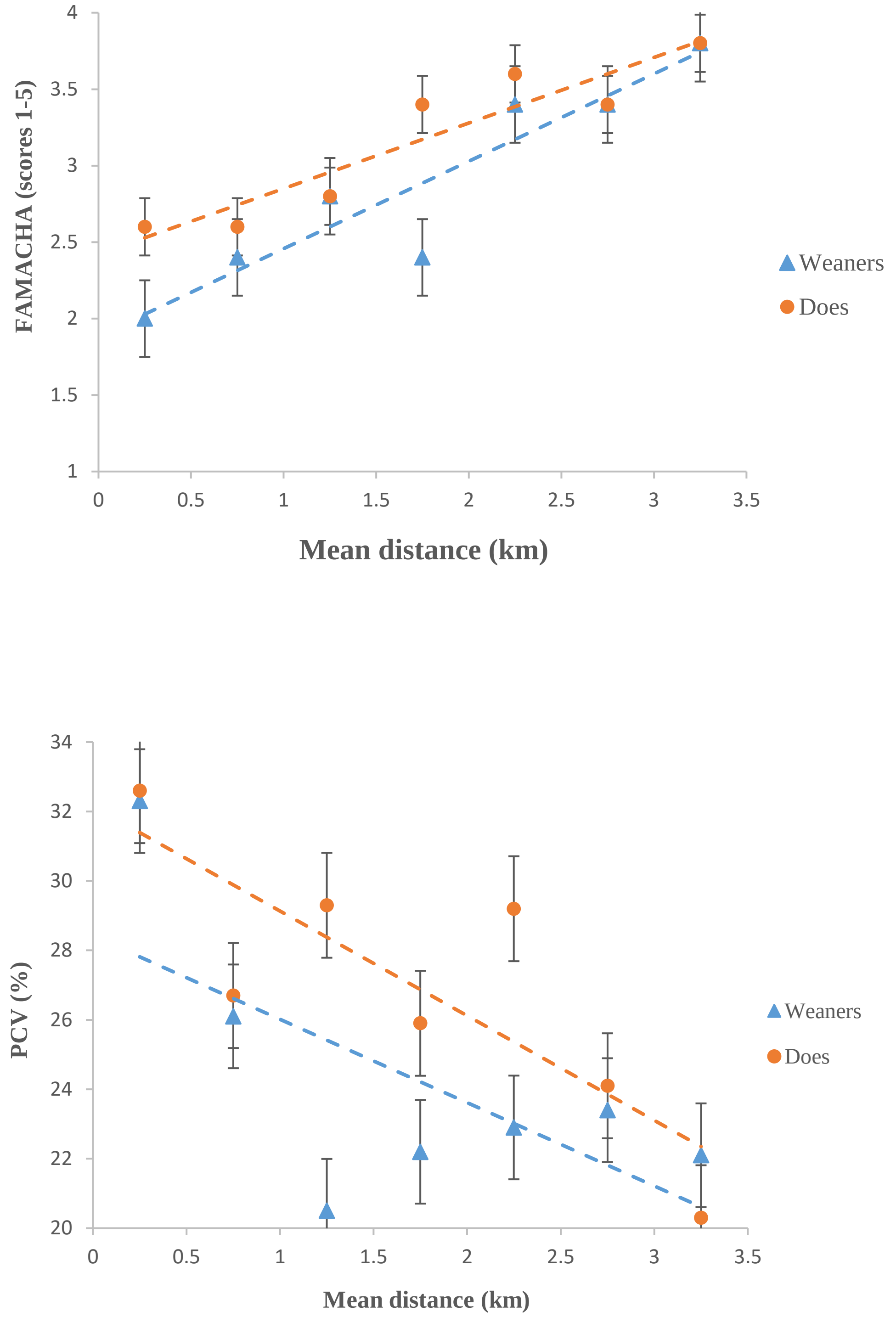


Figure 4. 2: Relationship between FAMACHA and packed cell volume with mean distance from water source in Nguni weaners and does

Body condition score is a useful tool for energy estimation of goats (Cabiddu *et al*., 1999).

The decline in the BCS could be due to walking stress which could have caused an alteration in metabolic and haemostatic processes. The observed increase in BCS of goats walking at a distance of 1.75 km to water source could be due to adaptability to heat and walking stress. Nicholson (1987) reported results that concur with the observation on BCS in relation with distance kilometres. The observed goats' BCS at distances of 2.25, 2.75, and 3.25 km could be due to browsing time being compromised during walking to drinking water source instead of browsing or grazing. Low BCS is associated with reduced feed intake. Goats deprived from drinking water have reduced feed intake (Silanikove, 1992).

The finding that PCV decreased with increasing distance is in contrast with the finding by Sejian *et al*. (2012), who reported an increase in PCV percentage due to walking stress. Garcia-Belenguer *et al*. (1996) also reported PCV percentage increment due to walking stress. Alam *et al*. (2011) observed an increase PCV percentage with increase in stress. Packed cell volume is a cheaper diagnostic test designed to aid mostly poor-resource communal farmers for detection of anaemic animals (Marcotty *et al*., 2008). The test thus requires laboratory facilities, however, provides a reliable status of anaemic animal (Grace *et al*., 2007). The observed decrease in PCV percentage could be due to inaccessible or poor water availability which results to haemo-concentration leading to low PCV percentage.

The finding that FAMACHA is positively related with the distance walked by goats to drinking water source is in accordance with the finding by Maurya *et al*. (2012). FAMACHA is an on-farm diagnostic method used to identify anaemic animals through observing and comparison of ocular mucous membrane colour (Papadopoulos *et al*., 2013). Falzon *et al*. (2013) observed a positive relationship between faecal egg count and distance walked. The relationship between faecal egg count and FAMACHA scores is positively related (Burke *et al*., 2007). The current finding thus concurs with the finding by Falzon *et al*. (2013) and Scheuerle *et al*. (2010). The possible biological clarification regarding these results is that within the range of FAMACHA score values observed, the goats had to either browse or graze for limited time and frequently travel to drinking water resulting to nutritional stress due to decreased iron intake amount from reduced feed intake.

Generally, rectal temperature is a good index when measuring internal body temperature of goats even though body parts vary in temperature. The findings about rectal temperature increment with increase in distance to water source are in accordance with the finding by Al-Haidary (2004) who found that rectal temperature increases with increase in heat stress. One of the biological explanation about these findings is that goats that drink water at distant water sources spend more time walking to water source, thus this increases chances of exposure to radiation heat during hot days, as a result goats are affected by heat stress. The findings revealed a slight fluctuation in rectal temperature as distance to drinking water source increases. The explanation about the fluctuation could be the variation in goat management practices within the households, and such practices include provision of kraal or shelter and type of kraal, and also the provision of additional drinking water which induce body cooling.

4.5 Conclusions

The distance from water source walked by Nguni weaners and does negatively affected BCS and PCV, and positively affected FAMACHA and RT. Minor unexpected findings may be due climate extremities, poor goat management within the village, and minor undetected errors during the study. Some of the values obtained in the current study are comparable to values recorded in other studies. Although both Nguni does and weaners were affected by the distance from water source, the effects were more adverse in weaners than in does.

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Chapter 5

General discussion, conclusions and recommendations

5.1 General discussion

Indigenous Nguni goats are prominent breeds in communal areas mainly kept for sales, ceremonies, and for meat. Production and nutritional status of goats in communal production systems is hindered by a number of challenges including poor water availability. Research studies have been conducted in assessment of walking stress to drinking water source, however, there is limited information available on Nguni goats based studies. Livelihoods of resource-limited farmers can be improved through sales and consumption of goat meat and other goat products, however, farmers need to first improve nutritional status of goats for sustainable livelihoods. Indigenous Nguni goats do not get adequate quality and quantities of water to support their optimum nutritional status.

In the first objective (Chapter 3), structured questionnaires were administered to compare the influence of water availability for Nguni goat flocks in wet and dry areas. The study revealed that more female farmers than male farmers were residing on farm. Disease prevalence, feed shortage, and water scarcity were the main challenges affecting goat production. Challenges to goat production varied within an area. Goats that were owned by farmers situated far (≥1 km) from the water source were likely to experience water shortage compared to goats that were owned by farmers situated nearer (<1 km) from the water source. These findings suggest that water was inaccessible for goats due to long distance apart from goats and water sources.

In chapter 4, the objective was to compare nutritional status responses of Nguni weaners and does to distance from water source. Body condition score (BCS), FAffa MAlan CHArt scores (FAMACHA), rectal temperature (RT), and packed cell volume (PCV) were monitored. The study was conducted, therefore, to test the hypothesis that nutritional status responses of Nguni weaners and does to distance from water source are different. The increase in distance from drinking water source caused a reduced BCS and PCV, and an increased FAMACHA score and RT. Nguni weaners and does responded differently to distance from water source. Thus, the hypothesis was then accepted since the nutritional status responses were different between Nguni weaners and does.

5.2 Conclusions

Water scarcity was among the major challenges to goat production. Farmers who did not provide additional drinking water for goats were likely to have goats experiencing water shortage compared to farmers who provided additional drinking water for goats. Distance to water sources highly predisposed the household's likelihood to experience water shortage. Both Nguni weaners and does were affected by the distance to water source, however, the effects were more adverse in does than in weaners. Nguni weaners and does can tolerate water shortages differently. These findings indicate that parameters such as BCS, RT, FAMACHA, and PCV can be used to asses nutritional status of goats under varying distances.

5.3 Recommendations and further research

In communal production systems, where water is a scarce resource, farmers should reserve nearest water source for their use only and allow goats to drink water at distant water sources. This could improve and sustain livelihoods of resource-poor farmers. Allowing goats to use distant water sources will reduce the demand and exploitation of fresh nearest water sources. Livestock species such as cattle and sheep, and other goat breeds should be considered in order to expand knowledge on livestock productivity as well, rather than on goat productivity only. Aspects that need further research include:

1. The assessment of other physiological parameters such as pulse rate, and respiratory rate is needed to ensure thorough understanding of the effect of distance from water source on physiological status of weaners and does.
2. The determination of the effect of distance from water source on physiological status of wethers and bucks.
3. The determination of the effect of water turbidity, smell, and viscosity on the physiological status of Nguni goats.

Appendices

Appendix 1. 1 Structured questionnaire

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

DST/NRF- Centre in Indigenous Knowledge Systems
CIKS

Objective: Farmer perceptions on the extent of use of indigenous knowledge to control nematodes, ticks and tick-borne diseases in goats and chickens

Questionnaire Number……Village name………………………Numerator name………………..Ward Number……

SECTION A: Household demography

A1. Sex of household: 1. M □ 2. F □

A2. Marital status: 1. Married □ 2. Single □ 3. Divorced □ 4. Widowed □

A3. Age: 1. 18-30 □ 2. 31-50 □ 3. >50 □

A4. Is the head of the household resident on the farm? 1. Yes □ 2. No □

A5. Highest education level: 1. No formal education □ 2. Grade 1-7 □ 3. Grade 8-12 □ 4. Tertiary □

A6. Have you ever received any training on livestock production? 1. Yes □ 2. No □

A7. What are major sources of income? 1. Crops □ 2. Livestock sales □ 3. Livestock products □ 4. Salary □ 5. Government grant □ 6. Other □, specify ……….

A8. Types of livestock species kept

	Cattle	Goats	Sheep	Chickens	Pigs	Other (specify)
Number						
Rank						

A10. What is the reason of using indigenous knowledge?
1. Effectiveness □ 2. Availability □ 3. Affordability □ 4. Quick solution □ 5. Works the same as conventional ways □ 6. Other □, specify ……….

A11. What is the source of indigenous knowledge?
1. Oral tradition from the family □ 2. Other farmers □ 3. Local elders □ 4. Own experience □ 5. Myths □ 6. Other □, specify ………………

A12. Do agricultural institutions promote and support the use of indigenous knowledge to treat animal diseases?
1. Yes □ 2. No □

A13. Which groups within the community uses traditional knowledge more?
1. Males □ 2. Females □ 3. Wealthy □ 4. Poor □ 5. Young □ 6. Educated □ 7. Non-educated □ 8. Other □, specify

A14. Do you see yourself using indigenous knowledge in future?
1. Yes □ 2. No □

A15. Which method would you recommend for preservation of indigenous knowledge?
1. Workshop □ 2. Educate young generation □ 3. Include in syllabus at school □ 4. Other, specify □ …

SECTION B: Goat production

B1. Why do you keep goats? (Please tick the first column for the purpose and the second column for ranking)

	Meat	Milk	Manure	Skin	Sales	Investment	Traditional ceremonies	Gifts
Tick								
Rank								

B2. Are you part of any farmer's association? 1. Yes □ 2. No □

B3. Who is the owner of goats? 1. Father □ 2. Mother □ 3. Children □ 4. Other □, specify ……….
B4. Who takes decisions about goat management?
1. Owner □ 2. Shepherd □ 3. Children □ 4. Other □, specify ……….
B5. What goat production system do you use?
1. Extensive □ 2. Semi-intensive □ 3. Intensive □ 4. Tethering □ 5. Integrated livestock/crop system □ 6. Other □, specify ……….
B6. How has climate change affected the quality of vegetation?
1. Dry □ 2. Species composition □ 3. No change □

B7. Do you practice supplementary feeding during periods of feed shortage?
1. Yes □ 2. No □
B8. What form of housing do you have for your goats?
1. Kraal □ 2. Stall/Shed □ 3. Yard □ 4. None □
B9. What are the challenges facing goat production?

Challenge	Feed shortage	Diseases	Ecto-parasites	Internal parasites	Inbreeding	Theft	Water scarcity
Tick							
Rank							

B10. What is the composition of your goat flock?

	Kids	Weaners	Does	Bucks
Male				
Female				

B11. What do you look for when selecting bucks?

	Scrotal circumference	Libido	Body conformation	Vigour	Scrotal palpation	Body condition
Tick						
Rank						

B12. How do you select does?

Condition	Body condition	Vigour	Mothering ability	Prolificacy
Tick				
Rank				

B13. How do you manage kids before weaning?
1. Let them go with mothers to the field □ 2. Leave them in the goat house □ 3. Leave them in the yard □ 4. Other □, specify ……….
B14. When do you wean kids?
1. Rainy season □ 2. Hot-dry season □ 3. Cool-dry season □ 4. Post-rainy season □
B15. Are housed kids provided with water when mothers are being herded?
1. Yes □ 2. No □
B16. How do productivity differ between past years and now?

Production parameters	**Past years**		**Present**	
	Increased	**Decreased**	**Increased**	**Decreased**
Conception rate				
Age at first kidding				
Kidding rate				

Kidding interval				
Kid mortality rate				
Goats mortality rate				

SECTION C: Goat health

C1. What causes kid mortality?

1. Lack of colostrum □ 2. No milk produced by lactating does □ 3. Predators (Jackals) □ 4. Feed shortage □ 5. Diseases □ 6. Other □ (specify) ………………

C2. How do you assess health challenges in goats?

1. Loss of body weight □ 2. Breathing difficulties □ 3. Not standing/playing □ 4. Not eating □ 5. Scratching □ 6. Diarrhoea □ 7. Tearing eyes □ 8. Limping □ 9. Abdominal swelling □ 10. Rash □ 11. Coughing/sneezing □ 12. Circling □ 14. Skin coat rises □ Other □, specify ……..

C3. What types of parasites are prevalent in this farm? (Can tick more than one)

	Ticks	Lice	Flies	Mites	Tapeworm	Roundworm	Liver fluke
Tick							
Rank							

C4. Who identifies parasites?

1. Household head □ 2. Shepherd □ 3. Other □, specify ……….

C5. What are different types of gastrointestinal parasites affecting your goats?

1. Roundworms □ 2. Tapeworms □ 3. Coccidia □ 4. Other □, specify ……….

C6. How do you identify a goat that has a problem with gastrointestinal parasites?

Symptoms	**Rainy season**	**Hot-dry season**	**Cool-dry season**	**Post-rainy season**	**Rank**
Loss of body weight					
Parasites in faeces					
Bottle jaw					
Anaemia					
Post-mortem					
Scours/Diarrhoea					
Stunted growth					
Enlarged abdomen					
Lethargy					
Rough hair coat					
Dry faeces					
Coughing/sneezing					
Fast breathing					
Poor/no appetite					
Other (specify)					

C7. How has the change in rainfall patterns affected the prevalence of gastrointestinal parasite?

1. Increase □ 2. Decrease □ 3. No change □

C8. How has the change in temperature patterns affected the prevalence of gastrointestinal parasite?

1. Increase □ 2. Decrease □ 3. No change □

C9. What do you use to treat gastrointestinal parasites?

1. Antihelmintics □ 2. Traditional medicine □ 3. Other □ (specify) ………………

C10. What is the effect of season on tick prevalence?

Ticks	Rainy season	Hot-dry season	Cool-dry season	Post-rainy season	Rank
Bont tick					
Brown ear tick					
Red tick					
Other (specify) ……….					

C11. How has change in rainfall pattern affected tick distribution?
1. Decrease □ 2. Increase □ 3. No change □

C12. How has increase in temperature affected the tick distribution?
1. Decrease □ 2. Increase □ 3. No change □

C13. What are different types of tick-borne diseases affecting goats?
1. Heart water □ 2. Tick-borne fever □ 3. Anaplasmosis □ 4. Babesiosis □ 5. Other □, specify ……….

C14. Do you prevent tick-borne diseases in goats?
1. Yes □ 2. No □

C15. What traditional medicines do you use to control gastrointestinal parasites?
1. Nhlashwana □ 2. Hlunguhlungu □ 3. Phehlecwathi □ 4. Umnala □ 5. Umganu □ 6. Inhlaba □ 7. Ukhoshokhoshwana □ 8. Icena □ 9. Isibiba samandiya □ 10. Umdladlathi □ 11. Uvovovo (umgxamu) □ 12. Halibhomu □ 13. Ikhambi lesisu □ 14. Ibozana □ 15. Ugebeleweni □ 16. Umqathongo □ 17. Iskhuvethe □ 18. Umhuluka □ 19. Isihlenama □ 20. Undonga zibomvana □ 21. Umababaza □ 22. Inkalane □ 23. Umqalothi □ 24. Umfusamvu □ 25. Ubhoqobhoqo □ 26. Uphongo □ 27. Umkhanyakude □ 28. Umkhuhlu □ 29. Inkomankomana □ 30. Umtshovane □ 31. Umvunguza □ 32. Other □, specify ……….

C16. How do you identify goats that have ticks and tick-borne diseases?

Symptoms	Rainy season	Hot-dry season	Cool-dry season	Post-rainy season	Rank
Loss of body condition					
Skin damage					
Scratching					
Anaemia					
Wounds					
Limping					
Abortion					
Inflammation of the udder					
Circling					
Red urine					
Increase pulse rate					

C17. What do you use to treat ticks and tick –borne diseases?
1. Scissors □ 2. Thorns □ 3. Grease oil □ 4. Jays fluid □ 5. Gashing □ 5. Cut the ears □ 5. Burn incense □ 6. Other □ (specify) ………………

C18. What are challenges you have experienced with acaricides?
1. Not killing ticks □ 2. Expensive □ 3. Other □ (specify)……………….

C19. Do you follow the instructions when using acaricides?
1. Yes □ 2. No □

C20. What are traditional medicines that you use to control ticks and tick -borne diseases?
1. Nhlashwana □ 2. Uzililo □ 3. Ushisizwe □ 4. Phehlacwathi □ 5. Inhlaba □ 6. Ingcotho □ 7. Umkhwango □ 8. Umdladlazo + Upelepele □ 9. Umahlanganisa □ 10. Umfusamvu □ 11. Umhlahlampethu □ 12. Other □, specify ……….

SECTION D: Chicken health

D1. Why do you keep chickens? (Please tick the first column for the purpose and the second column for ranking)

Purpose	Meat	Eggs	Manure	Income	Traditional ceremonies
Tick					

Rank					

D2. What chicken production system do you use?

1. Extensive □ 2. Semi-intensive □ 3. Intensive □ 4. Other □, specify ……….

D3. What are the challenges facing chicken production?

Challenges	Nematodes	Diseases	Mortality	Low egg production
Rank				

D4. What is the chicken flock size and composition?

Range	Hens	Chicks	Cocks
≤ 10			
10 - 30			
30 – 50			
50+			

D5. What method do you use to feed chickens?

1. Broadcast □ 2. Local made feeders □ 3. Commercial feeders □ 4. Other □, specify ……….

D6. How often do you clean chicken houses?

1. Once a week □ 2. Once a season □ 3. Once a year □ 4. When remembered □ 5. None □ 6. Other □ (specify) ………………

D7. What are problematic parasites in your chickens?

1. Internal parasites □ 2. Ecto-parasites □

D8. How do you diagnose chickens with nematodes?

1. Diarrhoea □ 2. Loss of body weight □ 3. Low egg production □ 4. Anaemia □ 5. Feather drop □ 6. Reduced appetite □ 7. Coughing □ 8. Saliva excretion □ 9. Swollen comb □ 10. Closed eyes □ 11. Dirty cloacal region □ 12. Increased thirst 13. Head nodding down 14 Other □, specify ……….

D9. How do you select cocks for mating?

1. Health □ Colour □ Size □ Other □, specify ……….

D10. Do you use traditional medicines to treat nematodes or parasites in chickens?

1. Yes □ 2. No □

D11. If yes, how long have you been using medicinal herbs to treat nematodes in chickens?

1. < 5 years □ 2. 5 – 10 years □ 3. >10 years □

D12. Which medicinal plants do you use to treat nematodes in chickens?

1. Isithezi □ 2. Umnala □ 3. Icena □ 4. Inhlashwana □ 5. Inhlaba □ 6. Umdlandlatho □ 7. Umthombothi □ 8. Umhlonhlo □ 9. Ulilo □ 10. Umgwadla □ 11. Uhalibhomu □ 12. Ikhambi lesisu □ 13. Umtshovane □ 14. Umgxamo □ 15. Amasethole □ 16. Isibiba samakula □ 17. Umanyazini □ 18. Isnemfu □ 19. Ushibhoshi □ 20. Other □, specify ……….

D13. Which type of chickens flock is mostly affected by nematodes?

1. Chicks □ 2. Hens □ 3. Cockerels □

SECTION E: Climate change

E1. What are the sources of water for goats?

1. Dam/Pond □ 2. River □ 3. Borehole □ 4. Water well □ 5. Spring □ 6. Tap □ 7. Rainwater □ 8. Grey water □ 9. Other □, specify ……….

E2. How does the number of water sources for goats differ in the past years and now?

		Dam/Pond	River	Borehole	Water well	Spring	Tap	Rainwater	Grey water
Past years	Increase								
	Decrease								
Present years	Increase								
	decrease								

E3. Comparing temperatures in the past years and now, how do they differ?

Season	**Present**		**Past years**	
	Increased	**Decreased**	**Increased**	**Decreased**

Rainy season				
Hot-dry season				
Cool-dry season				
Post-rainy season				

E5. For how long can goats live without water?
1. 2 – 3 days □ 2. 4 – 7 days □ 3. > 10 days □

E6. If water is not available at all, do you supply water to goats?
1. Yes □ 2. No □

E7. How frequent is water being supplied to goats?
1. Freely available □ 2. Once a day □ 3. Once in two days □ 4. Once in 3 days 5. Once a week □ 6. Other □, specify ……….

E8. How frequent are the incidents of water sources drying out?
1. Twice a year □ 2. Once a year □ 3. Once in 3 years 4. Once in 10 years 5. Other (specify) ………………….

E9. How much distance (km) is covered by goats to drinking water sources?
1. Short (<1km) □ 2. Moderate (1km) □ 3. Long (>1km) □

Appendix 1. 2 Ethical approval for questionnaire

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

23 January 2018

Professor Michael Chimonyo (28007)
Scool of Agricultural, Earth & Environmental Sc
Pietermaritzburg Campus

Dear Professor Chimonyo,

Protocol reference number: HSS/0852/017
Project Title: Indigenous knowledge of controlling nematodes and ticks in chickens and goats

HSSREC Approval – Expedited Application

In response to your application received 21 June 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **APPROVAL** for Trial 2 and Trial **3.**

NOTE:

AREC approval needs to be obtained for Trial 1 and Trial 4

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)

/ms

Cc Academic Leader Research: Professor Hussein Shimelis
Cc School Administrator: Ms Marsha Manjoo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
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100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood, Howard College, Medical School, Pietermaritzburg, Westville

Appendix 1. 3 Ethical approval for trial

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

14 August 2018

Professor Michael Chimonyo (28007)
School of Agricultural, Earth & Environmental Sciences
Pietermaritzburg Campus

Dear Professor Chimonyo,

Protocol reference number: AREC/043/017
Project title: Indigenous Knowledge of controlling nematodes and ticks in chickens and goats

Full Approval – Research Application

With regards to your revised application received on 29 June 2018. The documents submitted have been accepted by the Animal Research Ethics Committee and **FULL APPROVAL** for the protocol has been granted.

Please note: Any Veterinary and Para-Veterinary procedures must be conducted by a SAVC registered VET or SAVC authorized person.

Any alteration/s to the approved research protocol, i.e Title of Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

Please note: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of one year from the date of issue. Renewal for the study must be applied for before 14 August 2019.

Attached to the Approval letter is a template of the Progress Report that is required at the end of the study, or when applying for Renewal (whichever comes first). An Adverse Event Reporting form has also been attached in the event of any unanticipated event involving the animals' health / wellbeing.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Prof S Islam, PhD
Chair: Animal Research Ethics Committee

/ms

Cc Academic Leader Research: Professor Hussein Shimelis
Cc Registrar: Mr Simon Mokoena
Cc NSPCA: Ms Anita Engelbrecht

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