Socio-economic Contribution and Health Challenges of Indigenous Chickens in Smallholder Systems

By

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Declaration

I, Chuma Wande Zamxaka, hereby declare that this research is an outcome of my own investigation under the supervision of Prof. P. J. Masika; and has not been previously submitted to any University. Where reference to other researchers' work has been made and assistance was rendered; has been duly acknowledged in the text.

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Abstract

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By

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Indigenous chickens are kept for various socio-economic purposes by the majority of households in the developing countries. However, their contribution to the livelihoods of the households has been observed by a number of researchers to be bolow their potential. Therefore, main objective of this study was to determine the contribution of the indigenous chickens towards the livelihoods of the rural people and to establish the health challenges of these chickens. The study was conducted in two phases and in two villages, a coastal one (Gcina) and inland site (Ngcingcinikhwe). Phase one was through the use of a structured questionnaire, while phase two included the seasonal collection of specimens and lab analyses to determine disease and parasite prevalence patterns. The location and seasonal effects on disease and parasite prevalence were analyzed. In the first phase of the study, the socio-economic statuses of the two communities were measured by determination of household income levels, main source of income and food security status. The main source of income in 80% of households was government social welfare grants and the average food security scores, which are indicative of the application of food shortage coping strategies, were 22.8 and 27.3 in Gcina and Ngcingcinikhwe, respectively. In addition, the contribution of indigenous chickens to the livelihoods of selected locations was measured by investigation of selling and consumption frequencies of indigenous chickens and their eggs. It was observed that in Gcina and Ngcingcinikhwe, 55% and 48% of households sold chickens, respectively, while 11% and 15% of households sold eggs in Gcina and

Ngcingcinikhwe, respectively. Furthermore, 90% and 78.7% of households in Gcina and Ngcingcinikhwe, respectively, consumed indigenous chicken meat once a month while77.8% and 72.4% of households in Gcina and Ngcingcinikhwe, respectively, consumed eggs once a month. In addition, average flock sizes observed in Gcina and Ngcingcinikhwe were 8.3 and 10.4 chickens, respectively, and chickens were allowed to scavenge for their feed with maize offered as the only supplement. An average of 11.6 and 11.7 eggs were set for hatching in Gcina and Ngcingcinikhwe, respectively, and the average hatching rate was 78.4% in Gcina while it was 71.8% in Ngcingcinikhwe. However, the average chick survival rate to growing phase was 55% in Gcina and 59.5% in Ngcingcinikhwe. This low chick survival rate was attributed to disease and parasite infestation. Furthermore, the respondents mentioned respiratory and nervous symptoms as the most commonly observed disease symptoms while worm infestation was least mentioned as a health challenge. Furthermore, the respondent alluded to the fact that symptoms of ill-health were mostly observed in summer and autumn. However, scientific determination of disease and parasite prevalence mostly contradicted the assertions of the respondents with regards to disease and parasite prevalence patterns as chickens had the lowest Newcastle disease (NCD) antibody levels in spring. Therefore, this was the season when they were most likely to exhibit NCD symptoms. Further observation was that the proximity to the coast did not have an effect on the level of NCD antibodies observed in chickens. Furthermore, de-wormed chickens had higher NCD antibody levels for a longer period compared to the those that were vaccinated only. It was, therefore, concluded that helminthes had a negative effect on the NCD antibody response to vaccination. To this end, an investigation of the prevalence of the helminthes revealed that there were three helminthes species (*Railetina spp., Ascaridia galli and Heterakis gallinarum*) were dominant during all seasons. However, the highest helminthes prevalence was

observed in the inland location (Ngcingcinikhwe) in autumn. Futhermore, *Salmonella* positive feacal samples were reported in winter (20%) and summer (10%) in Gcina, whereas in Ngcingcinikhwe they were only reported in Spring (20%). In addition, the *Salmonella* serovars that were isolated from the positive samples were *Salmonella entiritidis* and *Salmonella typhimurium*. Based on this observation, it was concluded that there was a very low salmonella prevalence in the indigenous chickens of the two locations. In contrast, ecto-parasites were observed to be highly prevelant in both locations with season and proximity to the coast having effects on the species prevalence. *Menopon gallinae* exhibited the highest prevalence (90%) in the costal location in autumn whereas the fleas species (*Echidnophaga gallenacea*) was most prevalent in the inland area during spring. Furthermore, tick species (*Amblyoma hebraeum*) was most prevalent (70%) in the coastal area in spring and autumn, whereas another tick species (*Argus spp*) was most prevalent (40%) in the inland location in winter. In conclusion indigenous chickens had an insignificant contribution to the livelihoods of the people in the two study site due to health challenges that kept the flock sizes small and the production low. The health challenges were observed to differ by location and season. To this end, for an effective indigenous chicken health management strategy to be developed, the seasonal prevalence of diseases and parasites in a particular location needs to be established.

Keywords: indigenous chickens, rural households, production, health management

Dedication

I dedicate this thesis to my wife Nonkuthazo (Zim) and my children Uyivile and Khanyakhwezi.

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Chapter 1: Introduction

1. Background

Generally, The world population is divided into two broad categories based on where people reside, i.e. rural and urban inhabitants. These two categories have their particular and distinct socio-economic attributes that include cultural practices, sources and levels of income amongst others. Poverty is a prominent and perpetual characteristic feature of people residing in rural areas around the world, and it is estimated that 75% of poor people stay in rural areas (Rural Poverty Portal, 2015). Poverty renders people incapable of acquiring basic necessities of life and, consequently, leads to hunger, malnutrition and, ultimately, death (Knowledge Center, 2015).

About 16 million of undernourished people are found in developing countries, which include mainly South Asia and sub-Saharan Africa, and 28% of children in these countries are underweight with about 22 000 of them dying each day due to hunger (Woolard and Leibbrandt, 1999; Sha, 2013). Rural areas account for three quarters of people living on less that US$ 1 a day; Africa is predominantly rural (Sha, 2013; Pauw, 2005). In Africa the number of hungry people has increased between 1990-1992 and 2010-2012 from 175 million to 239 million people and 60% of this figure are women (World Hunger, 2013). In South Africa, particularly, poverty levels have not declined even after the advent of democracy in 1994, and poverty has been reported to be severe in former Bantustans (Westaway, 2012). Pauw (2005) and Westaway (2012) reported that poverty in rural areas of South Africa was 40% higher compared to urban areas and rural households had an average monthly income of R1276 (USD98.15) while urban counterparts had R2357 (USD181.30).

The former Bantustans Ciskei and Transkei in the Eastern Cape Province of South Africa are characterized by chronic poverty, low economic activity, low employment opportunities, dependency on welfare and growing food insecurity (Westaway, 2012). In these areas, about 73% of rural households live on less than R300 (USD23.80) per month and 75% of this amount is utilized to purchase food (Abdu-Raheem and Worth, 2011 and Westaway, 2012). People in the former Bantustans used to rely on field crops for food security, however, a sharp increase in production cost has led to a decline in agricultural activities over the past 60 years despite rampant food insecurity (Westaway, 2012). Consequently, only 1% and 4% of rural households are able to derive income from crop and livestock production, respectively (Abdu-Raheem and Worth, 2011).

Small scale farming has been regarded as a solution to food insecurity and poverty in rural areas, however, 50% of farming households are still regarded as poor (Westaway, 2012; Rural Poverty Portal, 2015). Smallholder farmers can produce food for own consumption and generate revenue from sales of produce, therefore, mitigating food insecurity and poverty. Government has directed considerable efforts in supporting smallholder farmers over the past few years with minimal or no success (Westaway, 2012). The observed lack of success can be attributed to high production cost, inadequate extension services and competitive advantage of large-scale farmers (Westaway, 2012). However, despite the glaring challenges facing the smallholder farmers, agriculture has a potential to mitigate poverty and food insecurity if the challenges identified can be addressed (Machete, 2004). Improvement of extension services, choosing a product that will not be in direct competition with those produced by large-scale farmers and selection of a simple production system that requires less capital input will go a long way in assisting rural inhabitants in mitigating poverty and food insecurity. Therefore, indigenous chickens, kept by a majority of

rural households, meet all these characteristics of a production system that can suite the needs of rural inhabitants.

Indigenous chickens form a significant part of the rural household livelihoods as a source of income and protein, and as gifts to strengthen social relationships (Kusina, *et al.,* 2001, Aklilu, *et al.,* 2007 and Copland and Alders, 2005). These chickens require low input cost to produce as they scavenge for feed, sleep in make-shift coops and require limited or no health management as they are generally regarded as resistant to many health challenges (Abdelqader, *et al.,* 2007 and Larbi, *et al.,* 2013). Although low growth rates and yields of meat and eggs are some of the disadvantages associated with indigenous chickens, possible disease tolerance and high quality meat and eggs are significant advantages (Makaya, *et al.,* 2014). There is a high demand for indigenous chicken eggs and meat due to their intense taste, flavor and aroma (Larbi, *et al.,* 2013). However, despite the positive attributes of indigenous chickens, they generally contribute far below their poteintial to the rural livelihoods in terms of the chicken products consumed and sold (Biswa, *et al.,* 2008). The revenue generated from sale of chickens and eggs, and consumption of these products is very low and this observation has been attributed to mainly low flock numbers (Abdelqader, *et al.,* 2007). The main contributing factors to the low numbers of indigenous chickens are health challenges, predation and lack of technical and practical skills necessary to produce chickens (Abdelqader, *et al.,* 2007).

Health challenges have a negative effect on indigenous chicken production by reducing egg and meat production and by increasing mortality rate (Makaya, *et al.*, 2014). The notable health challenges that affect indigenous chickens include parasites (internal and external), salmonellosis and Newcastle disease (NCD) (Njuga, 2003; Zeleke, *et al.,* 2005, Phiri, *et al.,* 2007;). Parasite infestation lead to reduced growth rate and egg production because they compete with the host

chickens for available nutrients (Skallerup, *et al*, 2005; Phiri, *et al.*, 2007). Furthermore, the parasites render the host susceptible to infections by an array of micro-organisms as they lead to reduced immunity (Njuga, 2003). Horning, *et al.*, (2003) reported that worm infested bird were more susceptible to NCD out-breaks because of lower NCD antibody levels. Newcastle disease is the most devastating disease in chicken production as it can cause mortality rates of up to 100% during out-breaks (Bhadaso, 2012; Rahman, *et al.*, 2013). However, a number of studies have reported that indigenous chickens seem to develop a natural protection against NCD, as a result, out-breaks do not lead to 100% mortality despite non-vaccination or absence of NCD control strategy (Skallerup, *et al.*, 2005; Aziz, *et al.*, 2010; Ogie, *et al.*, 2013; Msoffe, *et al.*, 2014; Tohidi, *et al.*, 2014). The prevalence of diseases and parasites is influenced by various factors which include husbandry, geographic location and season of the year (Skallerup, *et al.*, 2005; Phiri, *et al.*, 2007; Rahman, *et al.*, 2013). A number of studies have reported a higher prevalence of internal parasites during wet season and higher prevalence of external parasites during dry season (Horning, *et al.*, 2003; Skallerup, *et al.*, 2005). However, contradicting reports on seasonal effect on NCD prevalence have been published in recent years (Yongolo *et al.*, 2002; Zeleke, *et al.*, 2005; Aziz, *et al.*, 2010; Kemboi, *et al.*, 2013).

An effective and economical health management strategy for indigenous chickens has to be area specific by taking into consideration the seasonal and geographic effects on the prevalence of diseases and parasites. Moreover, considering the fact that the majority of indigenous poultry keepers are resource-limited, the ethno-veterinary medicines used by the chicken keepers also need to be evaluated for effectiveness as they might be less expensive alternatives to commercial medicines (Rahman, *et al.*, 2013). In addition, thermo-stable vaccines also need to be considered to eliminate the need for cold chain to preserve vaccines (Illango, *et al.*, 2008).

1.1 Problem Statement

Indigenous chickens have a potential to improve the socio-economic status of poor and food insecure rural communities. However, egg and meat production from this poultry production system is extremely low because of low chicken growth rate, low egg production rate and high mortality. The low production and high mortality is mainly attributed to low feed quality, high disease and parasite prevalence. The types of diseases and parasites that are prevalent in indigenous chickens are not well documented. Furthermore, the dynamics of health challenges, i.e. seasonal and location variation of the prevalence of these diseases and parasites, are also poorly understood, therefore, making it difficult to manage them. This is further compounded by nonexistence of a comprehensive and effective disease and parasite control strategy for the indigenous chickens.

1.2 Study Justification

The existence of an effective disease and parasite control strategy will go a long way in reducing the mortality and improving the production of indigenous poultry. The formulation of an effective disease and parasite control strategy requires the establishment of the prevalent diseases and parasites and the dynamics of their prevalence, i.e. location and seasonal variation. In addition, for the strategy to be declared "effective", it has to be evaluated. If the strategy is proved to be effective, the rural households will be able to use the increased production output from their indigenous chicken for various purposes that will improve their socio-economic status and livelihoods.

1.3 Main Objective

The main objective of the study was to determine the socio-economic contribution and the health challenges of indigenous chickens with the aim of developing an effective comprehensive health management strategy.

1.3.1 The specific objectives of the study were to:

- determine food security and socio-economic status of two selected rural communities;
- determine the contribution of indigenous chicken to the livelihoods of the people residing in the selected rural areas;
- determine the production status of indigenous chicken in two rural communities;
- determine seasonal prevalence of poultry diseases and parasites in indigenous chicken; and,
- evaluate an alternative disease and parasite control strategy if existant. The presence of absence of a health management strategy was to be investigated and, where one was in place, it was to be investigated. In the event where there is no health management strategy, one was to be recommended.

1.4 Hypotheses

1.4.1 Research Hypothesis

Indigenous chickens have a minimal contribution towards the livelihood of gererally poor rural households because of low production caused by rampant array of heath challenges.

1.4.2 Null Hypothesis

The following null hypothesis will be tested:

- There is no food insecurity in rural communities;
- Indigenous chickens do not have a significant contribution to the livelihoods of the rural people;
- There is no production of indigenous chickens in the rural areas;
- Diseases and parasites do not affect indigenous chickens; and
- There is no existing disease and parasite control strategy for indigenous chicken

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Chapter 2: Literature Review

Introduction

Poverty in developing countries around the world remains a perpetual challenge despite the implementation of various poverty alleviation initiatives. It is generally accepted that poverty is closely linked to food insecurity (Westway, 2012). The common definition of poverty is that it is the inadequacy of resources necessary for basic livelihood, while food insecurity is defined as in inability to acquire enough nutritious food (Labadarios, *et al.,* 2009). Severe poverty leads to food insecurity, which, consequently, result in hunger (Abdu-Raheem, *et al.,* 2011). Poverty leads to diseases, lower life expectancy, physical and mental retardation (Lwelamira, 2012). In addition, poverty is regarded as more of a rural phenomenon rather than an urban one as poverty rate is as high as 82.2% in rural areas compared to 42.1% in urban areas in South Africa (Pauw, 2005). Furthermore, Westway (2012) reported that poverty rate has not declined in South Africa since the advent of democracy in 1994 and it is severe in former Bantustans. However, Statistics SA (2014) reported a decline in poverty rate and percentage of people who go hungry between 2006 and 2011 (Table 2.1).

Table 2.1: Poverty and hunger rates measured over the years in South Africa (Stats SA, 2014)

Measure	2006	2011
Poverty Rate (%)	57.2	45.5
Extremely Poor People (%)	26.6	20.2
People Going Hungry (%)	-	12
Inequality (1 = total inequality and 0 = total equality)	0.72	0.69
Blacks Living under poverty line (%)	66.8	54
Poor children (%)	68.9	55.7
Poor Elderly (%)	68.9	55.6
Poor uneducated people (%)	78.5	66
Poor Rural People (%)	80.8	68.89

Sartorius, *et al.* (2013) reported that the following groups were most vulnerable to poverty:

1. Unemployed people
2. Older people with poor health and low income
3. Low wage earners
4. Females, in particular single parents
5. People residing in rural areas

The majority (63%) of South African population reside in rural areas and most of rural inhabitants are Africans (Pauw, 2005). In addition, rural households earned R1 276/month compared to R2 357/month earned by their urban counterparts and rural areas account for three quarters of people living on less than US$ 1 a day (Abdu-Raheem, *et al.,* 2011). About 30% of children who die of hunger and malnutrition on daily basis are in South Asia and Sub-Saharan Africa (Sha, 2013). Due to hunger and absence of employment opportunities in rural areas, rural people resort to migrating to urban areas. However, in recent years, urbanization has not been a certain getaway from rural poverty due to the poor economic situation and, consequently, urbanization has largely resulted in mushrooming of slums that are characterized by poverty and diseases (Sha, 2013). Furthermore, in recent years, 60% of migrant labour have not been able to remit money to rural areas as it was the case before (Westway, 2012).

The Eastern Cape Province is regarded as the second poorest province in South Africa and is characterized by high levels of unemployment and poverty, particularly in the rural areas (Pauw, 2005). Rural areas provide homes to about two-thirds of the Eastern Cape population (Pauw, 2005). Furthermore, 73% of people residing in the rural areas of the Eastern Cape live on less than R220/month, which is below R255 that was set as a poverty line by the presidency in 2008 (Westway, 2012). The astonishing fact about the Eastern Cape is the glaring disparity in the average income levels and, consequently, poverty rates between the western and eastern parts of the province. The average monthly household income in the eastern part is R1 240 whereas the whole province's average household income is R1 756 (Westway, 2012). This glaring inequality can be attributed to the fact that the eastern part of the province is dominated by the former Bantustan States, which were previously provided with very limited resources (Pauw, 2005). These former Bantustan states are characterized by chronic poverty, low economic activity, high

dependency on welfare, growing food insecurity and high expenditure on food (Westway, 2012). One of the prominent poverty characteristic in the rural areas is the disparity between male and female headed households. On average, a male-headed household earns about R2 100/month compared to R1400/month earned by female-headed households (Westway, 2012). In addition, the poverty gap in females in 2011 was 20.5% compared to 18.8% in males (Stats SA, 2014). Furthermore, poverty rate in 2011 was 43.9 and 25.7% in female and male-headed households, respectively (Ozoemena, 2010).

Rural inhabitants rely mostly on agriculture as a form of economic activity that can generate household income and employment (Pauw, 2005, ruralpovertyportal.org, 2015). However, there has been a decline in agricultural activity over the past 60 years (Collinson, 2009; Westway, 2012). Currently, only 1 and 4% of rural households derive income from crop and livestock production, respectively (Westway, 2012). The decline in agriculture production has resulted in food security and malnutrition concerns, particularly in the rural areas (Abdu-Raheem, 2011). Furthermore, agricultural activities have been observed to not present an important source of income to many rural households because the average poverty rate in agriculture-reliant households was 80.3% compared to 65.9% in non-agriculture households (Pauw, 2005). In contrast, Machete (2004) and Abdu-Raheem (2011) reported that most households that are involved in agriculture are less poor than those that are not involved. The decline in agricultural activity could be largely attributed to an increase in agriculture input costs, expanded government welfare grants and climate change (Mekonnen *et al.*, 2010). Though reliance on agriculture for food security seems to gradually fade, Abdu-Raheem (2011) and Machete (2004) reported that with a number of interventions agriculture can still play a vital role in the livelihoods of rural people. These interventions include the following:

- Improved extension services
- Improvement of production technologies
- Marketing of products to improve sales
- Utilization of resources at the disposal of the people to minimize production costs

Unfavorable global economy has led to a decline in commodity demand and demand for higher wages has led to massive job losses (Mekonnen, 2010). This has diminished the advantage of urbanization as an option to better life and a way out of poverty.

On the other hand, the majority of rural households keep indigenous chickens to generate revenue from eggs and live chicken sales, own consumption and for various cultural activities (Ndathi, *et al.,* 2006; Msoffe, *et al*., 2006). However, a number of recent studies have reported that fewer chickens and eggs are consumed or sold than what is deemed to be the standard, due to a number of constraints. Health challenges in indigenous chickens are a major constraint as they lead to poor production and increased mortality. A number of interventions aimed at addressing health challenges and, consequently, improving indigenous chicken production have been proposed. It is believed that through these interventions the rural socio-economic challenges like poverty, food insecurity and malnutrition can be ameliorated (Msoffe, *et al*., 2006; Ndathi, *et al.,* 2006; Harrison, *et al.,* 2010). Indigenous chicken production generate financial returns, which increases food security and, consequently, contributes to poverty reduction (Harrison, *et al.,* 2010). A study by Bagnol, *et al.* (2013) confirmed the effectiveness of indigenous chicken production in reducing poverty as it was observed that poverty-related incidents were 64% in poultry farming households compared to 85% in non-poultry farming households. In the same study, it was reported that the percentage gap below the poverty line was

38% for indigenous chicken keeping households while it was 56% for those households which did not keep indigenous chickens.

2.1 The socio-economic role of indigenous chickens

2.1.1 Women as owners

About 80% of indigenous chicken population in Africa is kept in rural areas in approximately 85% of households (Minga, *et al*, 2001, Westway, 2012; Larbi, *et al.*,2013), and women are mostly owners and managers of these chickens taking decisions on the management, consumption and sale of chickens (Okeno, 2012). Many publications have alluded to the fact that women, particularly, in female-headed households tend to experience higher levels of poverty than their male counterparts (Okeno, 2012; Assa, 2012). Bhadhaso (2012) reported that female indigenous chicken farmers indicated that chickens generated supplementary income for the household in addition to husband's earnings. Therefore, indigenous chickens can be used by women as a form of empowerment (ruralpovertyportal.org, 2015; Okeno, 2012). However, Westway (2012) reported that despite the economic benefits associated with keeping indigenous chickens, poor and female-headed households kept fewer chickens than less poor and male-headed households. Therefore, more support for rural women on various aspects of indigenous chicken production can result in increased chicken numbers and alleviation of rural poverty (Assa, 2012; Mtileni, *et al.*, 2013).

2.1.2 Sales and consumption

Indigenous chickens provide protein and revenue for the rural households, and production for household consumption is regarded as priority and the surplus chicken and eggs are sold (Ndathi, 2006; Badhaso, 2012; Bagnol, 2013). However, Ramdas (2009) observed that in India 60 to 70% of indigenous chickens are sold, 15 to 20% consumed at home and 15 to 20% kept for breeding.

The revenue generated from sales is normally utilized for other household commitments like groceries, health care and clothing (Bouzari *et al.*, 2004; Alders and Pym, 2009). Nonetheless, a number of constraints have resulted in less chickens and eggs sold or consumed by the rural households. Improvement of indigenous chicken production through various interventions will require exploration of more marketing opportunities to generate more cash income to off-set any additional expenses that might be incurred during implementation of interventions (Aklilu, 2007; Wambura, 2011). Furthermore, there is a need for understanding consumption and market patterns for the best development of indigenous chickens (Aklilu, 2007).

Ndathi (2006) reported highest indigenous chicken sales and consumption during major social and religious events. In addition, most sales of indigenous chicken take place around the rural areas though urban areas remain an untapped market for these products (Westway, 2012). The prices of indigenous chicken are also prone to market dynamics as they tend to change with location, demand and price of other meat types (Larbi, 2013). However, in recent years an increase in demand for indigenous chicken meat has been observed and it has been attributed to the following factors:

- Healthier than red meat
- As smaller amount of meat is harvested from chickens, it is not compulsory to refrigerate
- Lager animals are rarely slaughtered for home consumption (Badhaso, 2012).

A number of tasting or sensory evaluation studies have reported that indigenous chicken is tastier than commercial breeds' meat, and eggs are highly preferred because of their deep yellow colour (Dyubele, *et al.*, 2010; Larbi, *et al.*, 2013). Therefore, because of these distinct characteristics and organic production of indigenous chickens, people are prepared to pay a premium for

indigenous chicken products (Moges, *et al.,* 2010). Therefore, indigenous poultry production system can be considered as viable because the low productivity can be compensated for by the extra money paid for indigenous chicken products, which easily generate a net profit for poultry keepers (Minga, *et al.*, 2001). Nevertheless, despite these favorable attributes of indigenous chicken products, the production of indigenous chickens is low and this results in low sales and consumption of indigenous chicken products (Mtileni, *et al*., 2013).

Aklilu, *et al* (2007) observed that rural households consumed an average of indigenous chicken meat of about 0.6 to 1.2kg and an average of 6.8 to 17.1 eggs per year. In contrast, Sarkar, *et al.* (2009) reported an average annual per capita consumption of 32 eggs and 2.8kg chicken. Furthermore, Badhaso (2012) reported that chicken meat was consumed only once a month and on special occasions. A low number of eggs from indigenous chickens was consumed because most eggs were set aside for hatching purposes and people had low preference for indigenous chicken eggs (Badhaso, 2012; Ndathi, *et al.,* 2006; Moyo, 2009). However, Ramdas (2009) in a study conducted in India reported that more eggs tend to be consumed in summer as a preventative measure against spoilage. The reported low chicken consumption and sales in studies by Assa (2012) and Badhaso (2012) conducted in Malawi and Ethiopia, respectively, were attributed to the following:

- Chickens and eggs were sold only when cash is needed,
- Chickens were sold when they reached the desired body weight, and
- When high prices are likely to be paid for chickens.

Production of indigenous chickens presents a good opportunity to stimulate rural economies as low capital investment is required, it requires very low production costs and has a short

production cycle of chickens (Njagi, *et al.*, 2012). Indigenous chickens are not kept in chicken houses similar to those of commercial strains, they are rather kept in less expensive makeshift chicken houses, in the house or allowed to perch in trees (Dorji, *et al.*, 2011). Furthermore, the costs of producing indigenous chickens are kept minimal due to their ability to scavenge for feed and their ability to thrive under harsh conditions that enables them to survive and produce with minimal medication (Olwande, *et al.*, 2013; Alders, *et al.*, 2009). However, levels of inputs in indigenous chicken production depends largely on poultry keeper's or household socioeconomic circumstances (Mtileni, *et al.*, 2013). Nonetheless, indigenous chickens can be kept even by the poorest and uneducated social strata of the rural population (Mtileni, *et al.*, 2013). Therefore, value addition, processing and niche marketing of indigenous chicken products are valuable considerations if indigenous chicken production is to be considered as a viable option to improve the socio-economic status of rural people (Rodriguez, *et al.*, 2011; Ogunlande, *et al.*, 2009). In addition, organizing farmers to increase bargaining power and shortening marketing chain are also crucial in the development of indigenous chicken as a business (Badhaso, 2012). Furthermore, efforts to eliminate constraints in indigenous chicken production need to be intensified so as to increase chicken numbers because research has proved that the probability to sell and consume products increases with increase in flock sizes (Olwande, *et al.*, 2013).

2.1.3 Constraints

Constraints that affect the indigenous chicken production system can be traced to three areas; socio-economic status of the producers, the production process and the marketing of the products. Researchers have reported that better educated and relatively well-off poultry keepers tend to have larger flock sizes (Mtileni, *et al.*, 2013; Westway, 2012). In addition, the majority of producers lack technical knowledge on indigenous chicken production, particularly the effect

that different production parameters have on the profitability of the production system (Sonaiya, 2009). They also lack entrepreneurial skills required to plan and manage a rural business, particularly the marketing aspect (Ogunlande, *et al.,* 2009). In addition, Mwale, et al. (2009) reported that 96.2% of indigenous chicken producers were never trained in chicken production, 65% of farmers did not study past grade R and 84% of respondents relied on social grant for income. Untenable socio-economic situations render the chicken producers limited financially and, therefore, unable to purchase necessary inputs. The limited financial and technical abilities of poultry keepers results in birds not being housed, scavenging for feed and they do not have health management strategies (Justus, *et al*., 2013). Predators, diseases and parasites are some of the key production constraints of indigenous chicken production (Sonaiya, 2009). Furthermore, low biosecurity and inadequate sources of technical information on inputs and chicken management also contribute to poor indigenous chicken production (Sonaiya, 2009).

Rural areas, where most of indigenous chickens production takes place, are usually far from the urban areas, where potential customers with a better buying power are (Ndathi, *et al.,* 2006; Badhaso, 2012; Assa, 2012). To complicate matters further, the roads connecting rural areas to towns are usually non-existent or are in a bad state (Sartorius, *et al.*, 2013). Furthermore, as the chicken keepers are resource-limited, they struggle to purchase scientifically approved health management drugs and, as a result, they are compelled to use untested ethno-veterinary methods to manage diseases and parasites (Moreki, *et al.*, 2010; Chege, *et al.*, 2014). Muchadeyi, *et al.*, (2007) reported that in Zimbabwe only 15% of the production potential of indigenous chickens is attained because of the production constraints. Therefore, indigenous chicken were not utilized effectively to improve rural household livelihoods (Fentie, *et al.*, 2013). This was mainly

attributed to health challenges that included Newcastle disease (NCD), Salmonella and parasites (Msoffe, *et al.*, 2010).

Possible means of eliminating constraints that have been suggested include:

- Improved extension services and training of poultry keepers.
- Setting up of supply contracts between indigenous chicken producers and large quantity buyers.
- Establishment or refurbishment of road infrastructure.
- Organization of poultry producers to attain bargaining power on inputs and services.
- Development of a marketing strategy for indigenous chickens and eggs.
- Investigation of cost and effectiveness of ethno-veterinary medicines.
- Improvement of the combined production processes, i.e. vaccination, confinement, and supplementary feeding.

(Msoffe, *et al.*, 2010; Harrison, *et al.*, 2010; Alders, *et al.*, 2009).

Alders, *et al.* (2009) and Sarkar, *et al.* (2009) reported that vaccination against NCD in Mozambique and Tanzania resulted in higher flock sizes and improved selling and consumption rate of eggs and chickens. The interventions to minimize the effects of constraints must build on the scavenging system, they must not be costly and must ensure return on investment (Alders, *et al.*, 2009). Characterization and understanding of indigenous chicken production system is integral in the development of holistic improvement strategies (Okena, *et al.*, 2012).

2.2 The status of indigenous chicken production

2.2.1 Flock sizes: additions and loses

Flock sizes of indigenous chickens are affected by losses and additions to the flock. Sales, consumption, theft, predation and mortality due to ill-health and parasites infestation contribute to decrease in the number of chickens in a flock (Olwande, *et al.*, 2010; Wambura, 2011). In contrast, chicken purchases, received chicken gifts and hatched chicks are regarded as additions to the flocks (Tadesse, *et al.*, 2013). The relative rates of losses and additions determine whether the flock size increases, declines or remains static. If the rates of losses is higher than additions, the flock size will decrease and the opposite trend will result in flock size increase. Observations by Gondwe, *et al.* (2007) in Malawi were that growing and adult chickens constituted 9.45% of additions and 90.55% of exits, and an average of 38.74% exits per month. It was also reported in the same study that 56.16% of exits were for household consumption while 43.85% were due to mortalities. In Ethiopia, Halima, *et al.* (2007) observed that of the total flock additions, purchases, gifts and hatched chicks accounted for 61.56, 5.27 and 33.17%, respectively. Equal rates of losses and additions lead to static flock sizes. In most cases flock sizes of indigenous chickens tend to decline or remain static (Assa, 2012). Nonetheless, highly variable average flock sizes of 6, 22.4, 12 were reported by Kusina, *et al*, (2001), Iqbal, *et al.* (2008) and Badhaso (2012) in Zimbambwe, Jordan and Ethiopia, respectively. These small flock sizes were attributed to various constraints that included low egg laying, low chick survival rates and predation. Furthermore, Tedesse, *et al.* (2013) observed that flock sizes varied with agro-ecological area and season of the year. This variation was attributed to feed availability, predation level and climatic conditions during different seasons.

Indigenous chicken hens possess a gene that makes them broody for certain periods. However, the broodiness gene is selected against in commercial hens as it negatively affects egg production and, consequently, number of chicks that are added to the flock (Jiang, *et al.*, 2010; Olwande, *et al.*, 2010). The average broodiness period is about 34 days and there are four cycles of broodiness per year (Jiang, *et al.*, 2010; Iqbal, *et al.*, 2008). In contrast, Abdelqader (2007) reported that hens exhibited broody behavior after each clutch of 18-30 eggs, and they remained broody for 7-8 weeks after hatching. In addition, it was reported that hens that were not allowed to sit on eggs when broody returned to lay after 3-5 weeks. The broody hens during non-broody days tend to have a superior egg laying rate than non-broody hens, which circumvent the need to remove the broody gene in indigenous chickens. Furthermore, broodiness of indigenous hens is required as it affords the poultry keepers a natural and inexpensive means of incubating eggs for hatching (Olwande, *et al.*, 2010; Okeno, *et al.*, 2012; Kemboi, *et al.*, 2014). The late maturity of indigenous chickens means that they will produce fewer chicks during their reproductive life compared to commercial hens. Cockerels and pullets mature at 5-7 months and 5-8 months, respectively, compared to 5 months observed in commercial poultry (Mogesse, 2007; Badhaso, 2012). Furthermore, late maturity of as late as 10 months was reported by (Sentalo, 2013).

Despite the delayed start of laying and poor egg production, indigenous chickens usually exhibit a similar hatching rate compared to commercial breeds. Iqbal, *et al.* (2008), Olwande, *et al.* (2010), Badhaso (2012) and Fentie, *et al.* (2013) observed a hatching rate of 77-84.6% and this was attributed to relatively high male to female ratio compared to the recommended 1:10 in commercial set-ups. Badhaso (2012) reported a male to female ratio of 1:3 while Olwande, *et al.*, (2010) reported 1:2. However, the down side of the high male to female ratio is the iminent possibility of inbreeding (Badhaso, 2012). Abdeqader, *et al.* (2007) and Okeno, *et al.* (2012)

reported an inbreeding rate of 3.12% and 5.52% per generation, respectively, in indigenous chickens. These rates are well above the acceptable rate of 1-2% per generation (Okeno, 2012). However, the survival rate of chicks in an indigenous chicken production system tends to be low. Iqbal, *et al.* (2008), Olwande, *et al.* (2010), Badhaso (2012) and Fentie, *et al.* (2013) reported chick survival rates of 59%, 12%, 56.3%, 70%, 54.2%, respectively. These poor chick survival rates were attributed to the extensive nature of keeping indigenous chicken and a lack of health management strategy, which exposes the chicks to predation, hunger, cold, parasites and disease causing micro-organisms (particularly NCD virus) (Iqbal, *et al.* 2008; Mogese, 2007; Olwande, 2010; Fentie, *et al.,* 2013). High chick mortality is a main contributor to perpertually small flock sizes observed in rural areas (Biswa, *et al.,* 2008; Kemboi, *et al.*, 2013). Mortality due to health challenges account for 50% of mortalities while consumption, sales and theft account for 20, 14 and 6% of exits (Olwande, *et al.,* 2010). However, Gondwe, *et al.* (2007) attributed 44% of losses to diseases, predation, and theft, whereas exits were attributed to sales and consumption. Locally adapted chickens survive better compared to exotic breeds (Iqbal, *et al.,* 2008).

2.2.2 Egg production

Eggs are an important product of indigenous chickens as they are an integral part of the reproduction process and, consequently, expansion of flock size (Nonga, *et al.,* 2010). Indigenous chicken eggs are also consumed and sold to provide the much needed proteins and to generate income. Olwande (2013) reported in a study conducted in Kenya that eggs were mainly incubated for hatching, consumption and sales, in descending order of priority. In contrast, Abdeqader (2007) observed that in Jordan eggs were mainly used for consumption, selling and incubation, in decreasing importance. Studies in various countries around the world have consistently reported low egg production from indigenous chickens (Table 2.2) and this was

attributed to genetic composition, nutrition, health challenges and general husbandry. In contrast, Sentalo (2013) reported that cross-bred chickens produced an average of 200 eggs/bird/year.

Table 2.2: Indigenous chicken egg production observed in different countries

Publication	Country	Egg Production (/bird/year)
Iqbal, *et al.* (2008)	Kashmir	50-60
Olwande, *et al.* (2010)	Kenya	48
Okeno, *et al.,* (2012)	Kenya	64
Badhaso, (2012)	Ethiopia	50
Abdeqader, *et al.,* (2007)	Jordan	72
Olwande, *et al.* (2013)	Kenya	39
Grobbelaar, *et al.*, (2010)	South Africa	126-139
Mutayoba, *et al.* (2012)	Tanzania	20.4

Poor nutrition and housing conditions tend to have a negative effect on nutrient supply and utilization (Fentie, *et al.,* 2013; Mwembe, *et al.,* 2014). Scavenged feed availability and nutrient content tends to fluctuate with season and location, therefore, nutrients available for eggs formation will be inadequate at times (Mutayoba, *et al.,* 2012; Mwembe, *et al.,* 2014). In addition, the birds are exposed to fluctuating temperatures as they are normally left to roam with no housing provided. Temperature extremes negatively affect the chickens' health, appetite and nutrient utilization leading to suppressed nutrient availability and, consequently, egg production

(Justus, *et al.*, 2013). Furthermore, NCD leads to increased mortality and reduced egg production in affected chickens (Kemboi, *et al.,* 2013). Therefore, health management in indigenous chickens should be integral in the efforts to improve egg production.

2.2.3 Nutrition

It is a generally accepted phenomenon that feed accounts for about 70-80% of commercial chicken production costs, as commercial chickens consume four times more feed volume than indigenous chickens (Mekonnen, *et al.,* 2010). However, with indigenous chickens the feeding cost are nonexistent or very marginal, because chickens scavenge for feed, which includes insects, worms and grass or they are provided with human leftovers and kitchen waste (Mekonnen, *et al.,* 2010; Assa, 2012). There is, however, a down side to the scavenging of indigenous chickens because the production tends to be compromised by inconsistent nutrient content of the scavenged feed and erratic feed availability (Mwembe, *et al.,* 2014). This often leads to suppressed production and increased mortality due to consumed disease-causing micro-organisms (Okitoki, *et al.,* 2009). Furthermore, scavenging chickens consume insects which are intermediate host of various helminthes species, which predisposes them to infestation (Fentie, *et al.,* 2013).

Fentie, *et al.* (2013) observed in Bangladesh that all scavenging chickens were infested with helminthes and, as a result, they exhibited symptoms of nutrient deficiency. The nutrients that were reported to be in short supply were crude protein (CP), total metabolisable energy (TME), phosphorus (P) and calcium (Ca). The scavenged feed was reported by Mwembe, *et al.* (2014) to fluctuate with season in availability and nutrient content, being readily available during rainy seasons compared to dry seasons. Furthermore, Mwembe, *et al.* (2014) reported in a study conducted in Zimbabwe that the feeding activities of indigenous chickens declined as season

changed from late summer to early winter. The prolonged feeding time in late summer was attributed to the presence of herbaceous plants with high fibre content, low digestible energy and protein. On the other hand, early winter scavenged material predominantly comprised of seeds and ants which contains more digestible energy and proteins and, therefore, require less feeding time to meet nutrient requirements. The protein content of scavenged feed was observed to be at deficient levels during dry season while energy was deficient during rainy season. In agreement, Mekonnen, *et al.* (2010) and Mutayoba, *et al.* (2012) observed that the crop contents of indigenous chickens were heavier and more nutritious during the harvesting season. Furthermore, this has prompted a majority of households to supplement the scavenged feed by offering various feedstuffs (Okitoi, *et al.*, 2009; Olwande, *et al.*, 2010; Okeno, *et al.*, 2012).

A majority of households supplement their indigenous chickens with yellow maize grain, and very few supplement with commercial poultry feed (Dinka, *et al.*, 2010). Assa (2012) and Harrison, *et al.* (2010) reported in studies conducted in Malawi and Mozambique, respectively, that majority of farmers erratically supplemented the scavenged feed with energy rich feedstuffs like maize bran, barley, wheat and corn; and the supplementation was done mainly during cold dry seasons. In addition, Okeno, *et al.* (2012) reported in a study conducted in Kenya that producers supplemented mainly during harvesting and little or no supplementation occurred during periods of scarcity. Olwande, *et al.* (2010) and Mwembe, *et al.* (2014) reported that consistent and nutrient appropriate supplementation will result in larger clutch sizes, higher hatching rate, improved immunity, lower mortality and higher production. Information on the intake and nutritional status of scavenging chickens relative to requirements is crucial in order to introduce efficient supplementation strategies (Mokonnen, *et al.*, 2010). Okitoi, *et al.* (2009) reported that offering indigenous chicken choice of ingredients that contained energy and

proteins resulted in better FCR, weight gain, average egg weight and egg production compared to birds supplemented with energy and protein sources only. Therefore, it was concluded by Okitoi, *et al.* (2009) that indigenous chickens will consume the choice feedstuffs proportionally to meet their nutrient requirement, which were observed to be as follows:

- Feed intake = 64g/bird/day
- CP = 21.2%
- Trypsin = 0.9%
- Methionine + Cystine = 0.34%
- Metabolisable Energy (ME) = 3044 Kcal/kg (12.75 MJ/kg)
- Dry Matter (DM) = 56.7g

However, Alabi, *et al.* (2013) reported that indigenous chickens required 12.42 MJ/kg DM with 18% CP, and 12.66 MJ/kg DM with 17.8% CP during starter (0-7 weeks) and grower (8-13 weeks) phases, respectively. In addition, Kingori, *et al.* (2003) observed that indigenous chickens required 16% CP between 14 and 21 weeks of age and that weight gain, FCR and feed intake increased as CP levels increased from 10 to 16%. In the same study it was asserted that protein deficiency in feed suppressed growth rate as a consequence of depressed appetite, and, ultimately, intake of nutrients. Furthermore, surplus amino acid accumulate in the portal circulation after utilization of the limiting amino acid from a consumed unbalanced diet. This suppresses further breakdown of the limiting amino acid in the liver leading to its greater retention. As a result, the supply of limiting amino acids for peripheral tissues such as muscle is thereby reduced although protein synthesis in these tissues continues unimpeded (Mutayoba, *et al.* 2012). Furthermore, in both muscle and plasma the concentration of the first limiting amino acid declines while there is accumulation of those amino acids which were added and eventually

precipitated the imbalance. Eventually, the free amino acid patterns of both muscle and plasma may become so disarranged that it will trigger intervention of the appetite-regulating system to feed intake. Therefore, growth is depressed as a consequence of the depressed appetite and intake of nutrients. This depression in feed intake may be regarded as responsible for the retardation of growth rather than the genetic effect. Furthermore, Okitoi (2009b) computed the nutrient deficit percentage (%) of scavenging birds relative to maize and soya choice supplemented ones:

- CP = - 67.11
- Lysine = -55.56
- Tyrpsine = 14.29
- Methionine + Cystine = 12.5
- Crude Fibre = -15.66
- Crude Fat = 2.33
- Starch = - 4.57
- Sugar = 15.79
- Metabolisable Energy (Kcal/kg) = -0.27

NB: the negative percentage figures signify a nutrient level deficit relative to requirements.

Therefore, according to the observation of Okitoi (2009b), amino acids, particularly lysine, are critically deficient in scavenging birds. Furthermore, Kemboi, *et al.* (2013) and Gondwe, *et al.* (2007) recommended that chickens of different age and sex groups be fed or supplemented separately to cater for their markedly different nutrient requirements. Planting and provision of drought tolerant crops and use of drought resistant insects like termites can go a long way in ensuring consistent supplementation of scavenged feed. Mutayoba, *et al.* (2012) also observed a

higher preference for feed supplemented chickens by consumers and, as a result, they realized higher prices on the market. In addition, Harrison, *et al.* (2010) and Mutayoba, *et al.* (2012) observed that feed supplemented flock were larger in average size compared to un-supplemented flocks. Mutayoba, *et al.* (2012) reported that profit margin increased by 11.2% when indigenous chickens were supplemented with homemade diet and the profit margins declined by 3.4% when birds were supplemented with commercial diet. Furthermore, indigenous chicken meat and eggs can be developed and niche marketed as organic products as there are no inorganic substances included in their production (Mtileni, *et al.,* 2013). Research on locally available tannin-rich leguminous feeds, which improves growth, meat quality and fatty acid composition and reduce nematode burdens, should be given priority (Mtileni, *et al.,* 2013). Harrison, *et al.* (2010) observed that households that did not offer supplement feed were likely to be affected by NCD as the immunity is compromised by poor nutrition. In contrast, Abdelqader, *et al.* (2007) reported in a study conducted in Jordan that scavenged feed met protein, mineral and vitamin requirements of indigenous chickens. Nonetheless, the improvement of quality and quantity of feed provided to indigenous chickens should be done concomitantly with improved health management and general husbandry as feed supplementation only does not reduce chicken losses (Mbyuzi, *et al.,* 2012).

2.2.4 General Husbandry

Indigenous chickens have a unique ability to live and produce in a broad spectrum of socio-economic and physical production environments (Mtileni, *et al.,* 2010). In contrast, Ogie, *et al.* (2013) reported high mortalities, and increased production costs of off-springs of indigenous and exotic chicken cross-breeds. An alternative approach to cross breeding for genetic improvement would be to apply selection within local chickens under extensive management, which will preserve superior adapted genetic material (Rodriguez, *et al.,* 2011). About 78% of the poultry

population in Kenya is kept under free-range production system compared to 12.7% and 9.3% kept under semi-intensive and intensive systems, respectively (Okeno, *et al.,* 2012). However, indigenous chicken production is generally characterized by poor husbandry practices which are based on local knowledge (Olwande, *et al.,* 2010). A number of researches have asserted that an improvement of indigenous chicken management can vastly improve production and, consequently, increase the socio-economic benefit from the chickens (Olwande, *et al.,* 2010, Okeno, *et al.,* 2012 and Assa, *et al.,* 2012). The improvement of management, which included improved housing, feed and water supply, health management and record keeping has resulted in increased production in Bangladesh, South Africa and China (Iqbal, *et al,*, 2008; Olwande, *et al.,* 2010).

There are no proper houses provided for indigenous chickens, instead they are housed in make-shift houses, patch on trees and kraals or allowed to sleep in the main house with humans (DFID, 2010). Gondwe, *et al.* (2007) and Badhaso (2012) reported that 85% and 59% of households allowed chickens to sleep in the house for security reasons, respectively. However, Halima, *et al.* (2007) reported in a study conducted in Ethiopia that 39% and 51% of households allowed chickens to sleep in the main house and in a chicken shed, respectively. The improvement of housing should be prioritized on chicks as they are prone to environmental elements (such as heat, cold and rain) and microorganisms (Mogesse, 2008). Badhaso (2012) reported that confining chicks for the first 4-5 weeks of life led to improved chick survival rate. However, Mogesse, (2008) observed that indigenous chicks were not as prone to environmental elements and microorganisms as exotic breeds or exotic-indigenous cross breeds chicks.

The amount of feed and water offered to chickens are crucial for production, however, the presentation of these is equally important. The form of presentation of water and feed not only

affects their utilization by the birds, it also affects their health. Mtileni, *et al.* (2013) observed that 93% and 96.7% of farmers provided supplemental feed and water, respectively, and water sources included dams, boreholes and streams. However, Harrison, *et al.* (2010) observed in a study conducted in Mozambique that 90% of households provided supplemental feed and, 74% provided water. In addition, Halima, *et al.* (2007) observed in Ethiopia that 99.5% of poultry keepers provided water in plastic, wood or clay bowls and the containers were filled only once a day. In the same study, it was reported that 97.6% of households threw supplementary feed on the ground, thereby increasing chances of its contamination. In addition, Larbi, *et al.* (2013) observed that a majority of households allowed chickens free access to water even though it was not clean and fresh. Therefore, Alfred, *et al.* (2012) concluded that poor hygiene was one of the factors that predisposed indigenous chickens to various diseases and parasites.

Training of indigenous chicken keepers and improved extension services should be central in the efforts to improve husbandry and, consequently, production (Dinka, *et al.*, 2010). Okeno, *et al.* (2012) observed in a study conducted in Kenya that 75% of indigenous chicken keepers did not receive extension services. Furthermore, integrated intervention approach at community and household levels is required to improve indigenous chicken production (Msoffe, *et al.*, 2010). Mbyuzi, *et al.* (2012) reported that a combination of interventions (vaccination, chick confinement and proper feeding resulted in increased average flock size from 28 to 43 chickens and chick survival rate from 37% to 83% in Kenya. Jestus, *et al.* (2013) reported a positive significant correlation between management level and production parameters including hatchability, survivability, flock size, number of clutches and egg weight.

2.3 Health challenges of indigenous chickens

Poor health management is one of the key characteristics of indigenous chicken production and it is further compounded by use of untested ethno-veterinary means of controlling diseases and parasites (Badhaso, 2012). Olwande, *et al.* (2010) observed in Kenya that 60% of poultry keepers used varying *Aloe Vera,* pepper and sisal leaves to treat and control indigenous chicken diseases. Health challenges of indigenous chickens include diseases and parasites which are the most mentioned constraint of this production system (Horning, *et al.,* 2003). Diseases and parasites not only lead to increased mortality but also suppressed production in terms of growth rate and egg production (Mungube, *et al.,* 2008). Poor production and high mortality results in low sales and consumption rate of indigenous chicken products (Simainga, *et al.,* 2010). This leads to low contribution of indigenous chickens towards the livelihoods of poor people residing in rural areas. A number of researchers have attributed the high prevalence of disease and parasites to the management practices employed during the production process (Chege, *et al.,* 2014). However, the high parasite prevalence without high mortality of the indigenous chicken population is indicative of adaptive response that enables them to act as carriers (Chege, *et al.,* 2014). These researchers unequivocally agree that for the improvement of indigenous chicken production to be achieved, it is imperative that a health management strategy be developed. This will require a profound understanding of the dynamics of the health challenges, as influenced by for example seasonal and location effect, prevalent diseases, parasites and susceptible bird categories (Nnadi, *et al.,* 2010). This will not only result in the development of the most effective strategy in terms of reducing health challenges, it will also be the most cost effective as the measures will be applied accordingly at the right time. Furthermore, rural poultry keepers are resource limited, therefore least expensive means of health management have to be taken into consideration. These

include exploring of ethno-veterinary medicine and improvement of housing, feeding and water supply (Chege, *et al.*, 2014; Moreki, *et al.*, 2010).

2.3.1 External parasites

External parasites cause irritation, tissue damage, transmission of pathogens, blood loss and toxicosis, which leads to a decline in quality and quantity of meat and low egg production (Salam, *et al.*, 2009). Moyo (2009) reported in a study conducted in the Eastern Cape province of South Africa that 96% of indigenous chickens harbored at least one species of external parasites. Simainga, *et al.* (2010) and Moyo (2009) observed in studies conducted in Zimbabwe and South Africa, respectively, that fleas were the most prevalent ecto-parasites, followed by mites then lice. However, Gondwe, *et al.* (2007) in a study conducted in Malawi ranked fleas third in terms of prevalence. In contrast, Salam, *et al.* (2009) reported in a study conducted in Kashmir that only lice species were observed during examination.

According to Moyo (2009) and Mwale (2009), the clinical signs of external parasite infestation are the following:

- Ruffled feathers
- Poor appetite
- Diarrhea
- Emaciation
- Reduced production
- Irritation
- Anemia

Mwale (2009) reported in a study conducted in South Africa that 25.8% of respondents regarded external parasites as a problem, whereas, Simainga, *et al.* (2010) reported in a study in Zimbabwe that 65% of respondents thought external parasites were a challenge. Whereas, all (100%) indigenous chickens and 8% of commercial chickens that were examined by Njunga (2003) were observed to host external parasites. Indigenous chickens that had external parasites laid 15% less eggs than the clean ones but there was no difference in weight gain (Njunga, 2003). Ecto-parasites exhibit higher prevalence during dry season than wet season (Mungube, *et al.,* 2008). Mites are the main reason some hens abandon their hatching nests, resulting in very low or no hatchability (Njunga, 2003). Chege, *et al.* (2014) reported that in Kenya 82% of respondents controlled ecto-parasites using Carbaryl, cooking oil and ectonin.

2.3.1.1 Lice

Lice are permanent ecto-parasites that spend their entire 3 week life cycle on the host, however, the three week cycle can be shortened or prolonged by temperature and humidity (Njunga, 2003). Salam, *et al.* (2009) reported in a study conducted in Kashmir that the prevalence of lice species varied with season and they were most prevalent in summer. This was attributed to optimal condition in summer that stimulated the proliferation of lice (Arya, *et al.,* 2013). This observation is further illustrated in Tables 2.3 and 2.4. In addition, Khan, *et al,* (2003) reported that Carbamates, pyrethroids, Cypermethrins, Trichlorphan, Carbaryl, Dichlorodiphenyltrichloroethane (DDT) Powder and Phenoln were used as means of controlling lice, however, the best results were obtained from Pyrethroids, i.e. Trichlophor and Pestoban.

Table 2.3: The percentage (%) of indigenous chickens hosting lice (Prevalence) in different countries

Reference	Location	Prevalence (%)
Rahman, *et al.* (2013)	Bangladesh	67.0
Nnadi, *et al.* (2010)	Nigeria	62.2
Chege, *et al.* (2014)	Kenya	17.6
Salam, *et al.* (2009)	Kashmir	100.0
Mekuria, *et al.* (2010)	Ethiopia	95.7

Table 2.4: The percentage (%) of indigenous chickens hosting different lice species in various countries

Reference	*Menopon gallinae*	*Menopon cornutus*	*Goniodes gigas*	*Lipeurus lawrensis tropicalis*	*Menacanthus stramieus*	*Goniocotes gallinae*
Njunga (2003) (Malawi)	77.00	74.00	53.00	46.00		41.00
Mungube, *et al.* (2008) (Kenya)					79.40	
Salam, *et al.* (2009) (Kashmir)	34.93	33.05	44.76		9.41	19.66

2.3.1.2 Fleas

The most commonly observed flea species in indigenous chickens is *Echidnophaga gallinacean* (*E. gallinacean*) also known as sticktight flea (Mungube, *et al.* 2008). *E. gallinacea* fleas firmly attach themselves along the ears and eyes of the host (Rust, 2010). They lay up to 20 eggs at a time and about 400 to 500 in a lifetime and their life cycle is completed in one to two months under optimal conditions (Njunga, 2003). Eggs hatch at 75% relative humidity and 25^0 C environmental temperature (Percy, *et al.* 2012). The development of the larva occurs when the relative humidity is at least 75% and when the environmental temperature ranges from 21 to 32^0 C (Rust, 2010). This was confirmed by Percy, *et al.* (2012) who reported a higher prevalence and load of *E. gallinacea* in summer relative to winter in Zimbabwe. Furthermore, Metzger, *et al.* (1999) reported that the average egg hatch of *E. gallinacea* was substantially reduced at 31.5% relative humidity and no larvae survived for more than 48 hours at less than 55% relative humidity. It was also observed that the developmental period of pre-imaginal fleas was prolonged at lower temperatures ($<21.1^0$ C). This environmental effect on flea development is further confirmed by the vast variation in flea prevalence in various countries with markedly different weather patterns (Table 2.5)

Table 2.5: The percentage of indigenous chickens hosting *E. gallinacea* observed in different countries

Reference	Country	*E. gallinacea*
Njunga (2003)	Malawi	62.0
Mungube (2008)	Kenya	76.7
Dube, *et al.* (2010)	Zimbabwe	17.0
Nnadi (2010)	Nigeria	35.7
Mekuria, *et al.* (2010)	Ethiopia	18.1
Chege (2014)	Kenya	47.1

2.3.1.3 Ticks

Ticks are critical ecto-parasites in indigenous chicken production though generally less prevalent compared to other ecto-parasites (Table 2.6). This can be attributed to their feeding and nesting habits. They tend to wait in the cracks and dark places of the fowl run for their hosts to comeback in the evening and they attach themselves to feed before climbing off (Pourseyed, *et al.* 2010). Therefore, it is possible that when the researchers examine the birds for ticks, the ticks are off the host and then the ticks are regarded as less prevalent. The most common tick species in indigenous chickens is the *Argus persicus*, commonly known as the fowl tick (Jinga, *et al.*, 2012). Tick infestation may cause blood loss which can lead to clinical aneamia and tick paralysis in extreme cases. Khan, *et al.* (2001) computed the total amount of blood sucked annually by the *A. persicus* in Pakistan to be 1 417 706 kg, which translates to financial loss

amounting to 2.3 million rupees (ZAR500 000). Furthermore, *A. persicus* is the carrier of septicemia causing bacteria, *Borrelia anserine*.

A. persicus has an affinity for relatively warm areas and times of the year (Percy, *et al.*, 2012). This can be attributed to the fact that higher temperatures cause faster development rates of tick larvae, nymphs and adults (Jinga, *et al.*, 2012). In contrast, declining temperatures and day length may inhibit tick activity altogether (Jinga, *et al.*, 2012). In agreement, Jinga, *et al.* (2012) reported higher prevalence of *Argus persicus* in summer compared to winter in Zimbabwe. Therefore, the variation in the prevalence of *Argus persicus* in different countries can be safely attributed to variation in prevailing climates (Table 2.6).

Table 2.6: The percentage prevalence of *A. persicus* in different countries

Reference	Country	Prevalence
Khan, *et al.* (2001)	Pakistan	8.2, 23.5 and 12.5% (Different areas of Pakistan)
Dube, *et al.* (2010)	Zimbabwe	30%
Mekuria, *et al.* (2010)	Ethiopia	9.3%
Jinga, *et al.* (2012)	Zimbabwe	82%

2.3.2 Internal parasites

The scavenging for feed by indigenous chickens predisposes them to internal parasites as they tend to consume intermediate hosts of these parasites, like cockroaches, locusts and other insects

(Skallerup, *et al.,* 2005; Phiri, *et al.,* 2007; Abdelqader, *et al.,* 2008). The prevalence of helminths species is relatively high in indigenous chickens compared to other parasites and tends to vary from country to country (Tables 2.7 and 2.8) Internal parasites, particularly helminths, compete with host chickens for nutrients, therefore, causing nutrient deficiency and consequently reduced production in terms of growth (-17%) and egg production (-12.5%) (Rahman, *et al.,* 2013). Furthermore, helminths leads to suppressed feed intake, injury, altered hormonal level, obstruction of the intestinal lumen and hemorrhage of the intestinal wall (Abdelqader, *et al.* 2008; Ogbaje, *et al.,* 2012). The less obvious, but ubiquitous, losses caused by reduced productivity as a result of helminths infestation are economically significant in poultry industry (Phiri, *et al.,* 2007). In a study by Phiri, *et al.,* (2007), de-wormed indigenous chickens had a significantly lower worm burden and higher weight gain than untreated birds. This signifies increased nutrient availability for the host chickens when the worm burden is reduced. In agreement, Rahman, *et al.,* (2013) observed a negative relationship between gizzard and crop metabolizable energy and crude protein levels and helminths load. In contrast, Ca showed a positive correlation with helminthes while P had a positive relation with cestodes and negative relation with nematodes (Rahman, *et al.,* 2013).

Table 2.7: The percentage of indigenous chickens infected with helminths in different countries

Reference	Location	Worm Prevalence (%)
Phiri, *et al.* (2007)	Zambia	95.2
Rahman, *et al.* (2013)	Bangladesh	93.6
Abdelqader, *et al.* (2008)	Jordan	73
Magwisha, *et al.* (2002)	Tanzania	100
Mungube, *et al* (2008)	Kenya	93.3
Nnadi, *et al.* (2010)	Nigeria	71
Ogbaje, *et al.* (2012)	Nigeria	76.1
Mwale (2011)	Eastern Cape, South Africa	99

Table 2.8: The prevalence of different worm species observed in various countries

Helminthes Species	Magwisha, *et al.* (2002) (Tanzania)	Phiri, *et al.* (2007) (Zambia)	Abdelqader, *et al.* (2008) (Jordan)	Chota, *et al.* (2010) (Zambia)	Rahman, *et al.* (2013) (Bangladesh)
A. suctoria	20%	85.6%	-	83.7%	-
T. americana	94%	80.8%	-	12.3%	-
A. galli	69%	28.8%	43%	0.5%	62.7%
G. ingluvicola	-	50.4%	-	0.5%	-
Railetina spp.	36%	81.6%	18%	-	58.7%
H. gallinarium	-	32.8	33	2.9	54.6

Malnutrition of indigenous chickens promotes the establishment, survival and fecundity of nematodes but the magnitude of the effect depends on factors such as host species, parasite species and magnitude of infection (Chota, *et al.* 2010). This is particularly the case with *Ascaridia galli*, which has a life cycle that is dependent on the nutrient uptake of the host chicken (Ogbaje, *et al.*, 2012). The life cycle of *A. galli* begins with ingestion of an infective egg, which hatches in the small intestines. The larva then imbeds in the mucosal layer of the duodenum for 3-56 days depending on age, immunity of the bird and nutritive value of the host feed. After maturity, the worm migrates to the intestinal lumen, where it lives from intestinal contents and blood of the host. Mature worms copulate and might start producing eggs after 28 days depending on the availability of nutrients (Permin, *et al.*, 2006). The sex ratio of *A. galli* is associated with mineral composition taken up from the host and infection dose, particularly,

Zinc-Co-Mn salt results in low *A. galli* numbers (Gabrashanska, *et al.*, 2004). Feeding host on feed rich in protein, vitamins and salts create an unfavorable condition for the development of ascaridis in chicken intestines and proportion is in favor of males due to their greater stability (Gabrashanska, *et al.*, 2004; Rahman, *et al.*, 2013). In contrast, Skallerup, *et al.* (2005) reported that there was no effect of feed supplementation on worm burdens though protein supplementation had a positive effect on growth rate. Nonetheless, chickens infected with parasites need treatment with biogenic elements to correct mineral deficiencies and restore the normal mineral balance (Gabrashanska, *et al.*, 2004).

Research has shown that indigenous chickens are heavily parasitized and, therefore, effective control measures need to be developed so as to improve uptake of nutrients and, consequently, increase production (Phiri, *et al.,* 2007). This can be attained once prevalence trends of various helminths species have been accurately established (Abdelqader, *et al.,* 2008). There is a considerable variation from year to year in the extent to which growth performance of indigenous chickens is reduced by helminths (Skallerup, *et al.,* 2005). This phenomenon has beeeb found to be linked to the helminthes burden in the host's intestines, which is, in turn, affected by prevailing weather and abundance of intermediate hosts (Mgwisha, *et al.,* 2002; Skallerup, *et al.,* 2005). The prevalence of intermediate host and, consequently, helminths tends to increase during years of heavy rains though the effect is not similar for all worm species (Mgwisha, *et al.,* 2002; Mungube, *et al.,* 2008). The rain effect on worm burden varies with species (Mgwisha, *et al.,* 2002). The burden of *A. galli* tends to be high during both rainy and dry seasons, whereas, humid and cool conditions tend to favor the prevalence of *H. gallinarium* (Skallerup, *et al.,* 2005). Furthermore, Rahman, *et al.* (2013) observed in a study conducted in Bangladesh that nematode prevalence varied with age of the birds and geographic location while cestode prevalence varied with location only. The variation in species load among different areas might be related to topography, ecological zones and availability of intermediate hosts (Rahman, *et al.,* 2013; Mwale 2011).

Elevated worm burden paves way for opportunistic infection of indigenous chickens by other microorganisms, particularly Newcastle Disease Virus due to compromised immunity (Horning, *et al.,* 2003). In severely worm infected birds the synthesis of immunoglobulins decreases drastically due to protein deficiency, leading to reduced humoral antibody response. This leads to

a rapid decline in NCD antibody levels after vaccination (Horning, *et al.*, 2003). Therefore, simultaneous vaccination and de-worming is recommended to ensure high and sustainable seroconversion (Illango, *et al.*, 2008).

2.3.3 Newcastle Disease

Indigenous chickens have high chances of contact with wild birds, which are carriers of many viral diseases, including avian paramyxovirus that causes NCD (Aziz, *et al.*, 2010). The lentogenic strains of avian paramyxovirus are avirulent but mesogenic and velogenic strains cause nervous respiratory and enteric symptoms and mortality (Njagi, *et al.*, 2010). Valogenic strains of NCD virus cause acute sickness and mortality of up to 100% in non-immune indigenous chickens (Kemboi, *et al.*, 2013). NCD is regarded as the main cause of small flock sizes in rural areas as its out-break usually leads to high mortality and poor egg production (Wambura, 2011). The documented clinical symptoms of NCD are as follows (Wambura, 2011; Lwelamira, 2012; Bagnol, *et al.*, 2013; Kemboi, *et al.*, 2013):

1. Sudden high mortalities
2. Respiratory symptoms: sneezing, abnormal breathing sounds, nasal discharge
3. Gastro-intestinal disorders: diarrhea with green-yellowish and blood stained excreta.
4. Nervous signs: twisted necks, inability to drink and eat properly.
5. Scabby lesions around the eyes
6. Swollen comb

A number of researchers have discovered NCD antibodies in birds that were never vaccinated, which was regarded as an indication that the birds were infected with the NCD virus at some point but not necessarily that it was suffering from the disease at the time of sampling (Wambura, 2011; Lwelamira, 2012; Kemboi, *et al.*, 2013) (Table 2.9). Fentie, *et al.*, (2013)

observed in a study in Ethiopia that there was an annual passage of NCD and survivors had an increased level of NCD antibodies which were initially passed on to the following generation in the form of maternal antibodies. However, these antibodies gradually declined and at the next viral challenge, the antibody levels of those with some antibodies are boosted, whereas those with no protection succumb (Kemboi, *et al.* 2013; Henning, *et al.*, 2008). This cycle is repeated every 1 or 2 years (Fentie, *et al.*, 2013). Furthermore, the wider range of NCD antibodies titers in unvaccinated chickens may be due to natural infection which is known to produce higher antibody titers than with vaccination (Aziz, *et al.*, 2010; Kemboi, *et al.* 2013). Horning, *et al.* (2003) monitored the NCD antibodies by haemaglutination inhibition (HI) test for five weeks after vaccination. It was observed that vaccinated birds seroconverted and had highest NCD antibody levels after 3 weeks but they declined at four weeks after vaccination. However, after another NCD challenge at four weeks, the antibody titers of de-wormed birds increased but there was no response in worm infested group. This was attributed to an immunosuppressive effect of worms (Horning, *et al.*, 2003; Illango, 2008).

Table 2.9: The percentage of indigenous chicken that tested positive (prevalence) for NCD in different countries.

Reference	Location	Prevalence (%)
Yongolo, *et al.* (2002)	Tanzania	81.5
Njagi, *et al.* (2010)	Iraq	46.0
Aziz, *et al.* (2010)	Kenya	81.5

Contrasting study reports have been published regarding the seasonal effect on NCD outbreaks. Kemboi, *et al.* (2013) and Fentie, *et al.,* (20130 reported greatest losses of indigenous chickens due to NCD during hot rainy season followed by hot dry season. Furthermore, Kemboi, *et al.* (2013) reported that NCD resulted in mortality of between 60 to 99% of the flocks especially during transition between seasons. In addition, Otim, *et al.* (2007) observed that it took a shorter (80 days) period for an out break to occur during dry season compared to a wet season (100 days). In contrast, Zeleke, *et al.* (2005) did not observe any difference in NCD prevalence between wet and dry areas of Ethiopia. Furthermore, Aziz, *et al.* (2010) reported that NCD virus incubation period was shorter and mortality higher at warmer temperatures than cooler ones. However, Azizi, *et al.,* (2010) did not find conclusive evidence linking the epidemiology of NCD in rural chickens to different geographical and climatic situations. Nonetheless, for protection of susceptible chickens, a routine vaccination program in spring and summer was recommended (Azizi, *et al.* 2010). However, Kemboi, *et al.* (2013) observed that birds of all age groups had higher NCD antibody titers during wet season compared to dry season, though the start of wet season is also associated with more NCD outbreaks. This was attributed to stress and feed shortage during dry season and beginning of wet season. Therefore, it was recommended that vaccination against NCD should be conducted in the beginning of the dry season to boost the birds' immunity (Azizi, *et al.* 2010).

Although all groups of indigenous chickens are susceptible to NCD, prevalence of NCD seems to increase with age and reaches peak in the group older than 12 months (Azizi, *et al.* 2010). The high Ab titers in old age groups is an indication of a more frequent exposure to field virus which might have survived the disease at an earlier age (Azizi, *et al.* 2010). In addition, Fentie, *et al.* (2013) reported that 40-60% of chicks died during the first eight weeks of life. Therefore,

strategic control of NCD in indigenous chickens is recommended taking into consideration the different age groups that are kept, seasonal and location effects (Gondwe, 2007; Njangi, *et al.,* 2010).

2.3.4 Salmonelosis

Poultry salmonelosis leads to either acute or chronic infections that mostly become sub-clinical infections. Salmonella infection results in contamination of chicken meat and eggs, which poses a high risk of food poisoning in humans (Makaya, *et al.,* 2014). There are different serotypes of salmonella that affect indigenous chickens and, consequently, elicit distinctive clinical symptoms (Makaya, *et al.,* 2014). *Salmonella gallinarum* causes fowl typhoid, which is regarded as being the most prevalent salmonella disease amongst the indigenous chickens (Ogie, *et al.,* 2013). However, Endris, *et al.* (2013) reported in a study conducted in Ethiopia that only 9.33% of indigenous chickens tested positive for *Salmonella gallinarum*.

Fowl typhoid is a septicaemic disease that affects both adult and young birds, and can cause morbidity and mortality of up to 100% in immunocompromised flock (Ogie, *et al.,* 2013 and Endris, *et al.,* 2013). Clinical signs specific to fowl typhoid include drowsiness and occasional closure of the eyes (Ogie, *et al.,* 2013; Barrow, *et al.,* 2014). Another serotype is *Salmonella enteritidis,* a food-borne disease in humans, which is characteristically leads to the loss of growth in poultry (Tohidi, *et al.,* 2014). Nonetheless, indigenous chickens have appropriate innate early immune responses to *Salmonella enteridis* infection, particularly in the caecum (Tohidi, *et al.,* 2014). The third salmonella serotype that affects indigenous chickens is *Salmonella pullorum* (pullorum disease) and it affects mainly young chickens from 2 to 3 weeks old (Endris, *et al.* 2013; Barrow, *et al.,* 2014). The existence of salmonella diseases in indigenous chickens is of

great concern as the diseases have a potential for horizontal and vertical transmission (Endris, *et al.,* 2013). In addition, pullorum disease and fowl typhoid frequently infect the reproductive organs in adult chickens, consequently, establishing a chronic infection with direct passage of organisms into the egg as formation takes place (Endris, *et al.,* 2013).

Despite observing 10% salmonella prevalence in commercial chickens, Makaya, *et al.* (2014) did not find any salmonella in indigenous chickens in a study conducted in Zimbabwe and this was attributed to non-confinement of these birds and their natural resistance. This natural resistance of indigenous chickens against salmonella was also observed by Ogie, *et al.* (2013) and Msoffe, *et al.* (2014) in studies conducted in Tanzania and Nigeria, respectively. In these studies birds were artificially infected with salmonella, and clinical signs of salmonella infection lasted longer in commercial layer chickens than indigenous chickens. This was attributed to inherent genetic ability to mitigate the infection effect by the indigenous chickens (Tohidi, *et al.*,2014). During early stages of salmonella infection, the bacteria is normally deactivated by monocytes (macrophages). However, as the bacteria overcome these leucocytes, other cells (heterophils or lymphocytes) take over, with heterophils first and followed by lymphocytes (Ogie, *et al.,* 2013). This pathway of mitigating salmonella was observed to be incomplete in commercial chickens but working effectively in indigenous chickens (Msoffe, *et al.,* 2014). The exotic breeds exhibited one surge in white blood cells number in response to infection compared to twice shown by indigenous breeds (Ogie, *et al.,* 2013). Furthermore, Ogie, *et al.* (2013) reported 87.5%, 80% and 37.5% mortalities among exotic breed, Fulani and Yoruba ecotypes, respectively, after artificial infection of birds with *Salmonella gallinarum*. Salmonella is unequivocally a critical disease in indigenous chicken production as it not only affects the production but also poses health risk to the consumers (Koyuncu, *et al.,* 2013).

2.4 Health Management

It is generally accepted that indigenous chicken production is a low input and low output production system, therefore, the costs of health management should be as low as possible (Mtileni, *et al.,* 2013). However, attaining a balance between improving production and keeping cost low is a challenge. Therefore, an accurate cost-benefit analysis is crucial if the livelihoods of rural inhabitants is to be improved through increased sales and consumption of indigenous chickens and eggs. Normally, health management in commercial poultry includes biosecurity, proper feeding, vaccination and treatment (Njunga, *et al.,* 2003). However, due to limitation of resources for indigenous chicken keepers and unavailability of drugs, ethnoveterinary methods of indigenous chicken health management end up being central (Mwale, 2009; Chota, 2010). In addition, costs of traditional herbs is negligible compared to costs of conventional medicines (Chota, 2010). Furthermore, use of plant ethnoveterinary medicines that function by mechanism different to that of chemotherapeutics are recommended as long as they are effective (Chota, 2010).

Ethnoveterinary medicine (EVM), which is also known as traditional animal health care practices, is defined as local or indigenous knowledge and methods for caring, healing, and managing livestock (Moreki, 2012). It is common for unconventional and untested substances to be used by the resource poor indigenous chicken keepers (Larbi, *et al.,* 2013). Moreki, *et al.,* (2010) and Simainga, *et al.* (2010) observed in studies conducted in Botswana and Zambia, respectively, that 86.7% and 83.5% of indigenous poultry keepers used ethnoveterinary means to manage the health of the birds and this was attributed to the following:

- Lack of cold chain for vaccines

- Lack of knowledge about vaccine use
- High costs of vaccines
- Unavailability of vaccines

A number of researchers have compared the efficacy of ethnoveterinary medicines against their commercial parts and variable results were observed. Moyo (2009), Moreki (2010) and Chege (2014) reported that respondents admitted to using the following products to control external parasites:

- Ash
- Madubula (Active ingredient: Tar Acid)
- Jeyes' fluid (Active ingredient: Tar Acid)
- Paraffin
- Used engine oil
- Cooking oil
- Soil
- Cow dung

Moyo (2009) reported that only 5% of respondent stated that they used commercial medicine (Karbadust) to control external parasites. However, when the efficacy of used engine, paraffin and Jeyes fluid were evaluated *in vitro*, they were observed to kill more than 82% of fleas (Moyo, 2009). Furthermore, an *in vivo* evaluation of used engine oil and Jeyes fluid resulted in 100% and 96% mortality of fleas, respectively, three days post application. This efficacy was reported to be similar to that of Karbadust.

Chota, *et al.* (2010), Chege (2014), Moreki (2010) and Mwale (2009) reported that indigenous poultry keepers used the following substances to control internal parasites in studies conducted in Kenya, Botswana and South Africa:

- *Aloe Vera*
- Pepper
- Potassium permanganate
    - Tobacco leaf (*Nicotiana tabacum)*
    - Snuff
    - Papaya seeds

However, there was no consensus on the intervals of use and dosages of the above-mentioned ethnoveterinary medicines (Mwale, 2009). Some respondents used them every three months while some used them every six months or when they see worms in the chicken manure. Chota, *et al.* (2010) reported a decrease in worm burden and an improvement in indigenous chicken body weight when papaya seeds were used as anthelmintic.

Biogenic elements and proper nutrition are recommended as an alternative for the treatment of helminths as they correct mineral deficiencies and restore normal mineral balance (Moges, *et al.*, 2010; Chota, *et al.* 2010). However, feed supplementation did not have effect on worm burdens in a study conducted by Slellerup, *et al.* (2005). Trifen, a combination of piperazine, phenothiagene and dichlorophen, was observed by Skellerup, *et al.* (2005) to be 100% effective against all nematodes and 67% effective against cestodes. However, Albendazon was observed to be 100% effective against *Hetarakis galinarium* only. Furthermore, it is recommended by many researchers that NCD vaccination should be applied concomitantly with deworming as this

ensures higher NCD antibodies for a longer period than vaccination alone (Horning, *et al.*, 2003; Kemboi, *et al.*, 2014). It is, therefore, imperative that sustainable means of controlling parasites and diseases be designed for improved indigenous chicken production and, ultimately, rural livelihoods (Mwale and Masika, 2011).

To circumvent the need for a cold chain to preserve NCD vaccines, a thermostable vaccine type (NCD I-2) has been evaluated by a number of researchers. Illango, *et al.* (2008) and Bognol, *et al.* (2013) conducted a study in which the efficacy of NCD I-2 was compared when offered through the eye, through drinking water and when it was combined with a de-wormer (levamisole). The antibodies of birds that were given the NCD I-2 through the eyes were higher than those given through drinking water and de-wormed birds responded better to NCD vaccination. Based on the antibody responses observed, Illango, *et al.* (2008) and Kemboi, *et al.* (2013) recommended quarterly vaccination against NCD to ensure effective protection. Furthermore, Bagnol, *et al.* (2013) and Gondwe, *et al.* (2007) suggested the following guide lines to ensure proper management of NCD in indigenous chickens:

- Enabling policy environment and involvement of government agencies
- Use of an appropriate vaccine that is quality assured
- Proper administration technique, cold chain and timely vaccination
- Effective and gender sensitive vaccination materials
- Simple evaluation and monitoring system
- Appreciation of the role of chickens in the rural livelihoods

In conclusion, an integrated approach that involves vaccination, confinement and proper nutrition will be the most effective strategies to manage health of indigenous chicken.

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Chapter 3: The socio-economic status of households in two rural communities of Mnquma Local Municipality and the contribution of indigenous chickens to their livelihoods

Abstract

Food insecurity in rural households of South Africa is a common phenomenon, which often culminates in poverty and malnutrition. Most households in the rural areas keep indigenous chickens, which have been identified to have a potential in mitigating the effects of food shortage. This study was conducted to establish the socio-economic status of two rural communities in Eastern Cape Province of South Africa and the contribution of indigenous chickens to the livelihoods of households. The socio-economic status and general livelihood of the two communities (sample sizes: 80 households in Gcina and 47 households in Ngcingcinikhwe) were measured using a structured questionnaire to gather information about level of household income, source of income, and food security status as indicators. The food secuturity status was measured through the application of Food Insecurity Coping Strategies Questionnaire. A proportion of 55% and 48% of households, sold chicken at average prices of R74.3 ($7.4) and R61.0 ($6.1) at Gcina and Ngcingcinikhwe, respectively. Few households, 11% in Gcina and 15% in Ngcingcinikhwe, sold eggs at prices of 80c ($0.8) and 95c ($0.95) per egg, respectively. Chickens were consumed once a month by 90% respondents in Gcina and 78.7% in Ngcingcinikhwe. On the other hand eggs were eaten once a month by 77.8% of households in Gcina and 72.4% in Ngcingcinikhwe. The main source of income in both communities (80%) was government welfare grants. The resultant average Food Security Scores of 22.8 (range 5 to 52) and 27.3 (range 2 to 78) in Gcina and Ngcingcinikhwe, respectively, indicated that the households had to apply coping strategies to survive food insecurity. In conclusion, indigenous

chickens had minimal contribution to the livelihoods of rural households in the two communities. Therefore, concerted effort needs to be employed to determine and address the challenges hindering the production of chickens in rural households so as to improve their contribution towards the livelihoods of rural households.

Key words: indigenous chickens, households, poverty

3.1 Introduction

Rural communities in South Africa are constantly faced with a challenge of food insecurity, which often leaves the inhabitants hungry and malnourished (Hendrics 2005). In many parts of Southern Africa the majority of the population is rural-based and involved in agriculture in one way or another (Bognol 2009). Previous studies have reported the fact that between 80 to 90% of rural households keep indigenous chickens and prefer meat and eggs from these chickens (Sonaiya 2000; Sartika and Neer 2005; Sorensen 2006). Furthermore, over 80% of the rural households in Low Income Food Deficient Countries (LIFDC), which are mainly found in Africa, Asia, Latin America and South Pacific keep indigenous chickens (Matshe 2009; Mtileni *et al* 2013). The inhabitants in these countries tend to rely heavily on government assistance for survival, however, the poor economic outlook, particularly in South Africa, is highly likely to diminish government's ability to support these resource-poor rural inhabitants. Improvement in the productivity and output of indigenous chickens in the rural areas is one of the alternatives available to governments to continue supporting rural inhabitants.

Despite the majority of rural households keeping indigenous chickens, their contribution to the livelihoods of these households is very minimal because of constraints like diseases, predation and poor housing (Mtileni *et al.,* 2013). These constraints lead to low production efficiency by

increasing mortality, reducing egg production and growth rate, therefore, resulting in indigenous chicken producers selling and/or consuming less chickens and eggs. Therefore, the actual contribution of indigenous chickens to the livelihoods of rural people needs to be determined so as to justify the interventions and their respective costs, which might be employed as measures to minimize the effects of production constraints in the indigenous chicken production system. This study was conducted to assess the socio-economic status of two rural communities in the Mnquma Local Municipality of South Africa and to establish the contribution of indigenous chickens to the livelihoods of households.

3.2 Materials and Methods

3.2.1 Description of Research Locations

The study was conducted in two rural villages with different agro-ecological attributes. Gcina (32.4 S 28.6E) is a coastal village situated about 500m from the sea while Ngcingcinikhwe (32.4 S 27.8E) is situated about 200km from the sea. Gcina is characterized by a forest and grass vegetation while Ngcingcilikhwe's vegetation is dominated by bush and Accacia Karroo trees. Gcina normally receives about 756mm of rain per year, with most rainfall occurring mainly during mid summer (saexplorer.co.za/south-africa/climate/centane_climate.asp, accessed in 2015). The monthly distribution of average daily maximum temperatures for Gcina range from 19.9°C in July to 25.7°C and the region is the coldest during July when the temperature drops to 8°C on average during the night (saexplorer.co.za/south-africa/climate, accessed in 2015). Ngcingcinikhwe normally receives about 598mm of rain per year, with most rainfall occurring mainly during summer. The average midday temperatures for Ngcingcinikhwe range from 17.9°C in June to 25.7°C in February. The region is the coldest during July when the temperature

drops to 4°C on average during the night (saexplorer.co.za/south-africa/climate, accessed in 2015). Maize is the grain of choice and it is planted during summer months when the rain is more abundent in both locations. The maize harverst is mainly used for human consumption and the surplus and spoilt maize is used to feed livestock including indigenous chickens.

3.2.2 Social facilitation

The permission to undertake the study was requested from the respective headmen of the study sites. Community meetings were convened to inform the people, providing details and to seek consent. The agricultural extension officers in charge of the two villages were requested to assist with social facilitation to sensitize the communities about the study.

3.2.3 Research process

3.2.3.1 Sampling design and techniques

All the households in both locations were listed to construct sampling frames of each village. A total of 250 and 100 households were listed in Gcina and Ngcingcinikhwe, respectively, and from these total numbers 100 and 50 sample households were randomly selected, respectively. Simple random sampling was done using random numbers generated by allocating a number for each household, putting numbers in a hat and arbitrarily selecting numbers. The selected households were requested to respond to a structured questionnaire.

3.2.3.2 Data Collection and Analysis

A structured questionnaire was used to collect data and mothers of the households were target respondents they are the main keepers of indigenous chickens. The questionnaire was divided

into four sections according to the type of information that was to be gathered about the household (APPENDIX 1). The sections were catergorised as follows:

A. Demographics
B. Contribution of indigenous chicken to the livelihood
C. Food Security
D. Indigenous Poultry Production Status

3.2.3.3 Demographics of households

Information related to the socio-economic attributes of the household was gathered from the respondents. This information included the age, sex and; also the family size, main source of income, employment status and highest education level of the household were asked.

3.2.3.4 Economic status of the households

A number of parameters were used to assess the socio-economic situation of each household in the study. Socio-economic indicators that will provide an insight into the economic activities and levels of income of households were selected. Therefore, the following indicators were measured:

- Sources of income
- Monthly income range
- Monthly expenditure

3.2.3.5 Food security status of the household

The food shortage coping strategies measurement framework by Maxwell (2008) was utilized to establish the food security status of the selected households. A score was allocated based on the extent to which the households would employ various strategies to cope with the shortage of food. A questionnaire with a number of food shortage coping strategies and respective scores

was used to establish the extent of food shortaged of the randomly selected households. The higher the score the more hard pressed the households were for food.

3.2.3.6 Contribution of rural chicken to the livelihood of households

A set of questions were posed with the aim of establishing the monthly contribution of the indigenous chickens towards the livelihoods of the selected households. The contribution of the indigenous chickens was computed by attaching a monetary value to the number of indigenous chicken and eggs consumed and adding these to the revenue generated through sales of indigenous chickens and eggs. Additional information on the selling and consumption of indigenous chickens and eggs was also gathered. It included the following:

- Purpose of keeping indigenous chicken
- Use of eggs
- Basis for chicken and egg pricing
- Consumption of various types of meat
- Reasons for the sale and consumption frequency of eggs and indigenous chickens
- Places where chickens and eggs are sold

The Statistical Analysis System of SAS version 8 (SAS, 1999) was used to perform data analysis. The **PROC FREQ** procedure was used to calculate the frequency analysis of qualitative data and the **PROC MEANS** procedure for the descriptive statistics of quantitative data. A simple t-test was used to compare differences between averages of parameters that were measured and a two-tail Z-test was used to analyze differences in percentages or proportions for observations that were expressed as such. The association between two variables was evaluated using command: **proc freq data=; tables Variable 1*Variable 2/chisq**

3.3 Results

The findings regarding the socio-economic status of the households in the two study sites and the contribution of the indigenous chickens to the livelihoods will be presented in two parts: (i) Household demographics and socio-economic dynamics and (ii) The indigenous chickens and their contribution to rural livelihoods.

3.3.1 Household demographics and socio-economic dynamics

The majority of respondents in both communities (82.5% in Gcina and 78.7% in Ngcingcinikhwe) were females who were mostly mothers in the households (Table 3.1). The average family sizes were 5 and 4 in Gcina and Ngcingcinikhwe, respectively. The average highest education level in a household was Grade 9 and 8 in Gcina and Ngcingcinikhwe, respectively (Table 3.1).

Table 3.1: The demographic characteristics observed in the two communities

Parameters	Gcina	Ngcingcinikhwe
Gender of the respondent (%):		
Female	82.5	78.7
Male	17.5	21.3
Average age of the respondents (Years):	53.8±16.34	53.8±16.17
Family position of the respondent (%):		
Daughter	11.3	4.3
Father	15.0	19.2
Mother	72.5	74.5
Son	1.3	2.1
Average Family Size (People):	4.8±2.63	4.1±2.24
Highest household education level (Grade):	8.8±2.92	7.7±2.75

The majority of households in both communities (80% in Gcina and 80.8% in Ngcingcinikhwe) relied solely on government welfare grants for survival while small businesses, local employment and city employment account for a very small proportion of income sources for the households (Table 3.2). The monthly income of the majority of households (80.8% and 75.6% in Gcina and Ngcingcinikhwe, respectively) was below R1 500 (USD115) (Table 3.2). The

household food insecurity coping score was 22.8 (range 5 to 52) and 27.3 (range 2 to 78) for Gcina and Ngcingcinikhwe, respectively.

Table 3.2: The main sources of income, monthly income levels and food security scores of households

Parameter	Gcina	Ngcingcinikhwe
Source of income (%):		
City employment	5.0	10.3
Government welfare	80.0	80.8
Local jobs	8.8	6.4
Small business	6.3	0.0
No income	0.0	4.0
Monthly income level (%):		
R501 - 1000	18.0	29.8
R1 001 - 1 500	62.8	46.8
R1 501 – 2 000	14.1	8.5
Above R2000	5.1	10.6
Household food security score	22.8±12.25	27.3±19.68

There was a significant ($p<0.0001$) association between the source and the level of income in Gcina as most people who were receiving government grant had a total monthly income of

between R1 000 (USD77) and R1 500 (USD115) This association was not significant in Ngcingcinikhwe.

3.3.2 The indigenous chickens and their contribution to rural livelihoods

The majority of respondents (78.8% and 68.1% in Gcina and Ngcingcinikhwe, respectively) kept indigenous chickens to generate some income, through selling and for household consumption. Small proportions of the households 21.3% and 23.4% in Gcina and Ngcingcinikhwe, respectively, did not keep indigenous chicken (Table 3.3). The eggs produced were mainly used for household consumption and for hatching to maintain or increase flock sizes (Table 3.3).

Table 3.3: Reasons for keeping indigenous chickens and use of eggs produced.

Parameter	Gcina (%)	Ngcingcinikhwe (%)
Reasons for keeping indigenous chickens:		
Own consumption	40.0	25.5
Own consumption and to generate revenue	38.8	42.6
Generate revenue	0.0	8.5
Use of eggs:		
Own consumption	4.9	11.1
Generate revenue and own consumption	6.6	16.7
Own consumption and set for hatching	62.3	47.2
Generate revenue and set for hatching	0.0	2.8
Set for hatching	26.2	22.2

About half of the households in both communities (44.7% and 51.6% in Gcina and Ngcingcinikhwe, respectively) did not sell their chickens and the majority of those who sold the chickens only did so once a month (Table 3.4). Only one to three birds were sold per month by the majority of the households that sold indigenous chickens (46.8% and 40.4% in Gcina and Ngcingcinikhwe, respectively) (Table 3.4). There was a significant ($p<0.05$) association between the family size and use of eggs in Gcina with households with family size of between

1 and 3 consuming significantly more eggs than larger family sizes.

Table 3.4: Frequency of selling chickens numbers sold

	Gcina (%)	Ngcingcinikhwe (%)
Frequency of selling:		
None	44.7	51.6
Once in 1-3 days	0.0	2.1
Once in 4-6 days	1.3	2.1
Once a week	0.0	4.3
Once in 2 weeks	0.0	0.0
Once in 3 weeks	4.0	2.1
Once a month or more	50	38.3
Number of Chickens sold per Month:		
None	44.2	53.2
1 to 3	46.8	40.4
4 to 6	5.2	6.4
7 to 9	1.3	0.0
10 to 12	1.3	0.0
13 and more	1.3	0.0

In both communities, the majority of households that sold eggs (89.6% and 85.1% in Gcina and Ngcingcinikhwe, respectively) sold only less than 12 eggs per month (Table 3.5).

Table 3.5: The frequency of selling and number of eggs sold

Parameter	**Gcina (%)**	**Ngcingcinikhwe (%)**
Frequency of selling eggs:		
None	89.6	85.1
Everyday	0.0	4.3
Once a week	2.6	0.0
Once in 2 weeks	1.3	6.4
Once in 3 weeks or more	6.5	4.3
Number of eggs sold per Month:		
None	90.8	85.1
1 to 6	4.0	4.3
7-12	1.3	6.4
19 to 24	2.6	0.0
25 and more	1.3	4.3

In the majority of households (78.7% and 82.6% in Gcina and Ngcingcinikhwe, respectively) chickens were sold only when there were financial needs (Table 3.6). Moreover, the majority of households (82.5% and 83% in Gcina and Ngcingcinikhwe, respectively) did not sell eggs and

those who sold eggs, sold those that were in excess of the number required for setting to hatch (Table 3.6).

Table 3.6: Reasons for the frequency of selling chicken and their eggs

Parameter	Gcina (%)	Ngcingcinikhwe(%)
Reasons for frequency of selling indigenous chicken:		
Do not know	14.9	8.6
To generate income	2.1	4.4
Low chicken numbers	4.3	0.0
When there is a financial need	78.7	82.6
Based on demand	0.0	4.4
Reasons for the frequency of selling eggs:		
Do not sell	82.5	83.0
To generate income	2.5	4.3
The demand is low	2.5	6.4
Sell excess eggs	10	4.2
Reserved for hatching	2.5	2.1

All respondents in the two villages sold the indigenous chickens and eggs locally within their respective communities (Table 3.7). The average price of the indigenous chickens was not

significantly higher in Gcina compared to Ngcingcinikhwe, however, the price of eggs was higher in Ngcingcinikhwe.

Table 3.7: Selling point and prices of rural chicken and eggs, and basis for pricing

Parameter		Gcina	Ngcingcinikhwe
Chicken price (R)		74.3 (±17.4) (USD7.43)	61.0 (±9.3) (USD 6.1)
Egg price (R)		0.8 (±0.3) (USD 0.08)	0.95 (±0.2) (USD 0.095)
Basis for pricing:			
I.	Costs incurred	11.6%	24.0%
II.	Demand	25.6%	20.0%
III.	Competitors	0.0%	8.0%
IV.	Local price	60.5%	28.0%
V.	Size	0.0%	20.0%

The majority of households consumed indigenous chicken meat only once a month (84.9% and 78.7% in Gcina and Ngcingcinikhwe, respectively) while the eggs produced were consumed once in three weeks by the majority of households (77.8% and 72.4% in Gcina and Ngcingcinikhwe, respectively) (Table 3.8).

Table 3.8 Chicken and egg consumption frequency

Parameter	Gcina	Ngcingcinikhwe
Indigenous chicken consumption frequency:		
Once in 3 days	1.3%	4.3%
Once a week	0.0%	10.6%
Once in two weeks	2.5%	2.1%
Once in three weeks	11.4%	4.3%
Once a month	84.9%	78.7%
Indigenous chicken egg consumption frequency:		
Every day	0.0%	4.3%
Once in 2-4 days	1.3%	2.1%
Once a week	10.1%	4.3%
Once in two weeks	8.9%	17.0%
Once in three weeks	77.8%	72.4%

The majority of respondents (52.5% and 48.6% in Gcina and Ngcingcinikhwe, respectively) mentioned that they only consume indigenous chicken meat when they felt like consuming it while a second largest proportion of respondents (23.7% and 28.6% in Gcina and

Ngcingcinikhwe, respectively) mentioned small flock sizes as the reason for low frequency of indigenous chicken meat (Table 3.9).

Table 3.9: Reasons for Chicken and Egg consumption frequency

Parameter	Gcina	Ngcingcinikhwe
Reasons for indigenous chicken consumption frequency:		
Culling	1.7%	0.0%
Small flock size	23.7%	28.6%
Want to consume indigenous chicken meat	52.5%	48.6%
For visitors	8.5%	0.0%
No money to buy broiler meat	6.8%	19.9%
Reserved for sale	6.8%	2.9%
Reasons for egg consumption frequency:		
Low preference for eggs	26.7%	10.8%
Low egg Numbers	3.4%	5.4%
Reserved for hatching	16.9%	29.7%
Meat substitute	22.5%	40.6%
Excess eggs	30.5%	13.5%

The households spent, significantly, more money on commercial chicken meat than other types of meat (Table 3.10). There was a significant ($p<0.05$) association between the source of income and monthly expenditure on commercial chicken meat in both study sites. The households that

were receiving government grant spent the highest amount of money on commercial chicken.

Table 3.10: Average amount of money spent on various types of meat each month

Meat type	Gcina	Ngcingcinikhwe	Prob.
Beef	R73.30(USD 7.3)	R33.50(USD 3.4)	<0.01
Mutton	R55.80(USD 5.6)	R33.80(USD 3.4)	
Commercial Chicken	R96.60(USD 9.7)	R73.60(USD 7.4)	

3.4 Discussion

Women formed the majority of respondents in both communities as they were the targeted respondents, in turn, they were also poultry keepers and mothers in the households. Findings in this study are in agreement with previous studies, which showed females to be the main keepers of chickens in rural areas (Aklilu, Almekinders, Udo and Van der Zijpp 2007). As part of the Eastern Cape Province, Mnquma is one of the municipalities with the highest levels of poverty, illiteracy and unemployment. An estimated 11% is unemployed, only 25% is employed while 64% of the municipal population is considered economically inactive (Mnquma Local Munucipality IDP, 2014/2015). The area has limited employment opportunities and this has huge implications on the increased need for welfare and indigent support in the municipal area; leading to some people, mostly men, seeking employment in big cities. Furthermore, the reason for the low employment opportunities could be that the area falls under the former Bantustan area of the former Apartheid government, which limited development in these areas.

The average family sizes per household observed in this study was 4.8 and 4.1 for Gcina and Ngcingcinikhwe, respectively, which is similar to the household size value of 4 people for

Amathole region of the Eastern Cape (dedea.gov.za, 2011, accessed in 2015). The family size is not far off from the family sizes observed in other studies (Stats SA 2011; Aklu et al 2007; Madhavan and Schatz 2003, dedea.gov.za, 2011, accessed in 2015). The low average family size was attributed to the increased inclination of people to start their own families and thus moving away from the traditional norm of the families staying together. Though the sizes of households in South Africa have shown a steady decline, there has been a concomitant increase in the number of households from 11.2 million in 2001 to 14.4 million in 2011 (Stats SA, 2011). Therefore, this shows that the decline in household size does not translate to a decline in population size and the threat of food insecurity due to population growth is still a reality.

The average highest education reported in this study for the two communities was Grade 9 and 8 in Gcina and Ngcingcinikhwe, respectively. This finding is similar to the municipality's generally low education status reported in 2014/15 IDP where it was stated that 7% of Mnquma's population has no schooling, 31% has completed primary school and 52% has completed grade 12 while no more than 9% of the population have a higher education. The low education standard in the area can be one of the contributing factors to the observed high level of unemployment and which also might have a hindering effect on the ability of the people to comprehend some of the technical advices they might be offered in order to improve their food security status.

The main source of income for 80% households in both communities was government welfare grants. This shows that most households could not survive without the financial assistance of the government grant, which ranged from R250 to R1200 per month (a child under 18 years qualifies

for R250 (USD19.23) per month while people above 60 years qualify for R1 200(USD92.31)). These amounts are deemed as an inadequate income level for the family sizes of households reported in this study if FAO's "one-dollar-a-day threshold" is considered (fao.org/docrep/003/y6265e/y6265e03.htm, 2014, accessed in 2015). The heavy reliance on government assistance by the rural communities results in experiencing of transitory food insecurity by the households where the food shortage is experienced towards the end of the month (Hendriks 2005; Kirkland *et al.* 2011). The transitory food insecurity could be mitigated in the rural households by encouraging production of balanced nutrient food products that can be utilized during the periods of food shortage (Hendricks 2005). This is why improving production approaches to the indigenous chicken farming system is paramount so as to bridge the periods of food insecurity.

The majority of household income levels of between R500 and R1500 is similar to the findings of Swatson *et al* (2001) and the Mnquma Local Municipality Intergrated Development Plan (IDP) of 2012-2017. Swatson *et al* (2001) reported that the household incomes in Alfred area of KwaZulu-Natal ranged from R500 to R1036 while the Mnquma IDP of 2012-2017 showed that 27% of households had a monthly income of less than R1600. Though the IDP of Mnquma Local Municipality of 2012-2017 states that 40% of households do not have income and they require subsidies, the findings of this study have shown that in the rural areas 80% of households relied solely on government welfare grant. This could be an indication that some rural communities are worse off compared to the Local Municipality average socio-economic status. A considerable decline in agricultural production in recent years could be one of the contributing factors in the observed limited resources amongst the communities under study.

The average food insecurity Coping Strategy Index based on the Coping Strategies revealed that the households in Gcina are more food secure compared to those of Ngcingcinikhwe. Though the food security scores observed in the two locations (Table 3.2) are much lower relative to the possible total score of 203, the scores show that the households have had to apply some food shortage coping strategies (Maxwell, 2008). A Coping Strategy is a good proxy for food intake, food budget shares, food frequency, income status and the nutritional status of the children in the household, however, the measurement cannot be repeated for the same community as the responses are likely to change (Hendrics, 2005). The food security results of this study confirm the assertion that rural communities of South Africa are characterized by poverty and food insecurity (Kirkland, *et al*. 2011).

The majority of households in the rural areas keep indigenous chickens for own consumption and, to a lesser extent, to generate revenue. Some households cited disease, predators or prolonged absence from home as the reasons for not keeping indigenous chickens. The eggs are mainly used for hatching and few are used for household consumption. The potential of utilizing indigenous chickens as means of food security has previously been reported by several authors (Swatson *et al.*, 2001, Gueye 2002; Ricalde *et al*., 2004; Mtileni *et al*., 2013). Grobbelaar et al (2010) and Mtileni *et al.* (2013) observed that the inhabitants in rural areas keep chickens mainly for food security and, to a lesser extent, to generate income and these findings are similar to those of this study. However, in order for the indigenous chickens to contribute significantly to food security, the research agenda must give greater attention to socio-economic and technical constraints pertaining to indigenous chicken production (Muchadeyi *et al*. 2013). This will be

done in order to minimize the constraints, improve indigenous chicken production and consequently enable rural inhabitants to consume and sell more chicken products.

Indigenous chickens still account for a significant part of all meat produced in many developing countries where poultry is an important component of rural, peri-urban and urban households (Gueye, 2005; Riise *et al*., 2005). High preference for indigenous chicken meat over the commercial broiler meat has been reported in a number of publications (Sonaiya 2000; Sartika and Neer 2005; Sorensen 2006). Grobbelaar *et al*. (2010) stated that a majority of indigenous chicken keepers tend to keep just a few chickens that can produce meat and eggs, get broody, hatch; and raise own chicks. This assertion was, however, contradicted in this study as the small flock sizes was attributed to disease and predation, not the choice on the indigenous chicken keepers. Therefore, the reason that few respondents mentioned the revenue generation as the purpose for keeping indigenous chicken is because of small flock sizes.

The majority of households that sell chickens do so only once a month in both communities. An overwhelming majority of households in both communities do not sell the eggs produced, but those who do sell only 1-3 eggs per month at 80c and 95c in Gcina and Ngcingcinikhwe, respectively. The average number of eggs sold per month in this study is lower compared to the average number of 6.25 eggs sold per month reported in a study conducted in rural areas of Ethiopia by Aklilu *et al*. (2007). The majority of households in both communities that sell chickens, sell between 1 and 3 birds per month. The observed low number of rural chickens sold by the households in this study was also reported by Muchadeyi *et al.* (2005) in a study conducted in rural areas of Zimbabwe where it was reported that an average of 0.03 – 0.1

chickens were sold in a month. Aklilu *et al.* (2007) also observed a low selling rate of chickens per household, reporting that each household in rural Ethiopia sold an average of 0.33 to 0.68 chickens per month. Muchadeyi *et al*. (2005) attributed the low sales of chickens and eggs to the high mortality rate, which was reported to be as high as 80%. The respondents in this study mentioned small flock sizes as the reason for low chicken and egg sales.

The reasons mentioned by the respondents for low sales frequency of indigenous chicken and eggs ranged mainly from "selling only when there is a financial need" to the problem of "small flock sizes" while the eggs were generally not sold but reserved mainly for setting to hatch. The people in the rural communities are losing out on an opportunity to exploit the much published general preference for indigenous chicken meat and eggs by not producing enough of these chicken products. The indigenous chicken meat is renowned for its specific texture, flavor, taste and it contains lower fat, and, therefore, tends to fetch higher prices in the market compared to its commercial counterparts (Sartika and Noor 2005).

All the households which sold chicken and eggs did so only to the local community. This could restrict the number of chicken and eggs sold, and, consequently, the revenue generated as the farmers do not access other potential markets such as urban areas. The average asking price per bird was significantly higher (at $p=0.05$) in Gcina (R74 equivalent to USD7.4) compared to Ngcingcinikhwe (R61 equivalent to USD6.1). The main basis of pricing varied in the villages, at Gcina it was the local selling price while in Ngcingcinikhwe it was based on the costs incurred, demand and bird size. The higher average prices fetched by rural chicken in Gcina could be linked to the higher average education level and higher monthly income of the households

compared to those of Ngcingcinikhwe. This assertion is based on the findings of Ricalde, et al (2004) who reported that people with higher socio-economic status tended to employ superior husbandry practices than those with a lower socio-economic status. The indigenous poultry farmers in Gcina could, therefore, be producing birds of a superior quality because of their improved husbandry practices and, consequently, manage to ask for higher prices in the market. However, this assumption was contradicted by the responses of the respondents of Gcina where the majority mentioned that their pricing is mainly based on the local price rather than the morphological characteristics of the birds being sold. It is, therefore, assumed that demand for indigenous chicken meat and buying power of the local people could be the reason for higher prices, and this assertion is based on the findings of this study that household income of the Gcina community was relatively higher than that of Ngcingcinikhwe. There seemed to be no consistent pricing framework for indigenous chickens in the rural communities.

The majority of households in both communities consumed indigenous chicken meat only once a month. Eggs were consumed only once in three weeks by the majority of households. These observations are comparable to those of Aklilu *et al.* (2007) who reported households in rural Ethiopia that consumed an average of 0.25 to 0.34 and 2.84 to 5.39 chickens and eggs, respectively, per month. There is a general preference of indigenous chicken meat over commercial broiler meat, however, small flock sizes limit the consumption of indigenous chickens. The reasons for low consumption of eggs ranged from low preference for eggs to reserving them for hatching. Aklilu *et al.* (2007) concluded that though the sale and consumption of eggs and chicken is low in rural households, there is a tendency to exhibit an inclination for selling rather than own consumption. On the contrary, in this study reserving eggs for setting was

the priority of the households rather than selling or consumption though the flock sizes were generally similar compared to those observed by Aklilu *et al.* (2007). Therefore, this signifies that the rural communities were not aware of the economic benefits of selling chickens and eggs hence they were selling less of these products.

The results of this study indicate that the indigenous chickens provide some form of food security though it is to a very small extent. However, indigenous chickens have a potential to provide protein nutrition, to diversify sources of household income and increase income levels of the rural population (Missohou, Dieye and Talaki 2002; Kingori *et al*. 2003). However, the respondents cited small flock sizes as the main reason for not consuming more indigenous chickens and eggs. Utilizing the source of meat and eggs at the rural people's disposal in the form of indigenous chicken and their eggs could mean that the households can spend the money normally used to purchase meat and eggs on other household necessities. The reasons for buying commercial chicken by the households is not based on its preference over the rural chicken but on the fact that the households want to preserve the rural chicken with the aim of increasing their flock sizes.

Households in both communities spent more money on purchasing commercial chicken meat compared to other meat types. The higher preference for chicken meat could be based on its relatively low price compared to other meat types and health benefits associated with it. However, the financial resources utilized to purchase the commercial broiler meat could definitely be spent on other household requirements if there was a larger number of indigenous chickens. The households tend to consume or sell less indigenous chicken meat and eggs in a bid

to reserve breeding stock and eggs for setting. If the mortality of indigenous chickens could be reduced, the flock sizes would definitely increase and, consequently, more indigenous chicken meat and eggs would be sold or consumed.

3.5. Conclusion

The various socio-economic indicators measured in this study showed that households in the two locations were struggling to survive and their status is bordering on poverty. However, based on the sales, consumption frequencies and numbers of indigenous chickens and eggs, indicated that indigenous chicken did not have a considerable contribution towards the livelihoods of the households in the two rural communities in this study. This is largely attributed to the small flock sizes of chicken being kept by the households. The notable contributing factor to the small flock sizes is high mortality rate as caused by disease and predation. Therefore, concerted efforts to increase the flock sizes kept by the households have to be made in order to improve the contribution of the indigenous chicken towards the livelihoods of the rural households. This can be done by identifying prevalent disease and parasites and development of a comprehensive disease management strategy.

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Chapter 4: The Production Status of Indigenous Chicken in Two Rural Villages of Mnquma Municipality, Eastern Cape Province – South Africa

Abstract

The majority of rural households in South Africa keep indigenous chickens for own consumption and revenue generation. However, production of indigenous chickens is very low compared to their commercial counterparts. This study was undertaken to establish the precise levels of indigenous chicken production and the factors that influence their production in two rural villages, Gcina and Ngcingcinikhwe. A structured questionnaire was used to gather the information from the respondents, and similar responses were tallied to determine their percentage frequency. The average flock size was 8.3 (±5.9) and 10.4 (±6.0) in Gcina and Ngcingcinikhwe, respectively, and the majority of households have been keeping chickens for more than five years. Supplementing scavenged feed with maize was done in 85.5% and 81.1% of households in Gcina and Ngcingcinikhwe, respectively. The average number of eggs produced per day was 2.8 and 3.8 in Gcina and Ngcingcinikhwe, respectively, and the eggs were kept unrefrigerated for more than seven days before setting, sale or consumption. The average number of eggs set for hatching was 11.6 and 11.7, the hatching rate was 78,4% and 71.8% and the chick survival rate was 55% and 59.5% in Gcina and Ngcingcinikhwe, respectively. Predators and diseases were the main causes of chick mortality in both communities. Therefore, indigenous chicken production could be increased by improved nutrition, disease management and housing.

Keywords: Indigenous chickens, eggs, production, diseases

4.1 Introduction

Keeping of indigenous chicken is a common agricultural activity in rural communities and the benefits for the households of owning indigenous chicken include financial income and food security (Muchadeyi *et al.,* 2005). Households are able to sell chickens and eggs and earn much needed revenue, and they can also consume the eggs and chicken meat to obtain the much needed proteins. Therefore, indigenous chickens have a contribution to the livelihoods of the rural households though it is lower than the potential expected (Swatson *et al,* 2003, Aklilu *et al.,* 2007; Olwande *et al*., 2010).

A number of researchers have raised concerns about the low contribution of indigenous chickens towards the livelihood of rural households, despite the perceived high potential of these chickens to have a considerable contribution (Muchadeyi *et al.,* 2005; Abdelqader *et al.,* 2007; Olwande *et al*., 2013). This perception is based on the low costs required to produce indigenous chickens and the high demand for indigenous chicken meat and eggs (Aklilu *et al.,* 2007). Indigenous chickens are generally kept in an extensive system where they scavenge for food, are provided with minimal or no feed supplementation and survive with little or no health-care as they are presumed to be resistant to various health challenges (Mekonnen *et al.,* 2010; Mtileni *et al*., 2012; Mutayoba *et al*., 2012). The meat and eggs of indigenous chickens are sought-after products because of their unique characteristics, which are taste and flavor. However, these products have not been able to make a significant impact on the livelihoods of the rural households because of perpetually small flock numbers kept by the households (Olwande *et al*., 2010). This results in low chicken and egg off-take for sale and consumption purposes.

The precise level of indigenous chicken production in South Africa and the factors contributing to the prevailing situation are not well understood. Finding of the reasons behind the observed production levels of indigenous chickens will be useful in the efforts to realize the true potential of indigenous chickens in terms of their contribution towards the livelihoods of rural households. The objective of this study was to determine the level of indigenous chicken production and to establish the factors that affect the level of production.

4.2 Materials and Methods

4.2.1 Description of Research Locations

Refer to Section 3.2.1

4.2.2 Social facilitation

Refer to Section 3.2.2

4.2.3 Research process

4.2.3.1 Sampling design and techniques

Refer to Section 3.2.3.1

4.2.3.2 Data Collection and Analysis

A structured questionnaire was designed to gather information on the production of indegenous chicken. The respondents were requested to provide reasons for the answers provided for the questionnaire. They were requested to attempt to give as accurate figures as possible for those questions that required numbers, e.g. flock sizes, number of chicken constituting various categories of chicken in a flock, egg numbers, hatchability and chick survival rates. The Statistical Analysis System of SAS version 8 (SAS, 1999) was used to analyze the data. The

PROC FREQ procedure was used to calculate the frequency analysis of qualitative data and the PROC MEANS procedure for the descriptive statistics of quantitative data. A simple t-test statistics was used to compare differences between averages and a two-tail Z-test was uses to analyze differences in percentages or proportions.

4.3 Results

The average number of birds per household was 8.3 (±5.9) and 10.4(±6.0) in Gcina and Ngcingcinikhwe, respectively (Table 4.1). Chicks constituted a majority of the chicken flocks while cocks were a minority in both communities. However, the average number of growers per households was significantly ($P < 0.05$) higher in Gcina (3.9 (±2.7)) compared to Ngcingcinikhwe (2.1 (±3.0)) (Table 4.1). A number of households in Ngcingcinikhwe caponized some of the cocks, however, these birds constituted a small proportion of the flock (Table 4.1). The majority of households allowed the chickens to scavenge for feed and supplement only with maize in both communities (Table 4.1).

Table 4.1: The chicken number frequency, average flock size, flock breakdown and chicken feeding method

Chicken Numbers:	**Gcina Frequency (%):**	**Ngcingcinikhwe Frequency (%):**
0	22.5	21.3
1-5	28.8	19.2
6-10	32.5	25.5
11-15	6.3	17.0
16-20	6.3	14.9
21-25	1.3	2.1
26 and above	2.3	0.0
Average flock size:	8.3 (±5.9)	10.4(±6.0)
Flock Composition:	**Number:**	**Number:**
Chicks	6.3 (±5.5)	6.4 (±7.0)
Growers	5.9 (±9.0)	2.1 (±3.0)*
Hens	3.9 (±2.7)	3.6 (±3.6)
Cocks	1.7 (±1.2)	1.4 (±1.8)
Capons	0.0	1.2 (±4.5)

Feeding Method	**Frequency (%):**	**Frequency (%):**
Scavenging with maize supplementation	85.5	81.1
Scavenging with maize and commercial feed supplementation	3.2	5.4
Scavenge only	1.6	0.0
Commercial feed only	9.7	13.5

* = Significant difference at 5% level of confidence.

The majority of indigenous chicken flocks in both communities produced less that six eggs per day and the average egg production per day was 2.8 (±2.4) and 3.8 (± 2.4) in Gcina and Ngcingcinikhwe, respectively (Table 4.2). Eggs were collected from the nest only once a day in 74.6% and 85.3% of households in Gcina and Ngcingcinikhwe, respectively.

Table 4.2: Egg numbers produced per day frequency, average number of eggs produced per day and egg collection frequency.

Egg numbers produced per day :	**Gcina Frequency (%):**	**Ngcingcinikhwe Frequency (%):**
1-3	69.6	47.1
4-6	19.6	44.1
7-9	7.1	2.9
10-12	3.7	5.9
Eggs produced per day:	2.8 (±2.4)	3.8 (± 2.4)
Egg collection frequency:	**Frequency (%):**	**Frequency (%):**
Once a day	74.6	85.3
Twice a day	8.5	11.8
Thrice a day	13.6	2.9

In Gcina 34.7% of households prepared special nests in which hens laid eggs whereas the proportion of households that did the same was higher (54.6%) in Ngcingcinikhwe (Table 3). All households in both communities kept the eggs unrefrigerated in various containers for more than seven days before they are set for hatching (Table 4.3).

Table 4.3: Egg laying place, egg storage time and egg storage method.

Egg laying place:	Gcina Frequency (%):	Ngcingcinikhwe Frequency (%):
Special nest	34.7	54.6
Unspecific places	65.3	45.5
Egg storage time before setting:	**Frequency (%):**	**Frequency (%):**
7 or more days	100	100
Egg storage method:	**Frequency (%):**	**Frequency (%):**
Basket	3.6	3.0
Closed container	1.9	5.7
Basin	38.9	20.0
Unused open container	55.6	71.3

The average number of eggs set for hatching was 11.6 (±2.4) and 11.7 (±2.3) in Gcina and Ngcingcinikhwe, respectively, with hatchability of 78.4% and 71.8 %, respectively (Table 4.4). The proportion of hatched chicks that survive to grower phase was 55% and 59.5% in Gcina and Ngcingcinikhwe, respectively (Table 4.4).

Table 4.4: Average number of eggs set, chicks hatched and chicks that survive to grower stage.

	Gcina	Ngcingcinikhwe
Average number of eggs set:	11.6 (±2.4)	11.7 (±2.3)
Average number of chicks hatched:	9.1 (±2.5)	8.4 (±3.0)
Average number of chicks that survive to grower phase:	5.0 (±2.6)	5.0 (±2.5)
Hatchability rate (%):	78.4	71.8
Survival rate (%):	55.0	59.5

In Gcina 72.6% of respondents mentioned predators as the main cause of mortality in chicks whereas in Ngcingcinikhwe the 56.7% of respondents considered a combination of diseases and predators as the main cause of mortality (Table 4.5). There was a significant ($p<0.05$) association between the number of chicks that were hatched and those that survived to a grower stage. A large number of hens that hatched 5 to 10 chicks mostly had only 1-5 chicks that survived to grower stage. The majority (77.4%) of respondents in Gcina and 64.9% in Ngcingcinikhwe considered the provision of better chicken housing together with vaccination and/medication to be the most important measures that could be employed in the efforts to reduce chick mortality.

Table 4.5: Causes of chick mortality and chick mortality reduction measures that are used.

	Gcina Frequency (%):	Ngcingcinikhwe Frequency (%):
Causes of chick mortality:		
Predators	72.6	13.5
Predators and diseases	17.7	56.7
Predators and cold	1.6	0.0
Diseases	3.2	18.9
Cold	0.0	2.7
Feed shortage	1.6	0.0
	Frequency (%):	**Frequency (%):**
Chick mortality reduction measures:		
Housing	38.7	16.2
Medication/vaccination	38.7	48.7
Feed supplementation	1.6	5.1
Predator control	1.5	2.7

In both communities a majority of households (80.3 in Gcina and 88.6 in Ngcingcinikhwe) had been keeping indigenous chickens for more than five years.

4.4 Discussion

The majority of households kept indigenous chickens, however, the average flock sizes observed in this study were lower than the one reported by Muchadeyi *et al* (2007) in a study conducted in five agro-ecological zones of Zimbabwe and the one by Olwande *et al* (2013). In a study by Muchadeyi *et al* (2007) it was reported that the average flock size across Zimbabwe was 16.7 birds with a range of 12 to 19.4 birds per flock while Olwande *et al* (2013) observed an average flock size of 15.8 (±8.17) birds per flock. However, the flock sizes observed in the study are similar to the flock sizes ranging from 2-10 birds observed by Iqbal and Pampori (2008). The small flock sizes observed in this study can be largely attributed to the absence of a disease control strategy and predation, which resulted in high chick mortality.

Chicks formed the majority category in both locations, contrary to the findings of Kusina, Kusina and Mhlanga (2001) where they observed that the category of hens was the dominant category of the flock. However, the number of cocks were similar to the findings of this study. Some respondents in Ngcingcinikhwe castrated their cocks because the capons are deemed to be less aggressive and their meat tastier and softer. This assertion is in agreement with the findings of Rimukari *et al.* (2009) where it was observed that the capon meat was tenderer and had less connective tissue than cocks.

The majority of households allow chickens to scavenge for feed and supplement with maize only. However, there are households that let the birds rely on scavenging only and those that offer commercial diet only. The households that supplemented the scavenged feed were only

offering maize grain as a supplement. A study by Mutayoba *et al* (2012) showed that there was no significant difference in the body weights and egg production of the birds that were supplemented with homemade diet and those supplemented with a commercial diet. The body weights and egg production of the un-supplemented birds was significantly lower than those of supplemented birds. The homemade supplement tested by Mutayoba *et al* (2012) was a complete diet, therefore, its effectiveness can not be compared with the supplementation with maize grain only as it is the case in this study. The supplementation with maize might offer extra energy for the birds, however, the birds might still be deficient in other nutrients resulting in low production. Olwande *et al* (2013) reported that supplementation of indigenous chickens with grains and kitchen leftovers only yields the lowest results compared to other production improvement interventions like vaccination, and housing. The supplementation of birds with a complete diet might be costly for the resource-poor rural households, however, this must be weighed against the benefits of improved production when bird are supplemented.

The average daily egg production was higher in Ngcingcinikhwe compared to Gcina, however, the difference was not significant. The low average daily egg production in this study was a result of small flock sizes and it could also be that some eggs were not collected because the hens laid in obscure places. Low egg production levels of 50-60 eggs/year and 40-60 eggs/year in indigenous chicken flocks was also reported by Iqbal and Pampori (2008) and Bhadaso (2012). The lack of supplementation with a protein source could also contribute to the low egg production (Iqbak and Pampori, 2008; Mutayoba *et al* 2012).

A marginally higher number of households in Ngcingcinikhwe provided special nests for the hens to lay eggs while the rest of the households allowed the hens to lay anywhere. This practice could have had a negative effect on the recovery of eggs as some could be laid in places that are

difficult to see or access, where the eggs can rot or end up falling prey to the predators. Some of the places that the hens lay in might be contaminated by micro-organisms, which might cause the eggs to rot during incubation. All the households kept eggs at room temperature, which could be about 23 – 30^{o} C in these villages. Exposure of eggs to ambient temperatures of above 15 degrees compromises their hatchability. Similarly, keeping eggs for longer that seven days, as was the practice in the study areas, compromises hatchability. Ideally, eggs meant to be incubated should be kept refrigerated at 12 to 14^{o} C and are never stored for more than seven days as the hatching rate could be diminished if they are stored longer than this period (Fanseko, 2007).

The average number of eggs set, chicks hatched and the number of chicks that survive to reach the grower phase was similar in the two study sites. The number of eggs set per hen as stated by the respondents is comparable to the range of 9.83-11 eggs reported by Olwande *et al* (2010). The hatchability rates of 78% and 71% in Gcina and Ngcingcinikhwe, respectively, observed in this study were lower than the hatchability rate of 87.2% observed by Olwande et al (2013), and 82% hatchability rate observed by Kusina *et al* (2001). However, the hatchability rates observed in the two study sites was comparable to the hatchability ranges of 77-81% observed by Iqbal and Pampori (2008) and 70.16-80.61% reported by Olwande *et al.* (2010). The hatchability rates observed in this study are comparable to the general hatchability standards of commercial broiler breeder flocks despite the fact that the birds were not confined. This shows that the mating ratios (male : female) were adequate for egg fertilization.

The high mortality of chicks observed in this study was attributed to predators and diseases, as a result, they suggested housing and medication as means by which the chick mortality can be reduced. The same causes of chick mortality were mentioned in the study conducted by Mtileni

et al (2013). Olwande *et al* (2013) reported that combined (vaccination, chick confinement and feeding) interventions resulted in 82.6% chick survival rate compared to 23.9% of the control group. The chick survival rates of 55 and 60% observed in this study were considerably higher than the 23.9% survival rate observed in a control group of the study by Olwande *et al* (2013), however, it is lower than the 70% survival rate observed by Kusina *et al* (2001).

An overwhelming majority of households in both locations under study had been keeping indigenous chickens for more than five years but the flock sizes are very low. The low numbers of indigenous chickens can be attributed to high chick mortality as caused by predators like wild cats, dogs and birds; diseases, hot and cold weather, and drowning in water pots (Henning *et al.* 2006; Biswa *et al*, 2008). This assertion is based on the fact that the hatchability rate of set eggs in both locations is relatively good considering the extensive and unsterile conditions under which the incubation takes place. However, the survival rate of the chicks tends to be very low resulting in fewer birds reaching the production and reproduction phase (Fentie *et al.*, 2013; Iqbal and Pampori, 2008).

4.5 Conclusion

The key chicken production parameters measured in this study revealed that the indigenous chicken production was very low in the two study sites. The general husbandry and the environment in which the indigenous chickens are kept are the main contributing factors to the observed production level. Poor feeding, non-housing and lack of health management are the direct causes of diseases, predation, low growth rate and low egg production. Therefore, an integrated approach that will minimize the challenges of indigenous chicken production will go a long way in improving the flock sizes, increase egg production and, consequently, the number of

eggs and chicken that can be consumed or sold by the households. Inclusion of a protein source in the feed offered as a supplement to the indigenous chicken can increase growth rate and egg production while housing of chicks during the most critical stage of growth can significantly improve their survival rate to full grown chicken. A comprehensive disease control program based on local health challenges will also improve flock sizes, growth rate and egg production.

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Chapter 5: The Health Status of Indigenous Chickens in Two Rural Communities in Mnquma Local Municipality, South Africa

Abstract

Health challenges are known to affect indigenous chicken production in rural areas, thus leading to low productivity and, consequently, low contribution to the livelihoods of rural households. A survey was conducted to investigate the health status of indigenous chickens in two communities of Mnquma Local Municipality. A structured questionnaire was used to gather information about commonly observed disease symptoms and parasites, their seasonal prevalence and means that farmers use to control such diseases. Respondents mentioned noting respiratory and nervous symptoms, together with swollen eyes, which are associated with Newcastle Disease. In contrast, worms were least mentioned as an observed health challenge. The symptoms mentioned were reported to be commonly observed during the Summer and Autumn months while worms were said to be common during Spring. There were no disease challenges reported during Winter months. The respondents reported using unconventional means in the control of the various diseases and parasites. However, the majority do not believe that these means are effective. Lack of an effective extension service was pointed out to be one of the reasons farmers did not have the necessary knowledge on how to prevent or control diseases and parasites in their flocks. Considering that health challenges of chickens in rural chicken are multi-dimensional, an integrated approach is required to control them and improve productivity of this farming system.

Keywords: indigenous chicken, diseases, parasites, mortality, season

5.1 Introduction

The majority of resource poor households in rural areas of South Africa keep indigenous chickens which are used for consumption and income generation. These chickens provide protein through meat and eggs and also generate household revenue from the sale of chickens and eggs (Mwale and Masika, 2009). In recent years, a number of sources have highlighted the unfulfilled potential of indigenous chickens to address the socio-economic challenges of people residing in rural areas (Muchadeyi, *et al.* 2005; Bhadhaso, 2012; Olwande, *et al.* 2013).

Although indigenous chickens are reportedly able to survive under challenging conditions, typical of many rural areas, the low production from this production systems has been a concern to many researchers (Riise, *et al.* 2005; Gondwe, *et al.* 2007; Halima, *et al.* 2007). Low output from indigenous chicken farming systems is attributed to small flock sizes and low egg production which, consequently, minimizes the rate of consumption and sale of meat and eggs (Iqbal, *et al.* 2008; Olwande, *et al.* 2010, Bhadhaso 2012; Okeno, *et al.* 2012).

The small flock sizes of indigenous chickens have been attributed to the high chick mortality caused by various health challenges due to the absence of health management program (Alfred, *et al.* 2012, Mbyuzi, *et al.* 2012). The observed situation is a result of lack of knowledge of diseases and parasites prevalences, ineffective diseases and parasites control methods and inability to afford commercial medicine (Mwale and Masika, 2009). There is limited information about indigenous chickens diseases and parasites challenge in the Eastern Cape province of South Africa. The knowledge and documentation of these chicken health challenges will go a long way in the development of an effective health management strategy for indigenous chickens. The objectives of this study were to establish the perceived health challenges in

indigenous chicken and the methods used to minimized these challenges in two communities of Mnquma Local Municipality.

5.2 Materials and Methods

5.2.1 Study site

Refer to Section 3.2.1

5.2.2 Social facilitation

Refer to Section 3.2.2

5.2.3 Data Collection and Analysis

All the households in both communities were recorded and each household was allocated a number. In Gcina there was a total of 250 households while in Ngcingcinikhwe there were 100 households. One hundred and fifty households samples were selected randomly in Gcina and Ngcingcinikhwe, respectively. The random sampling was done by putting all the allocated household numbers in box and the required number of households was picked without looking. The selected households were requested to respond to a structured questionnaire.

A structured questionnaire was used to gather information from the representatives, who were mainly women. The information collected was related to the perceived disease and parasite prevalence, disease symptoms and various methods used by the households to control diseases and parasites.

5.2.4 Statistical analysis

The Statistical Analysis System of SAS version 8 (SAS, 1999) was used to perform data analysis and the PROC FREQ procedure was used to calculate the frequency analysis of qualitative data

and tables Variable 1*Variable 2/chisq was used to analyze for association between two variables.

5.3 Results

The majority of respondents in both locations (57.4% in Gcina and 41.7% in Ngcingcinikhwe) reported that they rarely observed the disease signs in their chickens (Table 5.1). However, more respondents in Ngcinginikhwe (38.9% of the 58.3%) than in Gcina (14.8% of the 42.6%) observed disease symptoms more often. A higher proportion (24%) of respondents in Gcina asserted that they did not see any disease symptoms, stating that they only discovered birds when they are already dead. In both communities respiratory problems, lethargy, nervous symptoms and white watery droppings were the most mentioned common disease symptoms observed in indigenous chickens (Table 5.1).

Table 5.1: Frequency of observation of various indigenous chicken disease signs in two locations

	Location	
	Gcina(%)	**Ngcingcinikhwe(%)**
Frequency of disease symptoms observation:		
Often seen	14.8	38.9
Rarely seen	57.4	41.7
See only dead birds	24.6	13.9
Observed Disease Symptoms:		
Swollen eyes	9	3
Respiratory problems	22	9
Lethargy	19	5
Nervous symptoms	13	10
White watery droppings	8	8
Cannibalism	0	1
Green droppings	0	1
Sores	5	3
Lack of appetite	3	0
Worms	1	0

Health challenges varied from season to season during the year (Table 5.2). Mites were perceived to be the most common health challenge in Summer, in both locations. However, the frequency of mention of other challenges differed between the two communities (Table 5.2). In Gcina the mites challenge in Summer was followed by respiratory problems, sores, swollen eyes and nervous symptoms in that order, whereas in Ngcingcinikhwe other challenges were due to fleas and ticks, respiratory problems and sores (Table 5.2). About 95% of respondents in both communities reported that they did not observe health challenges in Autumn (Table 5.2). However, contrasting responses on disease challenges in the Winter season were recorded in the two communities with respondents in Gcina being adamant that they did not observe disease challenges in winter whereas in Ngcingcinikhwe the nervous symptoms followed by sores and white feaces were observed in the winter season (Table 5.2). In both communities, worms were reported to be the most common health challenge in Spring (Table 5.2). Overall, Autumn and Winter seasons were perceived as having lowest incidences of disease challenges while Summer had the highest incidents followed by Spring (Table 5.2).

Table 5.2: Frequency of seasonal observation of disease symptoms and parasites (Number expressed as a percentage (%) of the total sample.)

SEASONS	Summer		Autumn		Winter		Spring	
	Gcina	Ngcingci-nikhwe	Gcina	Ngcingci-nikhwe	Gcina	Ngcingci-nikhwe	Gcina	Ngcingci-nikhwe
Disease or symptom parasite:								
Bile	1.3	10.6	0.0	2.1	0.0	2.1	0.0	0.0
Mites	28.8	38.3	0.0	0.0	0.0	2.1	2.5	0.0
Fleas	1.3	21.3	0.0	0.0	0.0	2.1	0.0	2.1
Ticks	5.0	21.3	1.3	0.0	0.0	0.0	1.3	2.1
Respiratory Symptoms	13.8	8.5	2.5	0.0	0.0	0.0	1.3	0.0
Sores	11.3	6.4	1.3	4.3	0.0	6.4	1.3	2.1
Swollen eyes	10.5	0.0	0.0	0.0	0.0	0.0	1.3	0.0
Nervous symptoms	8.8	0.0	0.0	0.0	0.0	8.5	0.0	0.0
White feaces	2.5	6.4	0.0	0.0	0.0	6.4	2.5	0.0
Watery feaces	2.5	0.0	0.0	0.0	0.0	0.0	3.8	2.1
Worms	0.0	0.0	1.3	0.0	0.0	0.0	13.8	12.8
Unsure/Unseen	40.0	34.0	95.0	95.7	100.0	78.7	81.3	83.0

The majority of respondent (90.5% and 83.5% in Gcina and Ngcingcinikhwe, respectively) did not have chicken health management program (Table 5.3). The majority of respondents in both communities did not know the benefits of vaccinating chickens, whereas 26.7% of respondents in Gcina were aware that vaccination is done to prevent diseases compared to 5.4% of Ngcingcinikhwe . In the majority of cases, farmers applied disease and parasite control measures when they saw symptoms. The majority of respondents, in both communities, did not buy remedies for their chickens, but relied mainly on ethnoveterinary medicines and practices. However, despite the wide use of alternative remedies, the majority of respondents acknowledged that the health management practices they applied were not effective. Effectiveness of the interventions used, in both communities, was assessed by the mortality rate and physical appearance of the indigenous chickens (Table 5.3).

Table 5.3 Basis for the disease and parasite control frame work.

	Location	
	Gcina(%)	**Ngcingcinikhwe(%)**
Availability of disease and parasite control program:		
Present and used	6.4	13.5
Present but not used	3.2	2.7
Absent	90.5	83.8
Benefits of vaccinating chicken:		
Do not know	55.0	67.9
Cure diseases	15.0	23.2
Prevent illness	26.7	5.4
Improve production	3.3	3.6
Circumstances under which disease and parasite control measures are applied:		
When disease symptoms are visible	67.9	82.9
When the mortality increased	23.2	2.9
As a preventative measure	5.4	2.9
Do not know	0.0	11.4

Table 5.3 (Continued) Basis for the disease and parasite control frame work.

Are the disease and parasite control measures effective?:		
Yes	46.4	28.6
No	53.6	71.4
Basis of judging the effectiveness of disease and parasite control measures applied:		
Mortality rate	25.5	13.9
Production	11.8	2.8
Appearance	25.5	13.9
Do not know	37.3	58.3
Purchasing of chicken medicine?		
No	82.0	77.8
Yes	18.0	22.2

The respondents in both locations mentioned a number of unconventional means of controlling various diseases and parasites. The *Aloe spp* was reported to be used in the control of most disease symptoms (Table 5.4). In both research sites there was a significant ($P<0.001$) association between familiarity with health challenges and circumstances under which health management measures are applied. Most respondents mentioned that they were not familiar with health challenges of indigenous chickens and applies health management measures only when they see disease symptoms. A significantly ($P<0.0001$) high number of respondents in Gcina believed that the health management measures that they employ are effective and the vaccination of birds prevented diseases; and a significantly high number of respondents who believed that their health management measures are effective used the physical appearance of the birds after treatment as the basis for their judgment. There was a significant ($P<0.001$) association between the effectiveness of health management measures uses and the frequency of observation of symptoms, with respondents who asserted that their health management measures were working also stating that they rarely see disease symptoms in their birds. The respondents in Gcina who believed that parasites caused mortality in indigenous chickens mentioned that they were not aware of a health management program ($P <0.001$).

Table 5.4 Means of controlling various disease symptoms and parasites.

Mites:	**Facial sores:**	**White feaces:**	**Respiratory symptoms:**	**Swollen eyes:**
Ash	Aloe (saponins, salicylic acids)	Aloe	Aloe	Aloe
Blue death (carbaryl/permethrin)	Engine oil	Snuff	Potassium permanganate (Ukrakrayo)	Potassium permanganate
Bulalazonke (Mercaptothion)	Pig fat	Terremycine (*oxytetracycline)*	Care	Engine oil
Dip	Madubula	Potassium permanganate (Ukrakrayo)	Snuff	Vaseline (carbolated petroleum jelly)
Doom (cyphenothrin/d-tetramethrin/propoxur)	Paraffin			Rub with mguzane
Engine oil **(**Zinc Dialkyldithiophosphate)	Potassium permanganate (Potassium and Manganese)			Terremycine
Fast kill (d'phenothrin/imiprothrin/prallethrin)				Madubula

Table 5.4 (Continued) Means of controlling various disease symptoms and parasites.

Madubula (Tar Acid)	Salty water
Paraffin (anhydrous lanolin)	Disiel (alcohol)
Pig fat	
Remove	
Snuff (Nicotine)	

The majority of respondents in both communities (92.2% in Gcina and 86.5% in Ngcingcinikhwe) admitted that they did not know the symptoms of diseases that affect indigenous chickens and this was attributed mainly to the lack of extension efforts by the government officials (Table 5.5)

Table 5.5 Knowledge of chicken diseases and their respective symptoms

	Location	
	Gcina	**Ngcingcinikhwe**
Knowledge of diseases and their symptoms:		
No	92.2%	86.5%
Yes	7.8%	13.5%
Reasons for lack of disease knowledge:		
Lack of extension efforts by government officials	73.7%	75.7%
Lack of extension efforts by government officials and low education level	3.5%	0.0%
Lack of extension efforts by government officials and lack of interest	0.0%	3.0%
Never heard of chicken diseases	22.8%	15.2%

5.4 Discussion

The fact that the majority of the respondents in the two locations rarely saw disease symptoms while there was high mortality points either to sudden death or lack of ability to differentiate between sick and healthy birds. Sudden death of the birds, respiratory and nervous symptoms, as mentioned by the majority of respondents as common disease symptoms, are characteristic symptoms of Newcastle disease (Wallner-Pendleton, *et al.* 1991). However, this assertion has to be expressed with caution as some diseases tend to have similar symptoms.

Disease symptoms observed by the respondents in this study were similar to those that were reported by the respondents in a study by Kusina *et al.* (2001) who mentioned disease symptoms like green diarrhea, swelling of the neck and head, sudden death and nervous signs. Furthermore, respondents in a study by Alfred *et al.*, (2012) mentioned diarrhea, dark red faeces, black nodules on the head region, swelling of the eyes and nasal discharges as frequently observed disease symptoms in indigenous chickens. These symptoms are also similar to the observations in the current study. Therefore, based on a number of research publications, Newcastle disease is unequivocally described as the most critical disease in the production of indigenous chickens as it accounts for most mortalities (Zeleke, *et al.* 2005; Msoffe, *et al.* 2010; Alfred, *et al.* 2012).

Worm infestation was the least mentioned health challenge in indigenous chickens, however, this is contrary to the widely reported abundant infestation of rural chicken with worms (Siamba, *et al.* 2007; Abdelqader, *et al.* 2008; Mwale, *et al.* 2011; Ogbaje, *et al.* 2012). Worms have a negative effect on indigenous chicken production through reduced weight gain and increased mortality rate (Permin, *et al.* 2006). The reason for the least mentioning of the worms as a health

challenge compared to others could be the fact that worm infestations do not always lead to clinical signs, they only do so in extreme cases.

The high prevalence of worm infestation in Spring observed by the respondents in this study agrees with the report of a study by Ogbage, *et al.* (2012) where it was reported that the worms, particularly *Ascaridia Spp.,* were more prevalent in moist environmental conditions. It was stated that these conditions supported worm larval development and, consequently, worm proliferation. In agreement to these findings, Mungube, *et al.* (2008) reported higher prevalence of endo-parasites during the wet season while ecto-parasites were more prevalent during the dry season. However, Rahman, *et al.* (2013) did not find a seasonal variation in worm infestation and burden but found significant differences between different agro-ecological zones of Bhangladesh. In addition, certain species of ecto-parasites tend to be more prevalent in Summer while some tend to be more prevalent in autumn but, all in all, there is a generally low ecto-parasite prevalence in Winter (Salam, Mir and Khan 2009).

The absence of a health management in rural chicken production as observed in this study has been reported by a number of researchers as being characteristic of rural chicken production (Gueye 2002; Gondwe *et al.,* 2007; Siamba *et al.,* 2007; Henning *et al.,* 2008; Mbyuzi *et al.,* 2012; Okeno *et al.,* 2012). The lack of knowledge about the benefits of vaccinating the birds and financial constraints on the side of the indigenous chicken keepers could be the cause of the absence of a health management program that is aimed at controlling prevalent diseases and parasites (Moyo 2009). The financial constraints has resulted in a majority of households keeping indigenous poultry not purchasing medicine and resorting to using ethno-veterinary means to control diseases and parasites. However, a majority of respondents in this study dispute the effectiveness of the ethno-veterinary disease control methods. In recent years a number of

researchers scientifically validated the effectiveness of various ethno-veterinary medicines aimed at controlling diseases that affect indigenous chicken. It is believed that these medicines can go a long way in resolving the disease challenges of indigenous chicken because of their availability and affordability (Gueye 2002). Siamba *et al.,* (2007) concluded that *Tephrosia vogelli* and *Vernonia amygdalina* were effective against *Ascaridia galli* in indigenous chicken while Mwale and Masika (2009) reported that 83% of households used medicinal plants to control both internal and external parasites in indigenous chicken. Moyo (2009) reported that some of the ethno-veterinary medicines used to control fleas in indigenous chickens vary in efficacy and some are as effective as the commercial counterparts.

An overwhelming majority of respondents acknowledged their lack of knowledge about circumstances surrounding the health of the rural chicken, and they attribute the situation mainly to the lack of extension services. The extensive nature of the management of indigenous chickens, in particular absence of housing, can be another contributing factor in the lack of knowledge about the disease status of the chicken by the keepers. The current situation regarding rural chicken can be ameliorated by provision of training, extension, mentoring, record keeping and progress evaluation (Msoffe *et al.,* 2010, Muchadeyi *et al.,* 2005; Riise 2005). Indigenous chicken keepers would have been more vigilant in minimizing health challenges had they been conscious of causes of the challenges and the potential socio-economic benefits of healthy chickens.

5.5 Conlusion

The findings of this study confirm the fact that the health challenges in indigenous chicken are endemic. However, because of household financial constraints, it will be impractical to suggest

the tried and tested means of controlling the disease like the ones used in commercial setups. The health challenges in rural chicken are multi-dimensional and, therefore, an integrated and affordable approach is required to minimize these challenges. Therefore, it is necessary that a seasonal screening of indigenous chickens for diseases and parasites over a period of a year to establish the seasonal variation in the occurrence of the health challenges be conducted. This should be followed by the development of an affordable health management strategy that is based on the screening results and the outcomes of evaluation of alternative health management strategies.

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Chapter 6: Newcastle Disease Prevalence and Response of Indigenous Chickens to Vaccination in Two Rural Communities of Mnquma Local Municipality, South Africa

Abstract

Indigenous chickens produce below their potential, because of a number of constraints, the major one being health challenges. Newcastle disease (NCD) result in low production because of high mortality and, consequently, small flock sizes. The objective of this study was to establish the effect of season and location on the prevalence of NCD, and the effect of de-worming on the NCD antibody levels after vaccination. Two locations, one coastal - Gcina and the other inland - Ngcingcinikhwe, were selected and the prevalence of NCD was monitored seasonally. The birds were later de-wormed and vaccinated against NCD. The chickens had the lowest protection against NCD during Spring in both locations (60% in Gcina and 50% in Ngcingcinikhwe) relative to other seasons. The antibody levels increased significantly ($p<0.05$) as weeks progressed after vaccination and in Gcina the birds that were de-wormed and vaccinated had significantly ($p<0.05$) higher antibody levels relative to other treatments. In conclusion, the prevalence of NCD was not affected by proximity to the coast and chickens were at a higher risk of NCD out-breaks in spring due to low antibody levels. Vaccination against NCD should be conducted simultaneously with de-worming to enhance the effect of the vaccine.

Keywords: indigenous chickens, antibodies, worms, mortality, Newcastle disease, prevalence

6.1 Introduction

Indigenous chickens play a vital role in the socio-economic dynamics of rural communities in developing countries around the world (Okeno, *et al*, 2012). Households keep chickens for traditional ceremonies, own consumption and to generate revenue through sales of eggs and live chickens (Kusina, *et al*, 2001). However, recent studies have revealed that the potential value of keeping indigenous chickens is not fully realized as households are selling and consuming far less chickens and eggs than they possibly can (Wambura, 2011). The observed status has been attributed to a number of constraints but the most commonly mentioned are health challenges (Wambura, 2011).

Research conducted in three provinces of South Africa revealed that 95% of households consider mortality to be the main cause of poor production in indigenous chickens, while 46.2% of households in a study conducted in Ethiopia stated that diseases were the main cause of mortality (Harrison, *et al*, 2010, Msoffe, *et al.*, 2010). Mtileni, *et al*. (2013) reported in a study conducted in South Africa that 65% of households stated that disease, particularly Newcastle disease (NCD), was the main cause of mortality. NCD accounts for the largest proportion (up to 100%) of mortality, however, those that survive the disease develop immunity against the disease (Horning, *et al.*, 2003; Msoffe, *et al.*, 2010; Fentie, *et al.*, 2013, Msoffe, *et al.*,2014,). The NCD virus is a paramyxovirus that leads to pneumoencephalitis which has symptoms like respiratory problems, neurological challenges, enteritis, hemorrhagic lesions and extremely high mortality (Aziz, *et al.*, 2010). The absence of NCD control program and contact with wild birds predispose indigenous chickens to NCD virus (Aziz, *et al.*, 2010).

The development of an effective NCD control program requires a detailed understanding of dynamics of this disease. There has been contrasting reports from research publications regarding the effect of the seasons and geographic location on the NCD prevalence in indigenous chickens. Zeleke, *et al.* (2005) reported a non-significant difference in NCD antibody titers between dry and wet areas of Ethiopia whereas Aziz, *et al.*(2010) discovered that the incubation period of NCD virus was shortest and mortality rate highest under warmer temperatures (above 25^0Celcius). Aziz, *et al.*(2010) also asserted that different geographical and climatic situations might have little to do with the epidemiology of NCD in indigenous chickens. However, Bhadaso (2012) and Fentie, *et al.,* (2013) reported that mortality of indigenous chickens due to NCD was highest during the hot and rainy period of the year, whereas Minga, *et al.,* (2001), Gondwe, *et al.,* (2007), Otim, *et al.* (2007) and Kemboi, *et al* (2013), asserted that the chickens are more vulnerable to NCD during the dry season and this was attributed to feed shortages. Njagi, *et al.* (2010) discovered that NCD virus was significantly higher in the dry-hot zone compared to cool wet zone and NCD outbreak incidents increased during seasonal transition period from dry to wet season.

Newcastle disease challenge in indigenous chickens has been reported to be exacerbated by the high prevalence of parasites (Horning, *et al.*,2003; Nnadi, *et al.*,2010). A study by Horning, *et al.* (2003) and Illango, *et al.* (2008) revealed that de-wormed indigenous chickens exhibited persistently higher antibody response to NCD vaccination relative to the unvaccinated ones. The loss of proteins due to helminthes infection was thought to be the cause of poor response by unvaccinated birds (Illango, *et al.* 2008). Helminths are controlled by use of tested commercial medicines, however, resource-poor rural inhabitants utilize various unconventional means of controlling helminthes and these include aloe (Moyo, 2009). The effect of aloe on the NCD

antibody response of birds to NCD vaccination has never been reported. This aspect of NCD vaccination needs to be investigated as part of development of an effective, comprehensive and affordable NCD control strategy.

Contradicting reports on the dynamics of health challenges in indigenous chicken pose a challenge in the efforts to develop a comprehensive and effective health management strategy. These different reports imply that a universal strategy will not only be ineffective but it will be uneconomical as it might not be relevant to the local indigenous chicken health situation. The objective of this study was to investigate the effect of season and geographic location on the prevalence of NCD and the effect of aloe and de-wormer administration on the antibody response of NCD vaccinated birds in two rural communities of the Eastern Cape Province of South Africa.

6.2 Materials and Methods

6.2.1 Study site

Refer to Section 3.2.1

6.2.2 Social facilitation

Refer to Section 3.2.2

6.2.2.1 NCD Prevalence Survey

Ten households were randomly selected from each location and blood samples were collected from one chicken per household during each season between March 2013 and February 2014. The selected chicken was marked and blood samples were collected from the same chicken during all the seasons. In both locations the chickens did not have a history of vaccination.

Enzyme Linked Immunosorbent Assay ELISA test was conducted on the blood samples to determine the presence of NCD antibodies.

6.2.2.2 NCD ELISA test

ELISA test was used to measure the level of NCD antibodies in the blood samples. The blood samples were prepared and analyzed according to the procedure stipulated by the test kit supplier (IDEXX Laboratories, Inc.). In short, the process is as follows:

The ELISA is a rapid test used for detecting and quantifying antibodies or antigens against viruses, bacteria and other materials. This method can be used to detect many infectious agents affecting poultry and livestock. In ELISA technology, the solid phase consists of a 96-well polystyrene plate, although other materials can be used. The function of the solid phase is to immobilize either antigens or antibodies in the sample, as they bind to the solid phase. After incubation, the plates are washed to remove any unbound material. In some assays the conjugate is then added to the plate and allowed to incubate. The conjugate consists of either an antigen or antibody that has been labeled with an enzyme. Depending upon the assay format, the immunologically reactive portion of the conjugate binds with either the solid phase or the sample. The enzyme portion of the conjugate enables detection. The plates are washed again and an enzyme substrate (hydrogen peroxide and a chromogen) is added and allowed to incubate. Color develops in the presence of bound enzyme and the optical density is read with an ELISA plate reader.

6.2.2.3 NCD vaccination and de-worming

As the purpose of the study was to investigate the efficacy of vaccinating chickens against NCD, the effect of deworming on vaccine efficacy was also investigated. NCD *La Sota* was used as

NCD vaccine while Piperazine and Aloe were used as anhelminths. In addition, combinations of aloe and NCD vaccine, and piperazine and NCD vaccine were also tested to for interactions. Therefore, six treatments replicated three times (a replicate was represented by a household) in each location were prepared and the trial was conducted between August and November 2014. The treatments were as follows:

1. Treatment 1 – Control
2. Treatment 2 – NCD Vaccination
3. Treatment 3 – Piperazine
4. Treatment 4 – Aloe
5. Treatment 5 – NCD Vaccination and Piperazine
6. Treatment 6 – NCD Vaccination and Aloe

A household represented a replicate and three birds were marked in each household. NCD La Sota vaccine, Aloe and Piperazine were administered through drinking water. The medicine was supplied through drinking founts in the morning and the birds were allowed a period of two weeks to adapt to drinking from the founts. The Aloe was mixed at a rate of 20mL/liter of water and Piperazine was offered at 90mg/kg of body weight.

6.2.2.4 NCD Haemagglutination Inhibition (HI) test

Three milliliters of blood samples were collected from the marked birds before vaccination, one week, two, four and eight weeks after vaccination. The blood was allowed to clot and HI test was conducted on the serum according to the procedure outlined by Allan and Gough (1974). Antibodies against NCD were measured on the blood samples from the same birds in all

treatments. Serum samples were 2-fold diluted (1:2–1:2,048), and the titer was expressed as Log_2 of the reciprocal of the highest serum dilution showing inhibition of hemagglutination.

6.2.3 Data analysis

The number of birds that were positive for NCD after ELISA test were expressed as a percentage of the total number of tested birds. The Statistical Analysis System of SAS version 8 (SAS, 1999) was used to perform data analysis and the PROC FREQ procedure was used to calculate the frequencies. The following SAS program was used to compare NCD antibody levels based on treatments and weeks after vaccination:

6.3 Results

6.3.1 NCD prevalence

The samples from Gcina were all positive for NCD in winter and autumn and a significantly (P<0.01) low number of positive samples were observed in spring in both locations (Table 6.1 and Figure 6.1). The proportion of positive samples in Ngcingcinikhwe was non-significantly lower than those observed in Gcina for all seasons (Figure 6.1).

Table 6.1: The percentage of blood samples that were positive for NCD after ELISA test

	N	Winter (%)	Spring (%)	Summer (%)	Autumn (%)
Location:					
Gcina	10	100	60	90	100
Ngcingcinikhwe	10	80	50	70	90
Combined	20	90	55	80	95

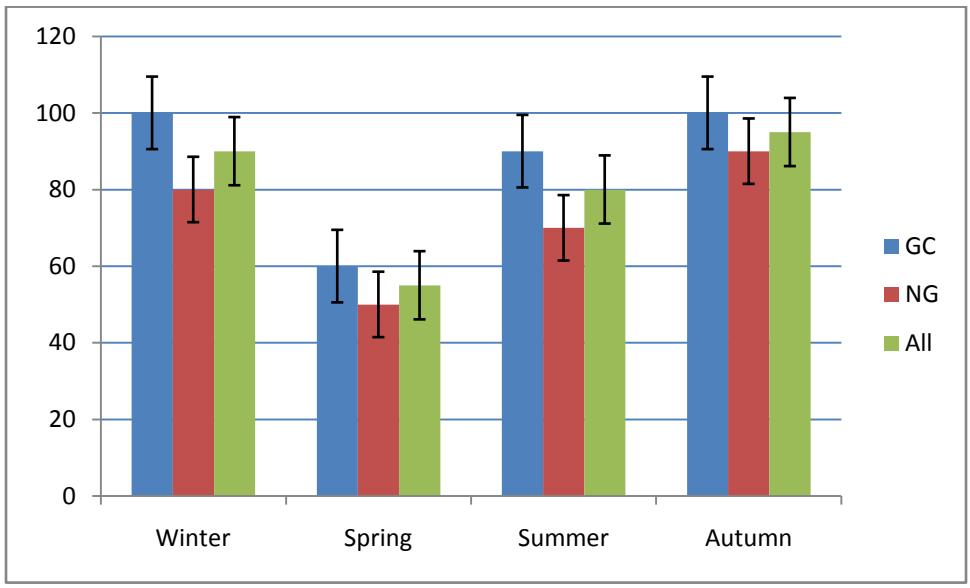

Figure 6.1: The seasonal prevalence (%) of NCD in Gcina and Ngcingcinikhwe

6.3.2 NCD antibody response to Vaccination

There was a significant ($P< 0.05$) difference in average NCD antibody levels as affected by treatment and weeks after vaccination in both location (Figure 6.2 and 6.3).

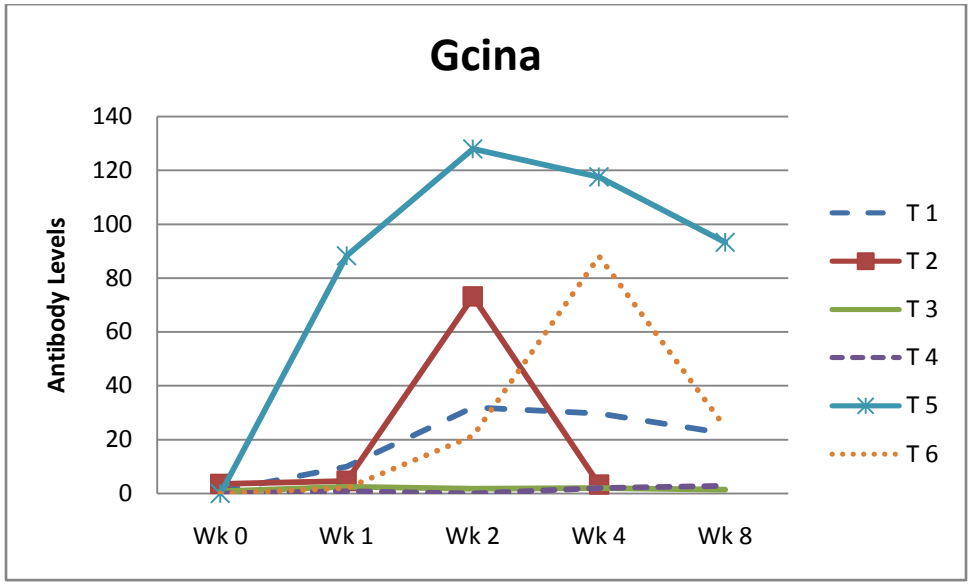

Figure 6.2: Average NCD antibody levels of chickens in Gcina

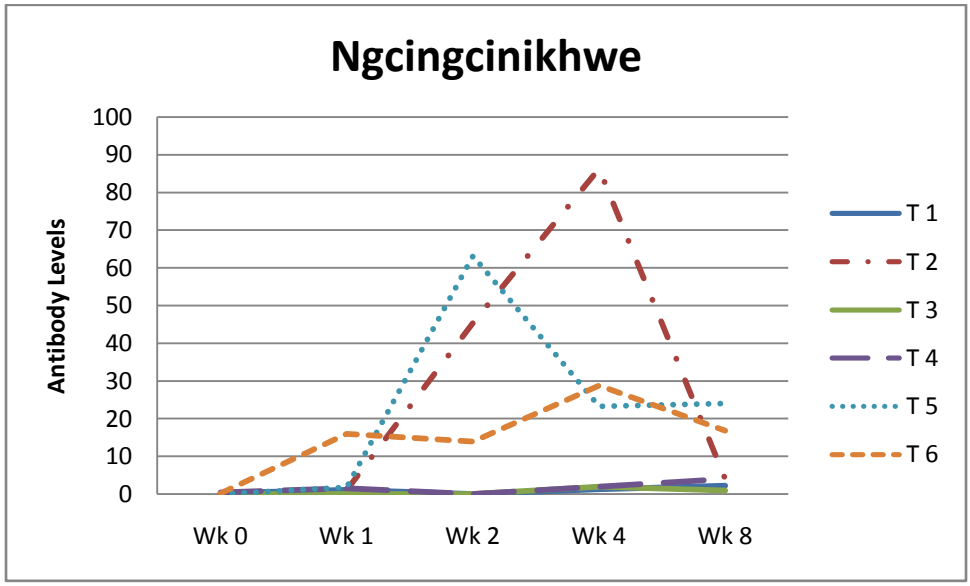

Figure 6.3: Average NCD antibody levels of chickens in Ngcingcinikhwe

Table 6.2: Treatments and weeks after vaccination that exhibited significant differences in average antibody levels in Gcina.

Treatment Comparison	Difference between Means	Week Comparison	Difference between Means
5-2	51.49	2-0	38.91
5-6	55.05	4-0	37.44
5-1	55.90		
5-3	73.08		
5-4	74.55		

In Gcina there was a significant ($p<0.05$) difference in antibody levels between treatments in week 8 and there was a non-significant difference in all other weeks. The difference (90.44) in antibody levels was between treatments 5 and 4 (Table 6.2). However, in Ngcingcinikhwe a significant difference ($P<0.05$) between means was observed in week 1 and in this week birds on treatment 6 exhibited superior antibody levels relative to all other treatments (Table 6.4).

Table 6.3: Treatments and weeks after vaccination that exhibited significant differences in average antibody levels in Ngcingcinikhwe.

Treatment Comparison	Difference between Means	Week Comparison	Difference between Means
2-4	29.10	4-0	24.19
2-1	29.33	2-0	23.61

Table 6.4: The frequencies of NCD antibody levels up to 8 weeks after vaccination in Ngcingcinikhwe.

	Week 0			Week 1				Week 2						
	Neg	**1:2**	**1:4**	**Neg**	**1:2**	**1:4**	**1:8**	**Neg**	**1:8**	**1:16**	**1:32**	**1:64**	**1:128**	**1:256**
T1	88.9	11.1	0	44.4	55.6	0	0	100	0	0	0	0	0	0
T2	100	0	0	50	50	0	0	71.4	0	0	0	14.3	0	14.3
T3	100	0	0	100	0	0	0	100	0	0	0	0	0	0
T4	88.9	0	11.1	33.3	55.6	11.1	0	100	0	0	0	0	0	0
T5	100	0	0	44.4	44.4	0	11.1	33.3	11.1	11.1	11.1	0	22.2	11.1
T6	88.9	11.1	0	50	0	0	50	62.5	0	12.5	12.5	12.5	0	0

1. Treatment 1 – Control; 2. Treatment 2 – NCD Vaccination; 3. Treatment 3 – Piperazine; 4. Treatment 4 – Aloe

5. Treatment 5 – NCD Vaccination and Piperazine; 6. Treatment 6 – NCD Vaccination and Aloe

Table 6.4 (Continued): The frequencies of NCD antibody levels up to 8 weeks after vaccination in Ngcingcinikhwe.

	Week 4								Week 8				
	Neg	**1:2**	**1:4**	**1:8**	**1:32**	**1:64**	**1:132**	**1:256**	**Neg**	**1:2**	**1:4**	**1:8**	**1:64**
T1	50	37.5	12.5	0	0	0	0	0	22.2	44.4	33.3	0	0
T2	33.3	16.7	16.7	0	0	0	0	33.3	50	0	0	50	0
T3	0	100	0	0	0	0	0	0	66.7	33.3	0	0	0
T4	25	50	25	0	0	0	0	0	0	100	0	0	0
T5	12.5	12.5	12.5	25	25	0	12.5	0	0	0	66.7	0	33.3
T6	0	0	0	40	40	20	0	0	20	0	20	40	20

1. Treatment 1 – Control; 2. Treatment 2 – NCD Vaccination; 3. Treatment 3 – Piperazine; 4. Treatment 4 – Aloe

5. Treatment 5 – NCD Vaccination and Piperazine; 6. Treatment 6 – NCD Vaccination and Aloe

Table 6.5: The frequencies of NCD antibody levels up to 8 weeks after vaccination in Gcina.

	Week 0			Week 1							Week 2			
	Neg.	**1:8**	**1:32**	**Neg.**	**1:2**	**1:4**	**1:8**	**1:16**	**1:64**	**1:256**	**Neg.**	**1:16**	**1:128**	**1:256**
T1	88.9	11.1	0	42.9	42.9	0	0	0	14.3	0	87.5	0	0	12.5
T2	88.9	0	11.1	33.3	33.3	0	16.7	16.7	0	0	71.4	0	0	28.6
T3	88.9	11.1	0	12.5	75	0	12.5	0	0	0	88.9	11.1	0	0
T4	100	0	0	60	40	0	0	0	0	0	100	0	0	0
T5	100	0	0	33.3	16.7	0	0	16.7	0	33.3	40	0	0	40
T6	100	0	0	25	50	25	0	0	0	0	83.3	0	16.7	0

1. Treatment 1 – Control; 2. Treatment 2 – NCD Vaccination; 3. Treatment 3 – Piperazine; 4. Treatment 4 – Aloe

5. Treatment 5 – NCD Vaccination and Piperazine; 6. Treatment 6 – NCD Vaccination and Aloe

	Week 4						Week 8							
	Neg.	**1:2**	**1:4**	**1:8**	**1:64**	**1:256**	**Neg.**	**1:2**	**1:4**	**1:8**	**1:32**	**1:64**	**1:128**	**1:256**
T1	33.3	44.4	11.1	11.1	0	0	50	16.7	16.7	0	0	0	16.7	0
T2	0	33.3	66.7	0	0	0	0	0	0	0	0	0	0	0
T3	16.7	66.7	16.7	0	0	0	42.9	42.9	14.3	0	0	0	0	0
T4	25	50	25	0	0	0	11.1	33.3	55.6	0	0	0	0	0
T5	0	0	20	20	20	40	0	0	33.3	16.7	16.7	0	0	33.3
T6	0	0	66.7	0	0	33.3	14.3	0	42.9	0	14.3	28.6	0	0

1. Treatment 1 – Control; 2. Treatment 2 – NCD Vaccination; 3. Treatment 3 – Piperazine; 4. Treatment 4 – Aloe

5. Treatment 5 – NCD Vaccination and Piperazine; 6. Treatment 6 – NCD Vaccination and Aloe

6.4 Discussion

6.4.1 NCD Prevalence

The proportion of positive samples or samples with protective levels of NCD antibodies observed in this study were higher than those observed by Aziz, *et al.* (2010). The observation of protective levels of titres in unvaccinated birds is an indication that the birds were exposed to the virus but not necessarily that they are suffering from NCD. In addition, it was observed that the least protection against NCD was in spring in both locations and this observation is in agreement with the report of Kemboi, *et al.* (2013), Njagi, *et al.* (2010) and Kemboi, *et al,* (2014) where it was reported that NCD resulted in mortality of between 60-99% during transition between seasons (Winter to Summer) due to low NCD antibody titres during this period. Kemboi, *et al,* 2013 observed higher NCD titres during wet season compared to the dry season. Mbyuzi, *et al.* 2012 and Kemboi, *et al,* (2013) attributed this observation to low Vitamin A content in the scavenged feed due to lack of green material during winter and beginning of wet season, therefore, resulting in poor protection against NCD. The prevalence of NCD in this study exhibited a geographic and seasonal prevalence as it was highly prevalent in Gcina and least prevalent in spring. In contrast, Zeleke, *et al.* (2005) reported a higher NCD prevalence in drier areas of the Rift Valley compared to the wet Southern Districts of Ethiopia. Otim, *et al.* (2007) reported that it took a shorter period (80 days) for NCD outbreak to occur during dry season compared to 100 days it took during the wet season. However, Aziz, *et al.* (2010) asserted that the different geographical and climatic situations may have little to do with epidemiology of NCD in domestic village chickens.

6.4.2 NCD Vaccination

Vaccination against NCD resulted in highly variable responses in terms of antibody levels and, therefore, led to mostly non-significant differences between vaccinated and unvaccinated groups. This can be attributed to the drinking water vaccination method that was used. With this method water with vaccine was put at the normal drinking points in the morning following complete water withdrawal with the assumption that chickens did drink. However, there is no certainty if the birds drank the vaccine and/or drank within the recommended 30 minutes after mixing since the birds were not confined. Illango, *et al.* (2008) and Bagnol, *et al.* (2013) reported consistently higher NCD antibody levels in chickens that were vaccinated via eye-drop method compared to drinking water method and this was attributed to the fact that the vaccine was delivered directly to the harderian gland of the eye.

In Gcina vaccination and de-worming resulted in significantly higher NCD antibodies relative to other treatments and the antibodies were significantly higher in weeks 2 and 4 after vaccination compared to antibody levels before vaccination. This finding confirms the assertions of Horning, *et al.* (2003), Illango, *et al.* (2008), and Nnadi and George (2010) who reported that worm infestation has a negative effect on the NCD antibody response to vaccination. Horning, *et al.* (2003) attributed the observation to low synthesis of immunoglobulins in worm-infested birds due to loss of proteins which might result in a reduced humoral antibody response. In contrast the vaccinated only group in Ngcingcinikhwe exhibited non-significantly higher antibody response relative to unvaccinated groups even though the vaccine elicited a similar significantly higher levels of antibodies in weeks 2 and 4 compared to antibodies before vaccination as in Gcina. The interaction between parasites and NCD antibody protection was reported by Horning, *et al.* (2003) in a study that was conducted in Zimbabwe. High parasite infestation compromised the sero-conversion and persistency of high NCD antibodies in vaccinated indigenous chickens,

and this was attributed to low immunoglobulin levels due to proteins lost during parasitism (Horning, *et al.*, 2003).

Horning, *et al.* (2003) reported similar observations on NCD antibody development after vaccination. It was reported that the antibodies reached their peak at 3 weeks after vaccination and declined gradually after 4 weeks, however, the antibody levels remained higher in de-wormed chickens. In this study, the vaccination trial was initiated in the beginning of Spring (August) and completed at the beginning of Summer (November) and this is the period that the chickens were observed to have lowest NCD levels of antibodies in the first trial. All the birds exhibited low or no NCD antibodies before vaccination and the antibody levels increased in all treatments as the Summer season was approaching. The improvement in the antibodies of vaccinated birds was expectedly more pronounced in vaccinated birds compared to unvaccinated birds though it was highly variable. The increase in the antibody levels of unvaccinated chickens as summer approaches was reported by Kemboi, *et al.* (2013) and Mbyuzi, *et al.* 2012. This was attributed to the improvement in the availability of highly nutritious scavenged feed. These results affirm the assertion that Spring is the most critical time of the year in the efforts to mitigate NCD effect as the birds are most vulnerable due to low NCD antibodies.

6.5 Conclusion

In conclusion, Winter and Spring are the most critical seasons of the year in relation to the NCD prevalence due to low availability of scavenged feed, therefore, resulting in low NCD antibody levels. The vaccination efforts should, therefore, be planned around this period and should be administered simultaneously with de-worming to enhance the effect of vaccination by resulting in sustained high antibody levels. In subsequent studies, the vaccination should be applied via the

eye drop method and de-worming conducted by drenching to minimize variation in responses to treatments.

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Chapter 7: Ecto-parasite Prevalence in Indigenous Chickens of Two Rural Communities in Mnquma Local Municipality, South Africa

Abstract

Health challenges are a major constraint in the production of indigenous chickens in the rural areas. Ecto-parasites (EP) result in low production, high mortality and, consequently, small flock sizes. Prevalence of ecto-parasites is known to vary with geographical location and seasons of the year. The objective of this study was to establish the effects of season and location on the prevalence of ecto-parasites in chickens. Two locations, one coastal – Gcina (GC) and the other inland – Ngcingcinikhwe (NG), were selected and EP were monitored seasonally (autumn, winter, spring and summer) by whole body examination of three chickens per household. Lice species (*Goniodes dissimilis*, *Goniodes gigas* and *Menopon gallinae*) were more prevalent in the coastal location. The highest prevalence was that of *M. galinae* (90%) in autumn in GC. The fleas (*Echidnophaga gallenacea*) were more prevalent (100%) in the inland location (NG) during spring. Two tick species (*Amblyoma hebraeum* and *Argus spp*) were observed. *A. hebraeum* was most prevalent in the coastal location in spring and autumn at 70%, whereas the *Argus spp* was most prevalent inland in winter (40%). In conclusion, lice and ticks were more prevalent in the coastal area while fleas were more prevalent in the inland area during spring.

Keywords: indigenous chickens; ecto-parasites; lice; fleas; ticks; prevalence

7.1 Introduction

Households in rural areas of South Africa keep indigenous chickens for traditional ceremonies, own consumption and also to generate revenue by selling eggs and live chickens (Mtileni *et al* 2013). However, recent studies have revealed that the contribution of indigenous chickens towards the livelihoods of rural households is low as very few chickens are sold or consumed (Sonaiya 2000; Sartika and Neer 2005; Sorensen 2006). The observed status has been attributed to a number of constraints but the most commonly mentioned are health challenges including parasites.

Parasites normally cause subclinical damage to indigenous chicken, however, heavy infestation can result in increased mortality. External parasites like fleas, lice and ticks are common in indigenous chicken and they lead to transmission of pathogens, anemia, skin irritation and reduced production (Njunga, 2003, Mungube, *et al.,* 2008, Salam, *et al.,* 2009). Varying prevalence rates (50-100%) of external parasites in indigenous chickens have been reported in studies conducted around the world (Njunga, 2003, Mungube, *et al.,* 2008, Salam, *et al.,* 2009, Nnadi, *et al.,* 2010, Rahman, *et al.,* 2013, Chege, *et al.,* 2014,). However, contradicting findings on the prevalence dynamics of ecto-parasites have been reported by various researchers. Mungube, *et al.*(2008) reported that ecto-parasites are more prevalent during the dry season of the year, whereas Salam, *et al.* (2009) stated that the optimum environment for ecto-parasites to thrive exists during summer months. The length of the life cycle of ecto-parasites is affected by the prevailing temperature and humidity levels, therefore, their prevalence are bound to be influenced by season and geographic location (Njunga, 2003).

In South Africa the geographical and seasonal effects on the prevalence of ecto-parasites in indigenous chicken has never been reported, and this makes it difficult to develop an effective ecto-parasite management strategy. The objective of this study was to establish the seasonal and geographic prevalence of external parasite in two rural communities of the Eastern Cape Province of South Africa.

7.2 Materials and Methods

7.2.1 Study site

Refer to Section 3.2.1

7.2.2 Social facilitation

Refer to Section 3.2.2

7.2.3 Sampling design and techniques

Ten households were randomly selected from the two locations and three chickens were selected per households for external parasite examination. In total 30 chickens were examined by whole body search for external parasites in each location per season.

7.2.3.1 Restraining of the chickens and parasite specimen collection

Each of the three birds that were selected for external parasite inspections was held firmly to limit its movement. The inspection was started on one side of the head and continued thoroughly throughout the entire body of the chicken. The feathers were lifted gently in each area of the body and all the parasites seen were collected into glass bottles containing 70% alcohol until they were identified.

The parasite specimens were separated according to type, i.e. the ticks were separated from fleas and lice. The ticks were identified using keys according to the procedure of Keirans, *et al* (1998). The lice and fleas were prepared for mounting and subsequent identification by placing the specimens in 10% KOH solution. The parasites were pierced with a fine needle at the dorsal or ventral intersegment membrane to allow thorough penetration of the caustic solution. The specimens were left in a KOH solution for 24 hours and then by gentle pressure with a pin head, the liquefied contents of the abdomen were removed. The specimens were rinsed well with distilled water mixed with a drop of glacial acetate to dilute the KOH and dehydrated for 30 minutes. They were then put through increasing strengths of alcohol (70, 80, 96 and 99%) to absolute (100%) for 30 minutes in each alcohol strength. The specimens were passed through clove oil and, thereafter, mounted on a slide in Canada balsam. The lice and fleas were identified based on the procedure of Kim, *et al* (1986) and Sergman (1995), respectively.

7.2.4 Data analysis

The Statistical Analysis System of SAS version 8 (SAS, 1999) was used to perform data analysis and the PROC FREQ procedure was used to calculate the frequency of the data values. Interactions and associations between various parameters that were measured were also analysed for.

7.3 Results

7.3.1 Lice

Three main species of lice (*G. dissimilis, G. gigas* and *M. galinae*) were found almost throughout the year at varying frequencies. The *G. dissimilis* was most prevalent in spring in GC while *G.*

gigas and *M. galinae* were most prevalent in summer and autumn, respectively (Table 7.1 and Figure 7.1). The prevalence of lice was generally lower in NG compared to GC (Table 7.1). Other species of lice (*Goniocotes gallinae, Goniocotes maculates, Menacanthus stramineus, Menacanthus pallidulus* and *Lipeurus caporis*) were discovered in the two study sites but their prevalence was very low. All lice species were collected mainly around the pelvic area of the chickens.

Table 7.1: Seasonal percent (%) frequency of chickens in which lice were encountered.

	G. dissimilis				***G. gigas***				***M. galinae***			
	W.	Spri.	Sum.	Aut.	W.	Spri.	Sum.	Aut.	W.	Spri.	Sum.	Aut.
GC	30	70	50	30	0	0	40	30	50	60	60	90
NG	0	0	10	0	30	0	20	10	20	30	50	40

Abbreviations: *G. dissimilis – Goniodes dissimilis; G. gigas – Goniodes gigas. M. galinae – Menopone gallinae.*

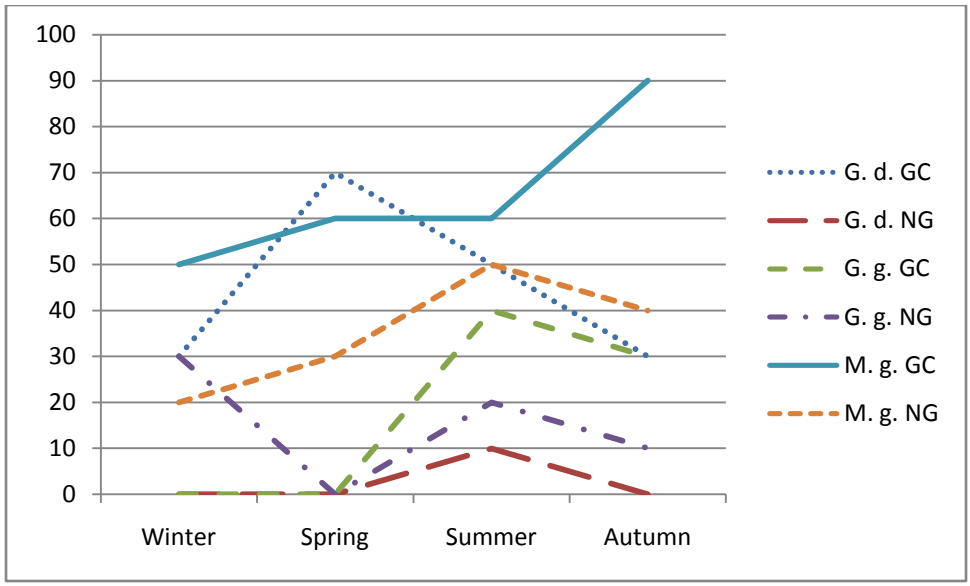

FIGURE 7.1 The Percentage (%) prevalence of lice in Gcina and Ngcingcinikhwe in Winter, Spring, Summer and Autumn.

Abbreviations: G. d. GC – *Goniodes dissimilis* (GCINA); G. d. NG – *Goniodes dissimilis* (NGCINGCINIKHWE); G. g. GC – *Goniodes gigas* (GCINA); G. g. NG – *Goniodes gigas* (NGCINGCINIKHWE); M. g. GC – *Menopone gallinae* (GCINA); M. g. NG – *Menopone gallinae* (NGCINGCINIKHWE).

The prevalence of the three species of lice exhibited an increase between winter and summer, however, there was a decline in their prevalence between summer and autumn, except for *Goniodes dissimilis* in GC (Figure 7.1). G. d GCs' prevalence showed an increase from 30% in winter to 70 and 50% in spring and summer, respectively; whereas G. g. GC's prevelance increased from 0% in winter and spring to 40 and 30% in summer and autumn, respectively (Table 7.1). In contrast, M. g. GC's prevalence increased from 50% in winter to 60% in spring and summer; and also increased further to 90% in autumn. In general, lice species prevalence

was lower in NG compared to GC, however, a similar trend of increased prevalence in summer was also observed in NG as in GC (Table 7.1).

7.3.2 Fleas

One species of fleas (*Echidnophaga gallinacea)* was found in all birds that hosted fleas, except for one bird that had *Ctenocephalides felis*. The fleas were mainly found in the head area, particularly around the comb and the eye lids. Ngcingcinikhwe had a significantly ($p<0.001$) higher prevalence of fleas relative to Gcina in all seasons and this was more pronounced in spring (Figure 7.1). Fleas were only encountered in summer and autumn in Gcina, whereas, they were found during all seasons in Ngcingcinikhwe (Figure 7.1).

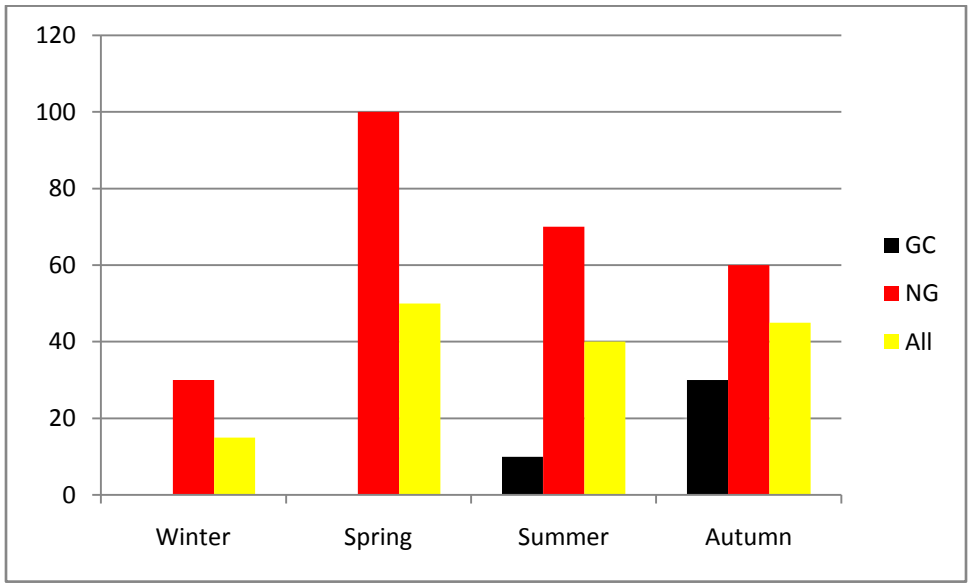

Figure 7.2: Seasonal percentage (%) of chickens in which fleas (*Echidnophaga gallinacea)* were encountered. (All refers to the combined GC and NG flea prevalence.)

7.3 Ticks

Two species of ticks (*A. hebraeum* and *Argas spp*) were found in both research sites, and both species were attached to the comb and wattles of the chickens. The prevalence of *A. hebraeum*

was significantly (P<0.05) higher in Gcina in winter, spring and autumn compared to Ngcingcinikhwe while *Argas spp* was more prevalent in Ngcingcinikhwe relative to Gcina during winter, spring and summer (Table 7.2).

Table 7.2: The seasonal percentage prevalence of *A. hebraeum* and *Argas spp.*

	A. hebraeum				*Argas spp*			
	Winter	Spr.	Summ.	Aut.	Winter	Spr.	Summ.	Aut.
GC	60	70	30	70	0	0	10	0
NG	10	10	20	30	40	30	20	0

Abbreviations: *A. hebraeum* - *Amblyoma hebraeum*; *Argas spp* - *Argas species*

7.4 Discussion

7.4.1 Lice

The highest prevalence rate (90%) of lice in this study was observed in autumn in GC and the observed rate was higher than 67% (in Bangladesh); 62.9% (in South-Eastern Nigeria) that were observed by Rahman, *et al.*(2013) and Nnadi, *et al.* (2010), respectively. Chege, *et al.* (2014) observed an extremely low (17.6%) prevalence of lice in indigenous chickens of Kenya, however, Salam, *et al.*, (2009) reported 100% prevalence of lice in a study conducted in Kashmir. The possible causes of the high variation in lice prevalence in these studies are varying climatic pattern, different agro-ecological traits and varying chicken husbandry practices of the study areas (Njunga, 2003, Nnadi, 2010; Arya, *et al* 2013). This assertion can be confirmed by the contrasting lice prevalence trends between inland NG and coastal GC study areas in this study. In contrast, Moyo (2009), in a study conducted in Amathole Basin in the Eastern Cape province of South Africa, reported that only 10.8% of respondents regarded lice infestation to be

a problem. This frequency of the responses by the respondents could be associated with the fact that lice infestations does not seem to cause mortality but high morbidity which results in poor growth rates, which are not easily noticeable to farmers (Moyo, 2009).

Njuga (2003), Khan, *et al.* (2003) and Salam, *et al.* (2009) encountered similar lice species as this study in researches conducted in Malawi, Pakistan and Kashmir, respectively. However, Mungube, *et al.* (2008) observed only *M. stramineus* in a study conducted in Kenya, while Moyo (2009) observed *M. galinae, M. stramineus* and *Knemidocoptes mutans*. These reports, therefore, confirm the difference in geographic prevalence of lice species. GC, a coastal village, generally had the higher prevalence of lice relative to NG, an inland village. This observation could be attributed to the shortened lifecycle duration of lice, and consequently higher proliferation, under warm and humid environment (Abdelqader, *et al.*, 2008; Surman, *et al,* 2013). These conditions are characteristic of coastal areas of the Eastern Cape Province of South Africa, hence the speculation that these conditions are the cause of higher lice prevalence in coastal GC. The observation that *G. gigas* is most prevalent in Summer (November to January) is in correlation with the results of Salam, *et al.* (2009). However, the results of this study regarding the seasonal prevalence of *M. galinae* contradict those of Salam, *et al.* (2009) where it was reported that the species is highly prevalent in summer as opposed to autumn. Once again, this difference in prevalence trend can be attributed to differences in climate and vegetation. In contrast to the findings of Salam, *et al.* (2009), *L. caporis* was one of the least prevailing lice species in this study. Furthermore, the observation in this study that prevalence of *G. gallinae* and *M. stramineus* was the lowest is in agreement with the results of Salam, *et al.* (2009).

The prevalence rates of *M. galinae, M. stramineus* and *Knemidocoptes mutans* of 12.4%, 5.3% and 0.57%, respectively, reported by Moyo (2009) in a study conducted in Amatola Basin in the

Eastern Cape province of South Africa are remarkably lower than those reported in this study though it was also conducted in the same province. Amatola Basin can be regarded as an inland area, therefore, the observed low lice prevalence in this area is in agreement with the observations of this study. However, the results of a study by Njuga (2003) on the prevalence of *M. galinae* that was conducted over a period of a year revealed that the species had 77% prevalence which is similar to the year average of this study. However, the average prevalence of *G. gigas* reported in the study by Njuga (2003) was higher than the one observed in this study, which can be attributed to differences in agro-ecological attributes of the areas.

7.4.2 Fleas

The discovery of a single species of fleas in this study is in agreement with the findings of Njuga (2003), Mungube, *et al.* (2008), Moyo (2009) and Chege, *et al.* (2014). In addition, a prevalence study conducted by Moyo (2009) in Amathole Basin in the Eastern Cape Province of South Africa reported a prevalence rate of fleas of 50.7%. However, in this study the highest prevalence rate of fleas (100%) was observed in Ngcingcinikhwe during Spring, and this rate was higher than the rates observed by Njuga (2003) (62%), Nnadi, *et al.* (2010) (35.7%), Mungube, *et al.* (2008) (76.7%), Chege, *et al.* (2014) (47.1%). The high prevalence can be attributed to the thatched roof houses in the rural areas that provide an optimal (warm and dry) environment for the multiplication of fleas (Mungube, *et al.*, 2008).

The prevalence of fleas showed the effect of geographical location and season by being more prevalent in NG than in GC. The observed sudden surge in the prevalence of fleas in NG in spring could be associated with the conducive environment allowing progression of the phases in the life-cycle of the fleas. Adult *E. gallinacea* emerge from the cocoons in response to increase

in temperature when relative humidity reaches 55% and an increasing number of fleas emerge as the humidity and environmental temperatures increase (Metzger, *et al.*, 1999, Percy, *et al.* 2012). The life cycle of fleas is normally completed in one to two months and it is shorter under optimal conditions (Njuga, 2003). In contrast, low humidity increases egg mortality whereas hatching starts occurring at around 25^0C (Percy, *et al.* 2012). This finding disagrees with the results of Mungube, *et al.* (2008) where it was reported that ecto-parasites are most prevalent during the dry season of the year. Furthermore, the discovery of a cat flea species (*Ctenocephalides felis)* in chickens in this study signifies the importance of considering the interaction of household animals in the efforts to control ecto-parasites. This talks to the dynamics of the free range production system, where different animal species interact freely, thus parasites too (Nyoni and Masika, 2012).

7.4.3 Ticks

Two species of ticks, *A. hebraeum* (hard tick) and *Argas spp.*(soft tick), were observed in this study whereas Sabuni (2009) reported the discovery of a typical chicken tick *Argas spp.* only at a prevalence rate of 5.6% in indigenous chickens in a study conducted in Kenya. This level of *Argas spp.* prevalence is lower than the yearly average of 22.5% that was observed in Ngcingcinikhwe in this study. In contrast, Chege (2014) observed general tick prevalence of 47.1% in a study conducted in Kenya. Some of the ticks might have crawled up the body of the chickens as they were scavenging for insects or while they were resting or dust bathing in or near the livestock kraals. The warmth of the birds and smell of blood might have attracted the ticks to climb up the chickens.

The discovery of *A. hebraeum* in chickens has never been reported in other cross-sectional surveys. This observation was considered as unusual as *A. hebraeum* is a tick that is generally

associated with ruminant livestock unlike the *Argas spp.* which is considered as a poultry tick. The chickens must have picked up the *A. hebraeum* ticks while scavenging for feed in the form of insects. This signifies the interaction of livestock in the rural households confirming the reported mutually beneficial symbiotic relationship between ruminant livestock and indigenous chickens (Sahito, *et al.*, 2013). Ticks are consumed by chickens as a source of protein. Many cross-sectional surveys, however, have reported absence of ticks in indigenous chickens (Njuga, 2003, Nnandi, *et al.*2009, Nnadi, 2010, Rahman, *et al.*,2013). In agreement with these observations, Moyo (2009) reported that only 6.5% of respondent considered ticks to be a problematic parasite in a study conducted in Amatola Basin in the Eastern Cape province of South Africa. However, the results of this study bring to the fore both geographic and seasonal effects of tick prevalence. The highest prevalence of *A. hebraeum* was observed in the coastal GC in autumn, winter and spring, whereas *Argas spp.* was most prevalent in NG in winter. This could be attributed to the environmental preference of the two tick species as *A. hebraeum* is known to thrive in moderately humid and warm savanna area, which is a typical weather condition of coastal GC (Dube, *et al,* 2010). In contrast to the environmental preference of *A. hebraeum*, Dube, *et al.* (2010) did not observe any difference in prevalence of *Argas spp.* during wet and cold season in a study conducted in Zimbabwe. However, Percy, *et al.* (2012) reported a higher prevalence of *Argas spp.* in summer. In this study, summer months exhibited low prevalence of both tick species which is in agreement with the assertion of Mungube, *et al.* (2008) that ecto-parasites are more frequently observed during dry season, which is typical condition of winter and autumn in South Africa, except for the Western Cape Province.

7.5 Conclusion

The observed seasonal and geographic effects on ecto-parasite prevalence is a significant discovery that will provide a considerable information towards the development of an effective health management strategy. Though the ecto-parasites seldom lead to mortality, their negative effect on growth rate and egg production justifies the efforts to control them. These efforts should be based on seasonal and geographic prevalence for them to be effective and economical. Furthermore, the discovery of species of fleas and ticks that are not typically associated with chickens in this study implies that the health management strategy for indigenous chicken should not be developed in isolation to those of other household livestock species. In addition, future studies should establish a link between parasite prevalence and weather conditions (i.e. humidity and temperature) by accurately measuring these weather parameters using data loggers.

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Chapter 8: Helminthes and Salmonella Prevalence in Indigenous Chickens of Two Rural Communities in Mnquma Local Municipality, South Africa

Abstract

Indigenous chickens produce below their potential because of a number of constraints, the major one being health challenges. Helminthes and salmonella are among the health challenges that result in low production, high mortality and small flock sizes. Health challenges tend to vary with location and season, which presents a challenge in the efforts to develop a health management strategy. The objective of this study was to establish the effect of season and location on the prevalence of helminthes and salmonella. Two locations, one coastal - Gcina and the other inland - Ngcingcinikhwe, were selected and helminthes and salmonella prevalence were monitored seasonally by chicken dissection and feaces analysis, respectively. Three worm species (*Railetina spp., Ascaridia galli and Heterakis gallinarum*) had a significant prevalence during all seasons. Helminthes exhibited the highest prevalence (80%) in the inland location during autumn. Confirmed salmonella positive samples in Gcina were observed in winter (20%) and summer (10%) whereas in Ngcingcinikhwe they were only observed in spring (20%). Salmonella serovars that were identified among the positive samples were *Salmonella* entiritidis and typhimurium. In conclusion, helminthes were most prevalent in the inland area in autumn, whereas the prevalence of salmonella was very marginal in indigenous chickens.

Keywords: indigenous chickens, helminthes, parasites, mortality, *Salmonella*, prevalence

8.1 Introduction

Rural households keep chickens for various traditional ceremonies, own consumption and also to generate revenue from eggs and live chickens sales (Aklilu, *et al.* 2007). Nontheless, recent studies have revealed that the potential value of keeping indigenous chickens is not fully realized as households are selling and consuming far less chickens and eggs (Halima, *et al.* 2007, Wambura, 2011; Badhaso, 2012). The low production of indigenous chickens is largely attributed to health challenges that include helminthes and salmonellosis (Rahman, *et al* 2013).

Helminthes normally cause subclinical damage to indigenous chicken, however, heavy infestation can result in mortality (Phiri, *et al.,* 2007, Mwale, *et al.* 2009). Furthermore, they compete with the host chicken for nutrients resulting in reduced productivity (low growth rate and egg production) and, consequently, economic loses (Skallerup, *et al.,* 2005; Phiri, *et al.,* 2007). In addition, helminthes carry pathogens and cause injury and hemorrhage of the intestinal wall (Skallerup, *et al.,* 2005). The losses due to increased morbidity after worm infestation should be considered of greater economic importance than the high worm burdens that cause mortality in few birds (Magwisha, *et al.,* 2002). The scavenging feeding method of indigenous chickens predisposes them to helminthes as they feed mainly on insects that are intermediate hosts of various types of worms (Skallerup, *et al.,* 2005; Phiri, *et al.,* 2007).

A number of research studies conducted to establish the prevalence rates of helminthes in indigenous chickens reported extremely varying rates of between 45 to 100% in various countries (Magwisha, *et al.,* 2002, Horning, *et al.* 2003, Phiri, *et al.* 2007, Mungube, *et al.* 2008; Hernandez, *et al,* 2012). However, there has been glaring contrasting reports from research publications regarding the effects of the seasons and geographic location on the helminthes

species prevalence in indigenous chickens (Skallerup, *et al.* 2005, Zeleke, *et al.* 2005 Phiri, *et al.*, 2007; Rahman, *et al.* 2013). A combination of husbandry practices employed in the production of indigenous chickens and the climate prevailing in the tropics has been blamed for the rife health challenges in indigenous chicken production (Phiri, *et al.*, 2007). Prevailing climate, topography and ecological zones provide a suitable environment for the multiplication of different helminthes intermediate hosts (Rahman, *et al.* 2013). Therefore, these environmental elements, consequently, affect the level of prevalence of various helminthes types. An example of this is the high prevalence of *Hetarakis gallinarium* in humid and cool environment whereas *Ascaridia galli* prevelance is indiscriminate (Magwisha, *et al.* 2002, Skallerup, *et al* 2005; Mwale, *et al.* 2011). Generally, helminthes require high rainfall and humidity to become infective, however, an extremely high temperature results in reduced egg development (Magwisha, *et al.* 2002, Skallerup, *et al.*, 2005; Abdelqader, *et al.*, 2008). In addition, the environmental effect on other indigenous chicken health compromising organisms, like salmonella, is not yet clear as contrasting observations have been published.

Salmonella bacteria do not only cause ill-health to poultry but may also affect the consumers of affected chickens (Tohidi, *et al.* 2014). The most common form of Salmonella infection in indigenous chickens is regarded to be the fowl typhoid caused by *Salmonella gallinarum* (Tam, *et al.* 2012; Ogie, *et al.* 2013). Salmonellosis or salmonella infection can cause depressed feed intake, low mobility and, ultimately, death (Msoffe, *et al.* 2006). However, these clinical signs of salmonella infection have been reported to last for a much shorter period in indigenous chickens compared to commercial chicken types (Msoffe, *et al.* 2006; Ogie, *et al.* 2013). This resistance to salmonella infection by indigenous chickens has been linked to their genetic make-up, which enables them to respond effectively to salmonella infection (Tohidi, *et al.* 2014). Good hygiene

and vaccination are the two widely used means of controlling salmonella in chickens but these two methods are hardly applied in indigenous chicken production as the salmonella prevalence is regarded as low (Tam, *et al.* 2012). Low salmonella prevalence rates in indigenous chickens of 10% and 9.33% have been reported by Makaya, *et al.* (2012) and Endris, *et al.* (2013), respectively. However, despite this low prevalence rate the ability of the bacteria to vertically and horizontally transmit is of great concern (Endris, *et al.* 2013). Furthermore, the inability of scientists to be precise about salmonella occurrence and distribution in most countries, including South Africa, has resulted in gross underestimation of the actual salmonella prevalence figures (Barrow, *at al.* 2011). Therefore, if salmonella is to be effectively controlled, prevalence patterns as affected by geographic location and season need to be established.

Contradicting reports on the helminthes prevalence dynamics in indigenous chickens pose a challenge in the efforts to develop a comprehensive and effective helminthes management strategy. This, therefore, implies that a universal strategy will not only be ineffective but it will also be uneconomical as it might not be relevant to helminthes challenge dynamics of a particular area (Abdelqader, *et al.,* 2008). In South Africa the geographical and seasonal prevalence of helminthes and salmonella in indigenous chicken has never been reported, which makes it difficult to develop an effective helminthes management strategy. The objective of this study was to establish the seasonal and geographic prevalence of helminthes and salmonella in two rural communities in the Eastern Cape Province of South Africa.

8.2 Materials and Methods

8.2.1 Study site

Refere to Section 3.2.1

8.2.2 Social facilitation

Refere to Section 3.2.2

8.2.3 Sampling design and techniques

Before the start of this study an ethical clearance was obtained from the University's Ethical Committee. Ten households from each location were randomly selected from the two locations during each season, and in each of the selected households one chicken was randomly selected for internal parasite examination. Ten fresh feacal samples were collected around the yard of the each of the selected household. The feacal samples were collected once a season. Each sample was collected into a separate marked sample bottle containing 10 mL of Rappaport-Vassiliadis broth, and stored at approximately 4^0C.

Chickens that were selected for worm inspections were sacrificed by cervical dislocation and the thoracic and abdominal cavities were cut open with scissors. Each section of the alimentary canal was tied on both ends to separate from other sections and to prevent the contents and worms from migrating to other sections. The whole alimentary canal and the trachea was gently removed and cut open to remove worms. Worms encountered in each section were collected into separate containers. The specimen collected were preserved in 70% alcohol until their identification.

8.2.4 Worm identification

The worms were prepared for identification by putting cestodes and nematodes on slides with Hoye's medium and lactophenol, respectively. These solutions cleared the body surface of the worms and made it possible to identify them by means of internal organs under microscope. The identification keys were used to identify cestodes and nematodes based on the procedures of Khalil, *et a*l. (1994) and Anderson, *et al.* (2009), respectively. Each worm species recovered per bird were tallied and recorded, accordingly.

8.2.5 Salmonella analysis and serotyping

Salmonella analysis and serotyping was conducted according to the procedure outlined by Makaya, *et al.* (2012).

8.2.6 Data analysis

The Statistical Analysis System of SAS version 8 (SAS, 1999) was used to compute mean helminthes species load in chicken from respective locations and during different seasons. T-test and Chi-Square were used to compare the helminthes means during different seasons and locations, and Spearman Correlation Coefficients were used to analyze for correlation between loads of various species of helminthes. Prevalence of salmonella and helminthes were calculated as a percentage confirmed salmonella positive samples from the total tested feacal samples and helminthes infested chickens out of the total examined chickens, respectively (Salam, *et al*., 2009).

8.3 Results

8.3.1 Helminthes

There were three main worm species (*Railetina spp.,A. galli* and *H. gallinarum*) that were observed in the two study sites. Generally, Ngcingcinikhwe had higher helminthes prevalence

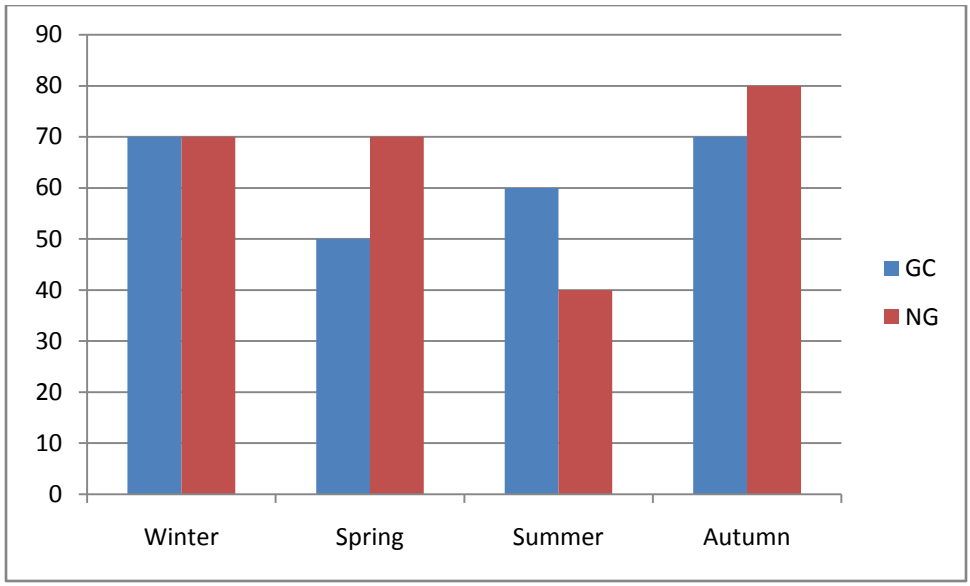
compared to Gcina (Table 8.1) and the three main worm species were most prevalent in autumn in this location. However, the *Railetina spp.* was most prevalent in winter and autumn in Gcina, whereas *A. galli* and *H. gallinarum* were not encountered at all in Gcina in spring and winter, respectively (Table 8.1). In addition, there were other worm species that were encountered in very few instances and these included *Capillaria sp., Hymenolepis carioca, Alodapa suctoria* and *Skrjbinia cestilus.*

Table 8.1: The percentage (%) prevalence of *Railetina spp., A. galli* and *H. gallinarium* during different seasons

	Railetina spp.				***A. galli***				***H. gallinarium***			
	W.	**Spri.**	**Sum.**	**Aut.**	**W.**	**Spri.**	**Sum.**	**Aut.**	**W.**	**Spri.**	**Sum.**	**Aut.**
GC	70	50	60	70	50	0	50	30	0	50	50	50
NG	70	70	40	80	70	40	30	80	50	10	60	80

Abbreviations: *Railetina spp.* - *Railetina species; A. galli – Ascaridia galli; H. gallinarium – Hetarakis gallinarium*

The *Railetina spp.* prevelance in Gcina showed a decline after winter but increased in autumn (Figure 8.1). However, the decline of this species was delayed in Ngcingcinikhwe and was only seen in summer though a similar but more pronounced increase was observed in autumn (Figure 8.1).



Figures 8.1: The seasonal prevalence (%) of *Railetina spp.* in Gcina and Ngcingcinikhwe.

A. galli was not observed in birds from Gcina that were examined in spring, however, this worm species was encountered in half of the birds that were examined in winter and summer but the figure declined to 30% in autumn (Figure 8.2). The prevalence of *A. galli* in Ngcingcinikhwe exhibited a similar trend to the one of *Railetina spp.* by declining in spring and summer before increasing in autumn (Figure 8.2).

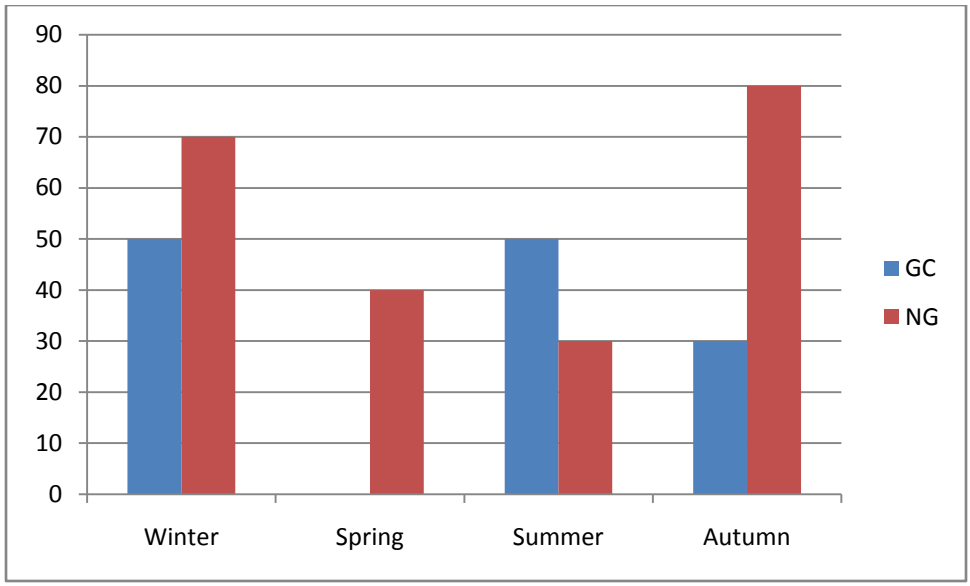


Figure 8.2: The seasonal prevalence (%) of *A. galli* in Gcina and Ngcingcinikhwe.

There was no *H. gallinarium* in birds that were examined in winter Gcina but it was encountered in half of the birds that were examined in spring, winter and autumn (Figure 8.3). In contrast the prevalence of *H. gallinarium* in Ngcingcinikhwe declined in spring but increased considerably in summer and autumn (Figure 8.3).

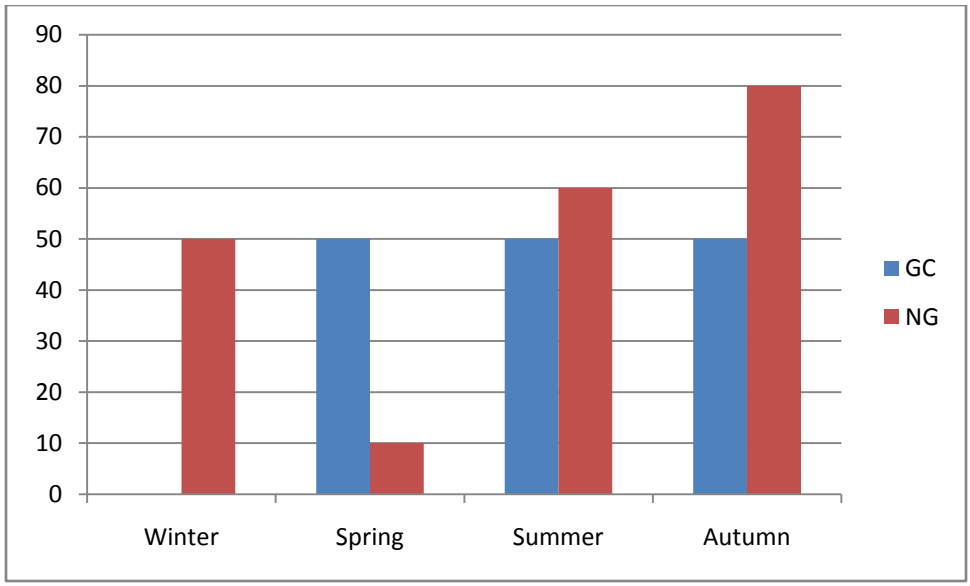


Figure 8.3: The seasonal prevalence (%) of *H. gallinarium* in Gcina and Ngcingcinikhwe.

There was a generally higher worm load in chickens from Ngcingcinikhwe compared to those from Gcina, however, significant differences ($p<0.05$) were observed in *Railetina spp.*, *E. carioca, S. cestilus, Hemanolepis spp.* and *A. suctori* loads (Table 8.2).

Table 8.2: The mean helminthes load (number of worm scolaces) observed in chickens from Gcina and Ngcingcinikhwe.

Helminthes Species	Gcina	Ngcingcinikhwe
Railetina spp.	4.72 ± 9.98	8.00 ± 9.31
H. gallinarium	5.60 ± 12.90	10.98 ± 30.74
A. galli	5.58 ± 10.78	6.63 ± 11.41
E. carioca	0.68 ± 4.11	0.63 ± 1.82
A. suctori	0.03 ± 0.16	1.13 ± 4.05
S. cestilus	0.00	0.23 ± 0.10
Capillarrinae spp.	0.03 ± 0.16	0.00
Hemenolepis spp.	0.00	0.08 ± 0.27

The load of *Railetina spp.*, *A. galli* and *Hemanolepis spp* was significantly ($p<0.01$) higher in winter compared to other seasons, whereas, the load of other helminthes species did not show significant differences between seasons (Table 8.3).

Table 8.3: The mean helminthes load (worm scolaces) tallied during different seasons of the year.

Helminthes Species	Autumn	Winter	Spring	Summer
Railetina spp.	11.45 ± 15.01	5.25 ± 7.09	5.55 ± 7.32	3.20 ± 4.97
H. gallinarium	8.60 ± 14.04	6.40 ± 19.50	2.65 ± 5.70	15.50 ± 40.12
A. galli	3.85 ± 5.59	15.80 ± 16.59	1.25 ± 3.68	3.50 ± 7.11
E. carioca	0.50 ± 1.47	0.00	1.80 ± 6.04	0.30 ± 0.92
A. suctori	0.05 ± 0.22	0.55 ± 2.04	0.20 ± 0.70	1.50 ± 5.39
S. cestilus	0.00	0.00	0.40 ± 1.39	0.05 ± 0.22
Capillarrinae spp.	0.00	0.05 ± 0.22	0.00	0.00
Hemenolepis spp.	0.00	0.15 ± 0.37	0.00	0.00

Significant ($p<0.001$) positive correlations were observed between the loads of *Railetina spp.* and *A. galli* (0.48)*;* and *A. suctori* and *Hemanolepis spp.* (0.38).

8.3.2 Salmonella

In Gcina the highest percentage of suspected Salmonella positive feacal samples was in summer followed by winter and least percentage were in spring and autumn (Figure 8.4). In Ngcingcinikhwe there were no suspected Salmonella positive samples in summer but there were 30% suspected positives in winter and spring (Figure 8.4).

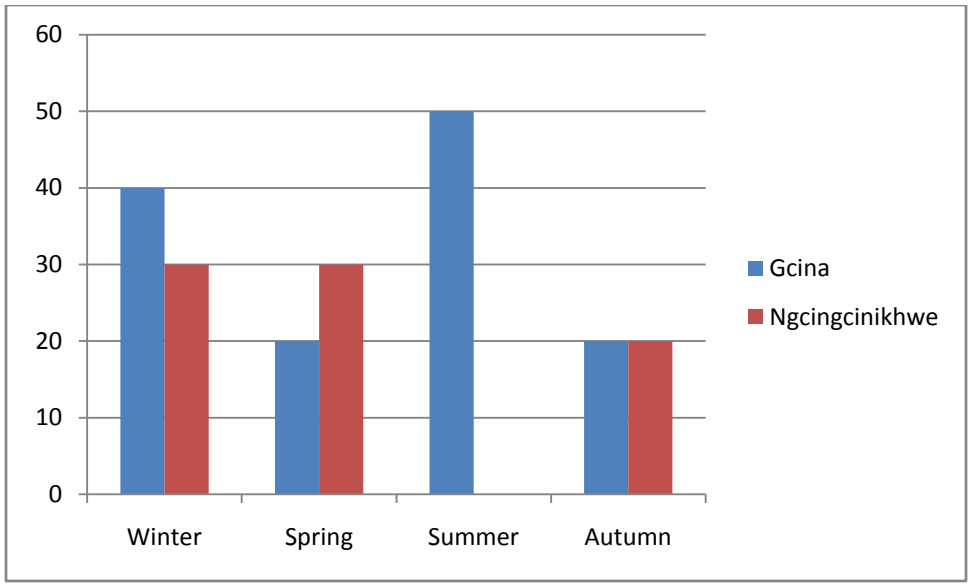


Figure 8.4: Percentage suspected Salmonella positive fecal samples from Gcina and Ngcingcinikhwe.

The confirmed serotypes identified in the confirmed positive samples were *S. enteritidis* and *S. typhimirium*, and the former was observed in winter in Gcina and spring in Ngcingcinikhwe whereas the latter was observed in summer in Gcina (Table 8.4).

Table 8.4: Confirmed Salmonella positive samples and respective serotypes.

	winter	spring	summer	autumn
Gcina	20	0	10	0
	(S. enteriditis)		*(S. typhimurium)*	
Ngcingcinikhwe	0	10	0	0
		S. enteritidis		

8.4 Discussion

8.4.1 Helminthes

The three helminthes species (*Railetina spp., A. galli* and *H. gallinarium*) that were found to be most prevalent in the two study sites of this study were also reported in other similar studies conducted in different countries around the world (Skallerup, *et al*., 2005, Phiri, *et al.,* 2007, Abdelqader, *et al.*, 2008; Mungube, *et al.,* 2008). However, markedly different rates of prevalence of these species have been reported, for example Phiri, *et al.* (2007), Skallerup, *et al*.,(2005), Abdelqader, *et al*.(2008) and Mungube, *et al.* (2008) reported that *Railetina spp.* had a prevalence rate of 81.6, 67, 17 and 33%, respectively. However, the same researchers reported that the prevalence of *A. galli* was 28.8, 100, 43 and 33.3%, respectively. Furthermore, Skallerup, *et al*.,(2005), Abdelqader, *et al.*(2008) and Mungube, *et al.* (2008) observed that *H. gallinarium* had a prevalence rate of 32.8, 100, 33 and 22.8%, respectively. *A. suctoria* was observed to be one of the fringe worm species in this study whereas Phiri, *et al.* (2007) and Percy, *et al.* (2012) observed it to be the most prevalent species. This can be attributed to the difference in average annual rainfall between the study areas of the different reports and that of

this study as the average annual rainfall from other studies was about 1000mm and those of this study are about 600mm and 756mm. This notion is further affirmed by Isaac, *et al.* (2013) who asserted that *A. suctoria* exhibited the highest prevalence in areas with an average annual rainfall of above 1000mm. Some of the reported prevalence rates in other studies are comparable to the results of this study while some tend to differ markedly, therefore, signifying the geographic and climatic effects on the prevalence of helminthes (Skallerup, *et al*.,2005, Phiri, *et al.* 2007, Abdelqader, *et al.*, 2008; Mungube, *et al.*, 2008).

The highest worm prevalence rates were observed in autumn in Ngcingcinikhwe whereas they were observed in autumn and winter in Gcina, which are relatively cool and dry seasons in South Africa. Therefore, this observation is in contrast with assertions of many research publications that endoparasites are most prevalent during wet months of the year (Magwisha, *et al.*, 2002, Skallerup, *et al*., 2005, Abdelqader, *et al.*, 2008, Mungube, *et al.*, 2008). Rahman, *et al.* (2013) reported in a study conducted in Bangladesh that helminthes prevalence varied with area, which is in line with the observations of this study. This was attributed to topography, ecological zones and availability of intermediate hosts. A wet and humid weather together with abundance of intermediate hosts, which the indigenous chickens scavenge, are known to provide a perfect environment for propagation of helminthes (Magwisha, *et al.* 2002, Njuga, 2003, Skallerup, *et al*. 2005, Mungube, *et al.*, 2008).

Mwale, *et al.* (2011) reported in a study conducted in another location of Centane, in the Eastern Cape Province of South Africa, that *H. gallinarium* (a nematode) was the most prevalent helminthes species and cestodes were the least prevalent. These findings were in contrast with those of this study as it was observed that cestodes were generally more prevalent than nematodes though the two studies were conducted in the same area. This implies that the

prevalence of helminthes species can vary markedly from location to location within the same area. Nonetheless, despite the varying helminthes prevalence during different seasons and in different locations, the worms were observed to be highly prevalent in indigenous chickens throughout the year. In contrast, Rahman, *et al.* (2013) observed that it was only the prevalence of nematodes that was not affected by seasons. However, Gondwe, *et al*. (2007) reported in a study that was conducted in Malawi that helminthes were prevalent during all the seasons of the year but the prevalence was pronounced during the wet-humid time of the year.

8.4.2 Salmonella

The results of this study have revealed that there was very low prevalence of Salmonella in indigenous chickens of Gcina and Ngcingcinikhwe, which is in agreement with a number of similar studies. Makaya, *et al.* (2012) did not find any salmonella in indigenous chicken whereas 10 % of exotic birds were positive with the bacteria. This observation was attributed to an inherent ability of indigenous chickens to resist salmonella infection and the non-confinement of indigenous chickens as opposed to intensification of commercial breeds. Indigenous chickens have an appropriate and early immune response to salmonella, particularly in the caecum (Tam, *et al.* 2012). In the early stages of salmonella infection, the bacteria is acted upon by the monocytes (macrophages) and as the bacteria overcome these leucocytes, other cells (heterophils and lymphocytes) take over (Msoffe, *et al.* 2006). In contrast, commercial chickens do not posses the second reaction mechanism that involves heterophils and lymphocytes, which renders them susceptible to salmonella infection (Msoffe, *et al.* 2006, Ogie, *et al.* 2013). Furthermore, the genetic make-up of indigenous chickens enabled them to react effectively to salmonella infection (Msoffe, *et al.* 2006, Schou, *et al.* 2010, Ogie, *et al.* 2013; Tohidi, *et al.* 2014,).

The salmonella serovars (*Salmonella enteritiditis* and *typhimirium*) observed in this study were also observed by Makaya, e*t al.* (2012), Endris, *et al.* (2013) and Tohidi, *et al.* (2014). Though their prevalence is low, these serovars pose threat to the health of the consumers and infected chickens' production. *Salmonella enteritiditis* result in reduced growth rate in chickens while *S. typhimirium* causes septicaemia, infect the reproductive system of hens and can be vertically transmitted to the chick through the egg (Makaya, e*t al.* 2012, Endris, *et al.* 2013; Tohidi, *et al.* 2014). Vaccination and organic acids are currently used around the world to control salmonella (Tam, *et al.* 2012; Koyuncu, *et al.* 2013).

8.5 Conclusion

Helminthes are highly prevalent in indigenous chickens and their prevalence is highest in autumn and in inland areas. Therefore, a de-worming program that is tailor-made for respective locations needs to be developed so as to effectively control helminthes. Furthermore, the observed low prevalence of salmonella in this study bodes well for the development of indigenous chicken production as means of improving the livelihoods of rural people. However, consistent and accurate monitoring of salmonella is imperative in ensuring that rapid response to infections is effected.

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Chapter 9: General Discussion, Conclusion and Recommendations

9.1 General discussion

Indigenous chicken production is generally regarded as one of the means of mitigating poverty in rural areas in the developing countries around the world (Ogunlande, *et al.,* 2009). However, a number of studies have decried the suboptimal contribution of indigenous chickens towards the livelihoods of characteristically poor rural people (Dyubele, *et al.*, 2010; Olwande, *et al.*, 2013). These research studies have pointed to poor production and high mortality of indigenous chickens as key causes of the observed low contribution of indigenous chickens towards rural livelihoods (Rodriquez, *et al.*, 2011). This poor production and high mortality has been attributed mainly to health challenges, which include diseases and parasites. Therefore, reduction or elimination of health challenges can lead to improved production and survivability of indigenous chickens and, consequently improved socio-economic contribution in rural communities. Nevertheless, the prevalence and form of indigenous chicken health challenges has been found to be affected mostly by geographic location and the season of the year (Jinga, *et al.*, 2012 and Tadesse, *et al.*, 2013). Therefore, for development of a cost effective and efficient health management strategy, health challenges prevalent in a particular area and the factors that might exacerbate or minimize them need to be established. To this end, the objective of this study was to establish the main health challenges of indigenous chickens in two rural communities, and to determine if the health challenges are affected by the locality and the seasons of the year.

In Chapter 3, the socio-economic status of the two selected communities and the contribution of indigenous chicken towards their livelihoods were investigated. It was observed that 80% of households in both communities relied solely on government welfare grants for survival. This reliance on government social grant by Eastern Cape rural residents was also observed by

Westway (2012), where it was also reported that 73% of rural people were living on less than R300 per month. This figure is below the poverty line of R400/month drawn by the Presidency in 2008 (Stats SA, 2014). Furthermore, 90% and 78.8% of households in Gcina and Ngcingcinikhwe, respectively, consumed indigenous chicken once a month, while eggs were consumed once a month by 77.8% and 78.7% of households in Gcina and Ngcingcinikhwe, respectively. Eggs were sold by 11% and 15% of households in Gcina and Ngcingcinikhwe, respectively, while live chickens were only sold when there was a shortage of money. These findings are similar to those of Mtileni, *et al*. (2013) in South Africa, where it was reported that the inhabitants in rural areas kept chickens mainly for food security and, to a lesser extent, to generate income. In this study, it was concluded that indigenous chickens had minimal contribution towards the livelihoods of the two study rural communities as there were few households that sold or consumed indigenous chicken meat and eggs. In addition, those households that consumed indigenous chicken product rarely did so. The main reason stated by the respondents for the low sales and consumption frequencies is the small flock sizes caused by high mortality rates, rather than the taste of the products. Therefore, in order for the indigenous chickens to contribute significantly to food security, the research agenda must give greater attention to socio-economic and technical constraints pertaining to indigenous chicken production (Muchadeyi, *et al.* 2013).

In Chapter 4, it was observed that the average flock sizes were 8.3 (±5.9) and 10.4(±6.0) in Gcina and Ngcingcinikhwe, respectively. This was the case even though the majority of households had been keeping the chickens for more than five years. The average flock sizes observed in this study were similar to those reported by other researchers, however, Harrison, *et al.* (2010) and Mutayoba, *et al.* (2012) reported larger flock sizes and improved performance of

feed supplemented flocks than un-supplemented ones. In this study, more than 80% of households in both locations supplemented the scavenge feed with maize only, and there was no reason provided for this. Nevertheless, it is logical to assume that the extensive use of maize as a feed supplement was due to its availability as it was a grain of choice in the two areas that were studied. Okitoi, *et al.* (2009) observed an improvement across all the production parameters that were measured when indigenous chickens were offered free access to energy and protein sources compared to when they were offered the two ingredients separately. For hatching purposes, an average of more than 11 eggs were put under the hens and more than 75% hatching rate was achieved. However, about 55% of hatched chicks survived to grower stage. Similar high losses of newly hatched chicks were observed by Okeno, *et al.* (2012) and Fentie, *et al.* (2013) in Kenya and Ethiopia, respectively. The observed high chick mortalities in this study and similar studies were attributed mainly to diseases and parasites, which included NCD, helminthes, lice, ticks and fleas.

In Chapters 5 and 6, respondents were requested to respond to a series of questions in a structured questionnaire regarding the health status of the chickens, which were later tested for antibodies against NCD to determine if they had been exposed to the NCD virus. It was observed that more that 80% of chickens tested positive for NCD, meaning they possessed NCD antibodies in their blood stream. This was observed in both study locations in autumn, winter and summer. However, the proportion of NCD positive blood samples declined to 60% and 50% during spring in Gcina and Ngcingcinikhwe, respectively. This observed reduction in antibody protection against NCD coincided with the period during which the respondents reported witnessing a spike in sudden chicken mortalities. This seasonal effect on NCD antibody titres was also observed by Kemboi, *et al.* (2013) in Kenya where 100% of birds had protective NCD

titre levels during the wet season compared to 83% during dry season. Shortage of nutritious scavenging material during the dry season was mentioned as the cause of the observed low NCD titre levels. In agreement to this observation, Njangi, *et al.* (2010) reported higher NCD virus prevalence in dry hot zone of Kenya compared to the cool wet zone. Later in this study, some of the chickens were vaccinated against NCD, some were de-wormed and vaccinated while the other group was neither vaccinated nor de-wormed. Both groups of vaccinated chickens exhibited an increase in NCD antibody levels, however, the increase was more pronounced in the de-wormed group. This observation was in agreement with that of Kemboi, *et al.* (2014) in Kenya.

In Chapter 7, it was observed that lice species (*G. dissimilis, G. gigas* and *M. galinae*) were more prevalent in the relatively more humid coastal location compared to the inland location. This difference was more pronounced with *M. galinae*, which was prevalent in 90% of the examined chickens in autumn. In agreement with this observation, Salam, *et al.* (2009) observed in Kashmir that lice thrived in a warm and humid environment, which are typical conditions in summer and early autumn in South Africa. Furthermore, Arya, *et al.* (2013) reported a strong positive correlation between the prevalence of lice and environmental temperature (+ 0.79) and photoperiod (+0.84), while the same were found insignificant with humidity (-0.23) and rainfall (-0.17). In contrast, fleas (*Echinophaga gallenacea*) were reported to be more prevalent in the drier inland location, and all the examined birds inland were found to be hosting fleas in spring. Jinga, *et al.* (2012) also observed higher flea prevalence in Zimbabwe during the warmer and more humid times of the year. However, Sabuni, *et al.* (2010) observed higher ecto-parasite prevalence in a drier semi-arid location compared to a wetter area. This can be attributed to the specific environmental requirements of the observed ecto-parasites, which might have differed

markedly from the requirements of the fleas. Furthermore, a typical cat flea (*Ctenocephalides felis*) was observed in one chicken in the inland location. Similarly, a characteristic ruminant livestock tick (*A. hebraeum*) was observed in both inland and coastal locations but there was a higher prevalence in the costal area in spring and autumn. In contrast, the soft chicken tick (*Argas persicus*) exhibited a higher prevalence in the inland location in winter and spring. This observation is in contrast to the observation in Zimbabwe of Jinga, *et al.* (2012) that the *Argas persicus* is more prevalent during summer months. These contrasting seasonal tick prevelances can be attributed to the similarity in vegetation of the two locations and similarity in prevailing environmental conditions though the seasons might be different. Nonetheless, despite the difference in observed tick prevalence in different locations, the prevalence of ecto-parasites is basically determined by existence of optimum conditions (mainly temperature and humidity) for their propagation and development (Salam, *et al.*, 2009).

In Chapter 8, helminthes were observed to be highly prevalent in indigenous chickens, in the study areas affecting as much as 80% of chickens at some instances. A similar discovery was made by Ogbaje, *et al.* (2012) in Nigeria, and high worm infestation was attributed to consumption of worm intermediate host (insects) when the birds scavenge for feed. In addition, in this study higher helminthes prevalence was reported in the inland location compared to the coastal location. This was particularly the case with *Railetina spp.*, *E. carioca*, *S. cestilus*, *Hymenolepis spp.* and *A. suctori* loads. This observation is in agreement with that of Mwale, *et al.* (2011) in the same local municipality in South Africa. In this study there was a generally higher prevalence of helminthes in an inland area compared to the coastal area, and some of the specie were observed in one location and not in another. Furthermore, the worm species were observed during all seasons of the year, however, the loads of *Railetina spp.*, *A. galli* and

Hemanolepis spp were significantly (P<0.01) higher in winter compared to other seasons. However, these observations were in contrast to those of Jinga, *et al.* (2012) in Zimbabwe where it was observed that helminthes were more prevalent during the summer months due to the abundance of earth worms, which are intermediate hosts of helminthes. Therefore, differences in helminthes prevalence in various countries could be a result of differences in climatic conditions and altitudinal differences of the countries (Jinga, *et al.*, 2012).

9.2 Conclusion

On the investigation of food security and socio-economic status of the study communities, it was observed that households were food insecure as they had to employ coping strategies in response to food shortage. Furthermore, majority of households in the two communities that were studied relied on government social grants as the main source of income, and their monthly income was found to be below the South African Presidency stipulated poverty line. In addition, though people were living in abject poverty, they did not utilize indigenous chicken to circumvent poverty and food shortage by selling and consuming indigenous chicken meat and eggs. This was the result of health challenges in the form of diseases and parasites that resulted in small flock sizes and poor production.

The indigenous chicken production parameters measured revealed suboptimal production. Average flock sizes were too small though the majority households that had been keeping indigenous chickens for more than five years. Furthermore, the hatchability of the set eggs rivaled that of commercial flocks but the mortality of newly hatched chicks was high, resulting in few chicks reaching the grower phase. Diseases and parasites were the main causative factors for the high chick mortality. NCD, internal and external parasites were observed to be the paramount

health challenges in the two communities. Though the NCD was observed to be endemic in the two locations based on the protective titres levels in the majority of chickens, the NCD antibody levels declined drastically in spring relative to other seasons of the year. Helminthes prevalence was high in both location, therefore, compromising production. Furthermore, helminthes prevalence was affected by location and season as more helminthes were observed in the inland location and during autumn, respectively. Similarly, ecto-parasites were also observed to be affected by the season of the year and location. Lice species and ticks were more prevalent in the coastal location in autumn and spring, respectively, while fleas were more prevalent in the inland location in spring. Furthermore, the majority of rural households used ethno-veterinary methods and substances to control diseases and parasites and very few purchased commercial veterinary medicines. However, the health management methods were used only when the chickens exhibited symptoms of ill-health. In essence, indigenous chickens do not have a significant contribution towards the livelihood of rural people because of an array of health challenges which compromise production. Furthermore, these health challenges mostly differ with location and the season of the year, therefore making it difficult to develop a universal indigenous chicken health management strategy.

9.3 Recommendations

The results of this study show that indigenous chickens were not contributing significantly towards the livelihoods of the two rural communities studied, despite rampant poverty and food insecurity in these communities. The low contribution of indigenous towards the livelihoods was attributed to small flock numbers and generally low production rates of indigenous chickens. To this end, this study showed that absence of a health management strategy and inappropriate scavenged feed supplementation contributed greatly to the observed high mortality and poor

production of indigenous chickens. Therefore, comprehensive and congruent efforts to improve management and husbandry of indigenous chickens need to be undertaken so as to increase flock sizes and, consequently, improve the contribution of indigenous chickens towards the livelihoods of rural communities. The following are recommendations aimed at improving flock sizes and indigenous chicken production and also highlight future research areas:

1. The observed lack of skills on poultry husbandry warrant training and mentorship of indigenous chicken producers on chicken husbandry and health management.
2. The seasonal and geographic variation in the prevalence of diseases and parasites requires determination of seasonal prevalence of chicken diseases and parasites in particular localities to develop tailor-made health management strategies. The strategies should include vaccination against prevalent diseases and parasites.
3. Chickens were supplemented exclusively with maize, an energy source, in the process chickens were deprived of other valuable nutrients that might have been deficient like proteins. Therefore, investigation of locally available protein and energy sources to be choice fed to indigenous chickens will result in improved production.
4. Chick mortality was observed to be too high due to exposure to predators and environmental elements. To this end, chick vaccination and confinement at least during the first three weeks of their life to protect them from predators and cold will help to curtail their mortality.
5. It is unequivocal that indigenous chicken keepers are resource limited and therefore can not afford to purchase commercial chicken medication. Therefore, evaluation of the effectiveness of various ethno-veterinary substances utilized by the resource poor

indigenous chicken producers will assist in controlling diseases at parasites at an affordable cost.

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Appendix 1:

Questionnaire

Date: **House Number:**

1. **Sections:**
   E. Demographics
   F. Contribution of indigenous chicken to the livelihood
   G. Food Security
   H. Indigenous Poultry Production Status
   I. Disease and Parasite Control – indigenous chicken keepers

Section A: Demographics

1. Gender of the respondent: …….. 2. Age of the Respondent: ……

3. Respondent's family position:…… 4. Household size:……

5. Main Source of income:…… 6. Number of children (U 18yrs):……

7. Number of unemployed adults (O 18yrs):……

8. Highest level of education in the household:……

Section B: Contribution of indigenous chickens to the livelihood of rural households

1. Source of income:	**2. Monthly income:**
a. Work salary/wages	a. R501-R1000
b. Business (not agricultural)	b. R1001-R1500
c. Pension/grant	c. R1501-R2000
d. Sale of agricultural products	d. Above R2000
e. Other	

3. **How much money is spent monthly on the following:**

a. Groceries

b. Agricultural Inputs

c. Health

d. School fees

Other:

4. **Purpose of keeping chicken:**

a. Own consumption

b. Generate revenue

c. Offer as gift

d. Rituals or traditional ceremonies

e. For exchange for other goods

Other:

5. Use of eggs:

a. Own consumption

b. Generate revenue

6. Price per chicken:

7. Price per egg:

8. What are the basis for pricing of chicken products?

c. Offer as gift

d. Set for hatching

e. For exchange for other goods

f. Other

a. Costs incurred

b. Demand

c. Competitors

d. Going price

e. other

9. How much is consumed monthly of the following meat types?

a. Beef

b. Mutton

c. Goat Meat

d. Broiler meat

e. Indigenous chicken meat

10. Chicken consumption frequency:

a. Once in 1-3 days

b. Once a week

c. Once in two weeks

d. Once in three weeks

e. Once a month or more

Other:

11. Reasons for the chicken consumption frequency:

12. Egg consumption frequency:

a. Every day

b. Once in 2-4 days

c. Once a week

d. Once in two weeks

e. Once in three weeks or more

13. Reasons for the egg consumption frequency:

14. Chicken sales frequency and price:

a. Once in 1-3 days

b. Once in 4-6 days

c. Once a week

d. Once in two weeks

e. Once in three weeks

f. Once a month or more

15. Number of chickens sold per month:

a. 0-3

b. 4-6

c. 7-9

d. 10-12

e. 13 and above

16. Reasons for the chicken sale frequency:

17. Egg sale frequency and price:

a. Every day

b. Once in 2-6 days

c. Once a week

d. Once in two weeks

e. Once in three weeks or more

18. Number of eggs sold per month:

a. 0-6

b. 6-12

c. 13-18

d. 19-24

e. 24 and above

19. Reasons for the egg sale frequency:

20. Where do you sell eggs and chicken?

a. Locally

b. In town

c. Pension Pay Points

d. Local shops

e. Other

Section C: Food Security (Coping Strategies)

Food Shortage Coping Strategies Frequency over the past 7 Days	Severity Score	Frequency X Score	Comments
1. Rely on less preferred or less expensive food.	1		
2. Borrow food or rely on help from a friend or relative.	2		
3. Purchase food on credit.	2		
4. Gather wild food, hunt or harvest immature crops.	4		
5. Consume seed stock held for next season.	3		
6. Send household members to eat somewhere.	2		
7. Send household members to beg.	4		
8. Limit portion size at meal times.	1		
9. Restrict consumption by adults so that children can eat.	2		

10. Feed working members at the expense of non-working members.	2
11. Reduce number of meals eaten a day.	2
12. Skip entire days without eating	4

Total Household Score

Section D: Indigenous Chicken Production

1. Number of chicken kept (Why:

a. 0-5

b. 6-10

c. 11-15

d. 16-20

e. 21-25

f. 26 and above

2. Chicken feeding (Why):

a. Maize supplementation

b. Scavenging only

c. Commercial feed

d. Kitchen leftovers

e. Other

3. Number of eggs set for hatching (Why):

a. 1-5

b. 6-10

c. 11-15

d. 16 and above

4. Number of chicks hatched (Why):

a. 0-5

b. 6-10

c. 11-15

d. 16 and above

5. Number of chicks that survive to grower phase (Why)

a. 0-5

b. 6-10

c. 11-15

d. 16 and above

6. Cause of chick mortality (Specify):

a. Predators (wild birds and animals, dogs and cats)

b. Diseases

c. Injuries

d. Cold

e. Feed shortage

f. Other

7. What measure taken to reduce bird losses?

a. Housing

b. Medication/vaccination

c. Feed supplementation

d. Control predators

8. Egg production – number of eggs collected per day

a. 1-3

b. 4-6

c. 7-9

d. 10-12

e. other

9. Egg collection frequency (Number of times/day)

a. Once

b. Twice

c. Thrice

d. Skip-a-day

e. Other

11. How long have you been keeping chicken?

a. 1 year

b. 2 years

c. 3 years

d. 4 years

e. 5 years

f. More than 5 years

14. Where do the birds lay eggs?

a. In specially made nests

e. 13 and above

10. Egg storage after collection:

a. Refrigerate

b. Basket

c. Closed container

d. Basin

e. Other

12. Flock composition:

a. Chicks =

b. Growing chicken =

c. Hens =

d. Cocks =

13. How long do you keep eggs before setting?

a. 1-2 days

b. 3-4 days

c. 5-6 days

b. Other (specify)

d. 7 or more days (specify)

Section E: Disease and parasite control measures applied by the indigenous chicken producers.

1. **Disease and parasite control program**

   a. Present and used

   a. Present and not used

   b. Absent

   c. Unaware of such programs

2. **Do you know chicken diseases and their symptoms?** Yes/No

3. **If yes to 2, what do you do when you notice disease symptoms?**
   a. Let the birds recover on their own.

   b. Administer commercial medicine.

4. **If no to 2, what is the reason for the lack of knowledge?**
   a. Lack of knowledge extension efforts by government officials
   b. Low level of education

c. Make your own medicine

d. Slaughter the sick birds (specify use)

e. Other

c. Lack of interest

d. Never heard of chicken diseases

e. other

5. What is the effect of internal and external parasites on the production of chicken?

a. No effect

b. Cause mortality

c. Weight loss

d. Diseases

e. Reduction of egg production

f. Slow growth

other

6. What are the benefits of vaccinating chicken?

a. Do not know/not sure

b. Cure illness

c. Prevent illness

d. Improve production

e. No benefit

other

7. What advices do you receive from the government officials on chicken disease and parasite control and how often?

8. **Provide information on different disease and parasite control methods used:**

Disease/Parasite	Method Used	Plant parts/chemical used	Preparation and Administration Method

9. **When are the disease and parasite control measures applied?**

    a. When disease symptoms are seen.

    a. When a certain number of birds die.

    b. As a preventative measure.

    c. Other.

10. **Are the disease and parasite control methods working?** Yes/No

11. **What are the basis of your judgment of success or failure of disease or parasite control method**

    a. Mortality rate

    b. Production

    c. Appearance

12. **What are the challenges in chicken disease control:**

d. other

13. How can these challenges be overcome?

14. Do you buy chicken medicine? Yes/No

15. If so, where do you buy chicken medicines and what is the respective price?

16. Disease symptoms

17. Describe symptoms seen in chicken

a. Frequently seen

b. Rarely seen

c. Not seen but mortalities

d. Other

8. Seasonal disease occurrence:

Season **Disease/parasite/syptoms**

1. **Summer**

2. **Autumn**

3. **Winter**

4. **Spring**