This dissertation is dedicated

to the

African village chicken farmers,

Particularly women

I declare that this thesis hereby submitted for the degree of Doctor of Philosophy at the University of the Free State, is my own independent work, and has not been submitted for degree purposes to any other university. I hereby forfeit any copyright of this thesis to the University of the Free State.

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NDIAFHI JANE TSHOVHOTE

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LIST OF ACRONYMS

AA	Amino Acids
ACIAR	AustralianCentre for International Agricultural Research
AMEn	Apparent Metabolisable Energy
ANOVA	Analysis of Variance
ANCOVA	Analysis of Covariance
AOAC	Association Of Analytical Chemists
BASED	Broadening Agricultural Services and Extension Delivery Project
BL	Body Length
BW	Body Weight
C	Crus
Ca	Calcium
CC	Chest Circumference
CP	Crude Protein
DM	Dry Matter
EE	Ether Extract
FAO	Food and Agriculture Organisation
F	Feet
F	Femur
GLM	General Linear Model
H	Head
HV	Household within a Village
HR	Human Resource
INFPD	International Network For Family Poultry Production Development
IFPPRD	International Family Poultry Production Research and Development
KZN	Kwazulu Natal

LSM	Least Square Mean
LDA	Limpopo Department of Agriculture
LWT	Liveweight
MK	Mukondeni
NGO	Non Government Organisation
NRC	National Research Council
P	Phosphorus
PH	Phindula
SAS	Statistical Analysis System
SE	Standard Error
SI	Small Intestines
ST	Satane
SFRB	Scavengeable Feed Resource Base
TM	Tarsometatarsus
TMEn	True Metabolisable Energy

CHAPTER 1

INTRODUCTION

The introductory chapter discusses the background of the study and considers the research motivation and objectives. Also, the outline of the subsequent chapters of the thesis is presented in this chapter.

1.1 Research Motivation

The policy of Apartheid, which created divisions in all spheres of life, has also created two distinctly separated agricultural production systems in South Africa. Practically, all resources and innovative inputs were aimed at the large scale commercial farming sector while little was done for smallholders in the former homelands. The migrant labour system, which provided remittances to off-set agricultural productivity deficiencies, completely eroded the small farming communities of the knowledge and skills to survive in marginal farming areas. Now, as the industry and commerce is restructuring and laying off workers, rural South Africa, in particular the Limpopo Province is facing a crisis. The rural population has lost the knowledge and basic skills to irk a living cost-effectively from a heterogeneous farming system characteristic of subsistence farming. Changes in policy brought about with independence tasked the agricultural support industries and institutions to redirect their attention to a new clientele, the smallholder farmers.

In the Limpopo Province, 49% of the economically active population is unemployed and 62% of households live in poverty (Mekuria and Moletsane, 1996). In spite of the high national levels of food self-sufficiency, the majority of rural dwellers in South Africa are food insecure (Van Rooyen et al., 1999). In this context, the project aims at enabling the Department of Agriculture to deliver its services to small farmers, who represent the majority of land users in the communal areas of the former homelands of the Limpopo Province. Farmer controlled experimentation and innovation is a key element of the chosen Participatory Approach.

The contribution of poultry to family nutrition and income has been found to be substantial in other parts of the world. In Bangladesh, it contributes 28 % of total protein supply and in Indonesia family poultry contributes 53 % of the total income in rural households (Sonaiya et al., 1999) whilst indigenous chickens in extensive systems contribute over 60 % of commercial slaughter in Malaysia (Aini, 1990). It has been reported that family-poultry is the most important income-generating activity for rural women, landless poor and marginal farmers in developing countries like Bangladesh (Sonaiya et al., 1999). The resource poor rural communities of Alfred District in Kwazulu Natal (Swatson et al., 2001) and Mukula village in Vhembe District in Limpopo Province (Swatson et al., 2004) kept village chickens for food security, socio-economic and cultural reasons. However, the relative importance of poultry in the Limpopo Province has been shown by Schuch (1999) who found that 74 % of farmers keep chickens compared to 41 % that keep bigger animals (cattle, goats, sheep and pigs)

Specific knowledge on the production circumstances and requirements of small-scale poultry producers in the Limpopo Province is lacking. Such information is vital if this sector is to be integrated in the economic activities of the poultry industry – currently they are peripheral. There is limitation in both access and use of technology in this production system. The price of chicken is largely dependent on the body weight and small scale farmers do not have scales to weigh chickens. Linear body measurements could be taken using a measuring tape to estimate the body weight from such measurements. Until such time proper technology could be introduced coupled with training farmers to utilise such, then linear body measurements could be used to predict body weight.

The nutritional environment plays a major role in poultry production. Keeping indigenous chicken is generally considered as low input and low output system (Duguma, 2009). The feeding regime is basically through scavenging on the available feed resource or scrap (Farrell, 2000). Given the choice of different food presented by the environment, indigenous birds within a flock are able to select a diet to suit their nutritional needs (Pousga et al., 2005) as opposed to commercial breeds which are given a balanced diet. There is a need to assess the physical and chemical composition of what scavenging chickens are eating in order for us to it) identify alternative feed resources which can be studied for suitability and availability based on their nutritive value and ii) estimate the nutritive value of the mixture of all feed items consumed from both crop and gizzard for us to have an idea on the ideal nutritional requirements of this bird in order to formulate supplementing diets where need be.

In this study, participatory research (action research) or local best practices research as described by Zuber-Skerritt (1991); Clark and Filet (1994); and Hagmann et al. (1996) were practiced. The underpinning principles are to enable people to collaborate with externally-introduced and externally-designed projects and in so doing the people are empowered with respect to acquisition of skills, knowledge and capacity to analyse their situation, select the most promising options from a range of possible solutions and take concrete actions.

With all of the above issues affecting the indigenous chicken poultry production system taken into consideration, there is a need to look into the total system and come up with a recommended model which will bring improvement in the system. This model should take into consideration all the inputs such as infrastructure, technology, resources, etc. and process involved which will lead to the improvement in the sector in order to attain the desired output.

1.2 Research Objectives

1.2.1 The descriptive (theoretical) objectives were:

1.2.1.1 To determine current poultry productions practices and identify constraints and opportunities for improving performance together with communities.

1.2.1.2 To identify readily available novel feedstuffs appropriate to develop feed rations.

1.2.2 The applied objectives were:

1.2.2.1 a) To assess the physical and chemical composition of the crop and gizzard contents of scavenging indigenous chickens separately, in order to estimate the nutritional value of the scavenged feed.

b) To assess the chemical composition of the alternative protein sources identified as feed observed in crop to be considered in feed formulation and supplementation.

1.2.2.2 To investigate the possibilities of using body measurements to predict the body weight of birds.

1.2.2.3 To compare the growth of chickens and body parts in order to assess whether ratios can eliminate variations due to independent variables.

1.2.2.4 a) To assess the available policies and capacity within the Limpopo Department of Agriculture to support the advancement of the indigenous poultry sector or sector in general, and

b) To develop a decision making tool for the organizations to improve their management of the sector.

1.3 Outline of the Thesis

Chapter two presents a brief review of the general indigenous chicken production system and a number of key issues regarding the system.

Chapter three focuses on the research design and methods used for data collection. It explains the sampling procedure, pilot work, procedure for ensuring that there is buy-in, cooperation and ownership by beneficiaries. Also, it presents the data analysis plan, time schedule for the study and the limitations of the study. The study area is also presented in this chapter.

Chapter four discusses the nutritional content of crop and gizzard contents which gave the nutrients that the chickens get from scavengeable feed resource base. Individual feed items identified in the crop where sourced from local farmers and analyse for chemical composition as the available novel feed resources that family chicken feed on.

Chapter five examines whether the linear body measurements can be used to predict body weight of indigenous chickens in the traditional farming systems where technology is not accessible and affordable. It gives an indication as to whether the traits measured are positively correlated with body weight.

Chapter six discusses the comparative analysis on ratios of body parts and body weight so as to establish whether the body parts contribute that much to the live weight. This could assist our small holder farmers to take a decision on whether to sell live chicken or dress the chicken and sell body parts as it is the case in commercial farming.

Chapter seven analyses the policies and strategies available to can facilitate change in this sector. It focuses on the institutional arrangements of the organization, the capacity and patterns of past behaviour towards the organizational change that influences changes in the indigenous chicken farming systems.

Chapter eight summarises the general conclusions of this study.

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CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

There has been growing concern over the worsening problem of poverty, hunger and malnutrition in Africa. Evaluation reports from a number of integrated development projects in Africa indicate that scavenging village chickens play a significant role in poverty alleviation and enhancing gender equity among the disadvantaged communities (Saleque, 1996; Bourzat and Saunders, 1990; Branckaert, 1996; Kaiser, 1990; Ngunjiri, 1995 and Tadelle, 2003). It has been shown that backyard chickens provide rural communities with a means to convert available low quality feedstuffs (Kitalyi,1998) around the household or village into highly nutritious products, i.e. meat and eggs (Mtileni et al, 2011). Chickens form a common resource for the different gender groups in the rural population of Africa to which the landless and those who do not possess cattle, sheep or goats attach high socio-economic value. Creating physical, economic and social environment to give access to a balanced diet is the new thrust on sustainable food and nutrition security program in Africa. Malnutrition is a common phenomenon in developing world resulting in increasing demand for good quality protein, thus in turn necessitates the increase in production of poultry and pig for human consumption, of which poultry makes the largest contribution to the animal source of food (Mengesha, 2012). It is argued that to achieve this objective village chickens should be placed high in food security programs.

Scavenging chickens have existed in the villages of the African continent from time immemorial. Horst (1991) described local chickens according to major genes of dwarf, naked neck, frizzle to mention just a few. The latter serves to confirm the existence of these chickens. Table 2.1 below shows local breeds described in African countries. The local chickens form part of the whole rural farming system. In most African countries village chickens scavenge within village boundaries. The nourishment of village level chickens is greatly determined by the availability of feed and local diseases situations. A number of socio-economic factors prevailing in the village dictates the use and off take of chickens. Due to considerable differences that exist in physical and socio-economic circumstances of villages in Africa there are a variety of village chicken production systems.

Table 2.1 Distinct local breeds described from different African countries

Country	Breed	Basis of description
Egypt	Fayoumi, Dandarawi, Dokky	Growth and reproductive traits
Sudan	Baladi, Betwil	Growth traits and physical appearance
Morocco	Beldi or Roumi	Growth traits
Cameroon	Dzaye,Tsabatha, Dongwe, Zanwa	Feather colour
Mali	Kokochie	-
Burkino Faso	Africa, Konde	Origin
South Africa	Koekoek, Naked neck, Lebowa-Venda, Ovambo	Production traits

Source: Marle-Köster and Casey (2001) and Gondwe (2005)

It is imperative for African countries to use village chickens production as a tool to alleviate poverty for the following reasons; nearly all families (poor and landless) are owners of poultry in countries such as Indonesia and Bangladesh (Sonaiya et al, 1999). Furthermore, poultry is mainly owned and managed by women. Poultry meat is a socio-culturally important relish with few religious taboos attached to it. Production is feasible at village level, where only low cost technology is needed to improve production considerably. Indirectly, only low investments are needed and also land is not needed which makes village production environmentally friendly.

Traditional poultry systems constitute 80% of the world poultry population, which consists of approximately 14,000 million animals (Permin, 2004). On world basis, the production has in the past 10 years increased from 20% to 30% of animal protein. However, despite the big volume, the majority of the production is entitled “low input – low output” systems, where the animals scavenge in the vicinity of the house during daytime, sometimes given broken grains, maize bran etc. Often there are only simple or even no housing systems for the animals and management are sub-optimal. In summary, mortality is high (often >80% within the first year after hatch), especially chick mortality is about 40% within the first 3 - 4 months.

2.2 Characteristics of Village Chicken Production Systems in Africa

Most village chicken production systems in Africa are based on the indigenous or native domestic fowl (*Gallus domesticus*). Generally speaking, a low level of inputs and output characterise these production systems. The main input is the feed from household refusals as well as that scavenged around the village/homestead. Provision of other inputs such as housing, additional feed and health care varies greatly between and within African countries, depending on the household's socio-economic circumstances. Figure 2.1 below depicts the low input-low output production system as adopted from the congruence model by Nadler and Tushman (1980) and described by Gondwe (2005). Despite being low level inputs- low level output system, village chicken is capable of providing cheap and readily available meat and eggs for immediate home consumption and sale to generate income. In some communities in Africa, village chickens are important in breaking the vicious cycle of poverty, malnutrition and disease (Roberts, 1992).

It should be understood that the production system of village chicken in Africa is marginalised by policy-makers, scientists and development promoters because of its low productivity compared to the commercial poultry production system as indicated in Table 2.2. Most poultry improvement programs in Africa have been directed towards the introduction of specialised or exotic breeds, crossbreeding and management intensification. In the modern poultry production systems, there have definitely been measurable improvements in the production of eggs and poultry meat. However, the high mortality of introduced breeds, low feed resource base at the village level and lack of understanding of the complex biological, cultural and socio-economic relationships have limited the success of most of these programs at village level (Njega, 2005).

Surveys in Africa including some other developing countries have shown that households have preferred to maintain their local stock (village chicken) for social and economic reasons (Alders et al 2007). In developing world it is estimated that 70% of the poultry products are produced by resource limited farmers and in family managed poultry systems (Sonaiya, 2000) of which 80% are found in the rural areas under free range system (Alders and Spradbrow, 2001).

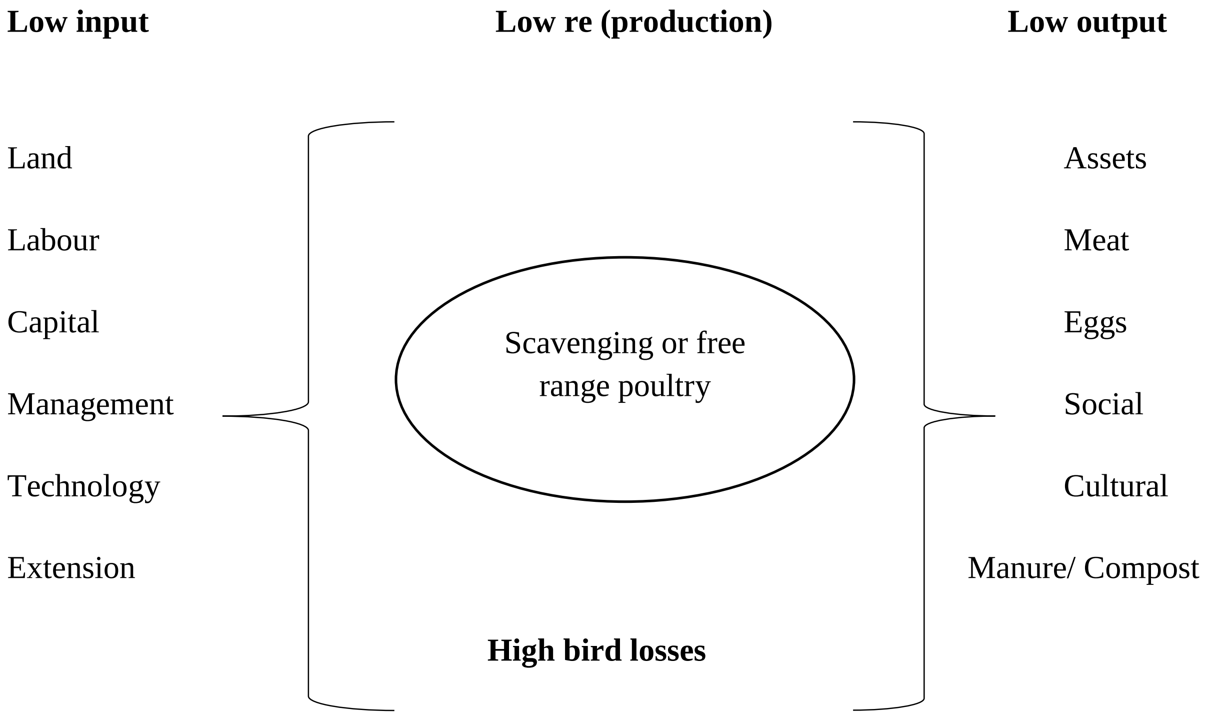

Fig 2.1 The low input- low output relationship in poultry production system adopted from congruence model by Nadler and Tushman (1980)

Regardless of the benefits village chickens bring, there is limited published data on the village chicken production system in South Africa (Nyoni and Masika, 2012). Poultry scientists have argued that the low productivity is as a result of low genetic potential, poor disease control programs and poor feeding.

2.3 Ownership and Management of Village Chickens in Africa

Ownership of village chickens in most African communities is a function of social and cultural aspects. Although village chickens move freely about the whole village, they are all attached to a specific household. The relationship between the chickens and the household head is unique and has led some researchers to describe the village chickens as part of the household, often sharing the same shelter and in most instances on woman headed household. In Ghana, for example, chickens move with the farmers between homesteads and fields (Williams, 1990).

There is a general school of thought that village chickens are in the domain of women (Kitalyi, 1996).

Tables 2.2 (a and b) below show a brief description of the different studies conducted in several African countries. The latter indicates that most African countries acknowledge the contribution of this sector in the per capita consumption of poultry meat. Estimates based on meat consumption in Ethiopia showed that village chicken provides 12.5 kg of poultry meat per capita while beef provides 5.34 kg (Forssido, 1986).

In South Africa, per capita consumption of poultry meat was estimated at 36 kg per annum which is roughly double that of beef and five times that of pork (Kreamer, 2013), out of which it is not yet known how much is from village chicken. For resource-poor households, village chicken products are often the only source of animal protein. For sick and malnourished children under the age of five, an egg provides a high-quality protein.

The attachment of the village chicken to the household and the variations in household relationships within the African villages result in different village chicken production systems. In some villages, the mixing of flocks between households is limited to scavenging periods only.

In some villages there is a greater association of flocks from different households, which can extend to sharing shelter and housing. Such situations are found in the Gambia where Rushton (FAO, 1995) described the management unit as a “compound flock”.

The management of village chickens is complicated by the presence of multi-age groups in the same flock. High chick losses have been attributed to poor feeding, housing and health control practices. With no preferential treatment of the chicks, some starve to death because of high competition for the available scavenging feed resource.

Where supplementary feeding and water is provided, the containers used are too deep for the chicks to reach the contents. Predation is also a major cause of high chick losses because the young stocks are more vulnerable. This management problem also leads to the failure or poor performance of health control programs. Competition for either vaccine, food or water results in unprotected birds. Feeding and health improvement programs will only be successful if this situation is given due consideration to ensure that the different age groups are covered

Table 2.2a Review of production and reproduction parameters in rural chickens from different studies in Africa

Reference	Country	Management	Chick weight, g	Weight at 8 week, g	Weight at 20 week, g	Adult weight, g	Age at first egg, week
Adetayo and Babafunso (2001)	Nigeria	Intensive, trial	24.3-26.5	-	858-1025	-	22
Demeke (2003)	Ethiopia	Intensive, trial	36	240	1300	-	-
Demeke (2003)	Ethiopia	Scavenging, trial	36	197	985	-	-
Dessie and Ogle (2001)	Ethiopia	Scavenging, survey	28	185	-	1035	28
Msoffe et al. (2004)	Tanzania	Intensive, trial	26-30	118-358	741-1089	-	-
Ndengwa et al. (2001)	Kenya	Intensive, trial	-	187-200	1677-1724	-	-
Tadelle, 2003	Ethiopia	Scavenging, survey	-	-	-	-	27
Tadelle et al.(2003b)	Ethiopia	Intensive, trial	30.8	150	643-877	-	-
Pederson, (2002a)	Zimbabwe	Semi-scavenging, trial	33	256	993	1726-2714	27

The importance of the flock unit in management calls for use of flock productivity indicators as a means for improvement. The failure of some past improvement programs can be attributed to a lack of appreciation of these unique features of village chickens relative to industrial poultry production.

2.4 Village Level Poultry Production in the South African Context

The low input indigenous chicken production system is very popular amongst the resource limited rural communities of South Africa. The importance of these chickens for rural food security is evident (Swatson et a.l, 2001; Van Marle-Köster et al., 2009; Mtileni et al., 2011). The resource poor rural communities of Alfred District in KwaZulu- Natal, South Africa keep village chickens for food security, socio-economic, religious and cultural considerations (Swatson et al., 2001). The relative importance of village chicken production in the Limpopo Province has been shown by Schuch (1999), who indicated that 74% of farmers keep chickens compared to 26% that keep bigger animals (cattle, goats, sheep and pigs). Indigenous chickens serve as an important source of animal protein (McAinsh et al., 2004) and source of income for the rural poor (Swatson et al., 2001; Muchadeyi et al., 2005; 2007)

Although, other poultry species which include amongst others, ducks, turkeys, guinea fowls and pigeons, rural chickens are the most important and major contributing species in the village production system of South Africa (Dyubele et al., 2010). In South Africa like in any other developing country, indigenous chickens are of dual purpose; that is, they produce both meat and eggs (Swatson et al., 2001; Mwalusanya et al., 2002; Tadelle et al., 2003; McAinsh et al., 2004; Muchadeyi et al., 2004) have the added advantages of nesting, better resistance to diseases, ability to thrive in harsh nutritional and environmental conditions (Van Marle-Köster et al, 2009). Table 2.3 below indicates the South African Local breeds as documented by Van Marle-Köster (2001). These chickens are reared in an extensive system and to a lesser extent semi intensive under subsistence farming.

Chickens are left to scavenge for food to meet their nutritional requirements. Village chickens freely roam around homesteads and scavenge for food like in any other developing world (Moreki et al. 1997; Mushi, et al., 2000, Swatson et al, 2001) with very little supplementary feeding being provided. The supplementary feeds provided depend on the grain crops planted in that particular region. Nyoni and Masika (2012) recorded the yellow maize, sunflower cake, grower mash and wheat. Kitchen waste is the most common supplementary feed as recorded in Limpopo Province, Northern Cape and Eastern Cape (Mtileni et al., 2011).

The major disease that severely affects traditional small-scale poultry production is Newcastle Disease, the highly infectious viral disease (Alders et al., 1997; Moreki et al., 1997; Mushi et al., 2000, Swatson et al., 2004, Nyoni and Masika, 2012). The extremely high mortalities reported for Newcastle disease is one of the major factors that discourage peasants from investing much of their time and scarce resources in expanding flock size (Foster et al., 1997).

Table 2.2b Review of production and reproduction in rural chickens from different studies in Africa

Reference	Country	Management	Flock size	Female: male ratio	Egg weight, g	Hatch rate, %	Chick survival, %
Adetayo and Babafunso (2001)	Nigeria	Intensive, trial	-	-	38	-	-
Mopate and Lony (1999)	Chad	Scavenging, survey	16.3	6	-	79	55
Dessie and Ogle (2001)	Ethiopia	Scavenging, survey	-	4	-	81	39
Mwalusanya et al. (2001)	Tanzania	Scavenging, monitoring	16.2	-	38	84	60
Missohou et al. (2002)	Senegal	Scavenging, survey	23	-	-	77	57
Kondombo et al. (2003)	Burkina Faso	Scavenging, survey	34	-	43	64	68
Msoffe et al. (2004)	Tanzania	Intensive, trial	-	-	44-49	62	-
Maphosa et al. (2004)	Zimbabwe	Scavenging, monitoring	23-35	4-6	-	68-73	38-66
Tadelle (2003)	Ethiopia	Scavenging, survey	-	3	-	69	51
Peterson (2002a)	Zimbabwe	Semi-scavenging, trial	-	6	44	72	45

Housing may or may not be provided and where is available, usually, the local substandard materials are used. Swatson et al. (2004) and Nyoni and Masika (2012) reported different forms of housing provided in Limpopo and Eastern Cape Provinces respectively. However, there are also cases where chickens roost on trees overnight and or in open spaces especially in the kraals.

The indigenous chickens vary in body size, from relatively small to larger birds with long legs (Horst, 1991). Poor nutrition, housing , lack of breeding principles, poor animal husbandry principles as well as cultural attitude are the major constraints in the success of this sector.

Table 2.3 Description and reproduction performance of the South African local chicken lines

Chicken line	Phenotypic Identification	Average weight hen (kg at 11wks)	[1]Age at first egg (g)	Eggs laid (51 wks.)	Egg weight (g)
Potchefstroom Koekoek	Black and white speckle males inherit. Light grey bars on feathers	1.10	138.5	204	52.02
Naked Neck	Very colourful. Naked Neck major gene	1.06	129	139	49.80
Lebowa-Venda	White and Black/ white and brown plumage, green on fearther tips	0.94	139	122	50.90
Ovambo	Brown and black plumage, aggressive birds	1.18	134.5	91	43.80

Source: Van Marle-Köster (2001) and [1] Grobbelaar et al (2010)

For farmers who need to market their chickens, price determination becomes difficult as it is dependent on body weight and there are no weighing machines or scale available in villages. Farmers look at size of the chicken (Guèye et al., 1998) to determine the price. There is a need to research on the simple technologies that village chicken farmers could use to estimate body weight.

To meet the demand of the consumers on both free range chicken and or slaughtered/ packaged portions, broilers are required to have high slaughter yields for both. Indigenous chickens are sold as whole birds (Zhao et al., 2012, as cited by Packard (2014) and this creates an opportunity where studies could be conducted to assess both quality of the carcass and the use of portions as a ratio to body weight. It is therefore important to study the carcass yield, both whole chicken and proportions (Owens et al., 2010).

2.5 Extension services and social networks in the rural chicken production system

Indigenous chickens are kept throughout the rural area and constitute a significant portion of animal kept by poorer households for consumption and marketing. The sector has been cultural and market driven with limited support from Government (Agricultural Policy in South Africa, 1998). The latter confirms that rural chicken production is carried out with minimal agricultural, veterinary or marketing extension support. Households make use of their indigenous poultry rearing knowledge acquired over a long period of time and they require training in poultry husbandry (Swatson et al., 2004). Most households shared relevant information with neighbours, usually when there is a disease outbreak or there is a need to market birds. There are no farmers or poultry organisations or platforms in rural areas from which households can share poultry husbandry information and knowledge. Individuals are members of certain organisational structures (i.e. political, religious) but there are no agricultural structures to address farmer's issues. Indigenous free-ranging chicken development has not been accorded the recognition it requires in terms of development, marketing and policy support by NGO’s and governmental institutions.

Government agricultural extension workers have the task of bringing scientific knowledge to rural farmers. The objective of their task is to improve the efficiency of agriculture, for instance, in chicken production (Nyoni and Masika, 2012). There is a need to assess the capacity of government to support sector and also assist in developing the model that could be used to enhance the productivity of this sector. It is also important to indicate that after assessment, strategies should be developed to close the gaps were there will be lack or low capacity to address the sector challenges.

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CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Research Design and data collection

3.1.1 Benchmarking & Case Study: Production and marketing

Villages from Vhembe District of the Limpopo Province were selected for the benchmarking/case study exercises. Family poultry producers and community and individual project members involved in small-scale commercial production were identified and worked with throughout the project.

The benchmarking was done through a series of community meetings and interviews:

Introducing the project and raising awareness meeting (resource mapping, community development issues, food security and wealth rankings, etc.)

a) Identification of poultry producer’s needs (including the real needs of

   resource poor community members and women) through group and sub-group meetings (disaggregating group by gender, production system, and other community recognized groupings)

b) Prioritisation of problems and needs

   Identification of possible solutions focusing on people’s own knowledge (indigenous knowledge) and current best local practices and integrating ‘new’ / external solutions to improve these

c) Identification of individuals/groups to experiment on different options

d) Identification of marketing activities and outline marketing plans of the participants, the market channel from production to consumers.

e) Assessment of record keeping practices of participants throughout production.

f) Determinants of selling chicken (is it school fees, wedding, etc.). What they sell, where, when and at what price do they sell? Is it an all year round sales?

This process enabled the community to be actively involved in the projects and provided invaluable knowledge and skills in working with rural communities and in action research.

3.1.2 The nutritional content of the scavangeable feed resource base in the area

The nutritional status of the family flocks over a 12 month period was monitored by purchasing birds from the study areas in four seasons: October –November – hot and dry, December to March – hot and wet, and April to June – cold and July to September – warm and dry. The purchased birds were sacrificed and dressed.

Weights of internal organs were recorded and the digestive tract was opened and the feed in the crop and gizzard weighed and the feed items identified through eye observation. The contents were then dried and analysed for protein, energy and mineral content. These methodologies allowed for development of technologies specifically targeted to this sector. The nutritional status survey allowed for development of supplementary feeds that complement the scavenging activity of the birds by providing those nutrients deficient at specific times of the year. The latter would greatly reduce cost of supplementary feed and will encourage higher adoption rates of the practice.

3.2 Novel feed resources

3.2.1 Evaluation of novel and less utilised feed resources

Cost and access to balanced feed is a constraint to increased productivity of poultry from rural households. Sorghum, Cow peas and Bambara nuts are examples of feed sources readily available to such households but that are not utilised by large-scale feed manufacturers because of limited quantities and uncertainty of continuous supply. The chemical composition, energy and amino acid digestibility of the readily available novel feed resources were evaluated using the adult cockerels. Crude protein content was determined with a LECO EP2000 nitrogen analyzer, based on the Dumas combustion method (AOAC, 1990). Amino acids (AA) concentrations were obtained using the AA Analyzer (Beckman System 6300, Pato, California, USA). The precision technique described by Mc Nab and Fisher (1984) was used to determine the value of the novel feed resources , that is nitrogen corrected apparent and true metabolisable energy (AMEn and TMEn) and the true AA digestibility of the samples.

3.2.2 Feed supplementation

Based on the nutritional status survey, the readily available feed resources would allow for development of supplementary feeds that complement the scavenging activity of the birds by providing those nutrients deficient at specific times of the year. Also the novel feed resources were choice fed to the birds so as to obtain an indication of what proportions of the available novel feed resources the chickens ate towards obtaining the requirements of family poultry. The cost of supplementary feeding could be greatly reduced.

3.3 Data Analysis

Data analysis for chapter four was performed using the General Linear Model Procedure of SAS (SAS, 1989). The model included the effect of household within village, season and age.

In Chapter five, summary statistics was computed and the Pearson's correlation coefficients were estimated between body weight and all body measurements. Also, the stepwise multiple regressions procedure of SAS was performed for regression equations to be estimated for the overall data and when the data were separated by sex.

When evaluation ratios on Chapter six were done, the data was analysed using simple analysis of variance procedure of SAS (2006) with each individual body part expressed as ratio of body weight and secondly live body weight was used as a covariate in the analysis of other body parts using the analysis of covariate procedure of SAS (2006).

The chemical analysis of common feed supplements, crop and gizzard contents were done according to AOAC (1990) procedures. Apparent and True Metabolisable energy were determined using the formula described by Wiseman (1987). The descriptive analysis was performed using the mean and standard deviation for each outcome variable. Data was analysed using the General Linear Model Procedure of SAS (1999).

In assessing the current ability of the organisation to execute the recommendations, the Congruence Model (Nadler and Tushman, 1980) was used to analyse the degree of congruence or fit between recommendations and the implementation plans of organisation to enhance production in this sector.

3.4 Study Area

The case study was conducted in the Mukula tribal land, Thulamela Municipality in Vhembe District of Limpopo Province, South Africa (Fig 3.1). Mukula is situated about 20 km on the North East of Thohoyandou. The area falls between latitudes of 30° 33'00" and 30° 36' 00", and longitudes of between 22° 050' 00" and 22° 052' 30". It experiences mild to moderate winters (mean 8-15°C), hot summers (mean 23-27°C) and an annual rainfall of 750 mm-1000 mm per annum. The inhabitants in the area are about 15000.

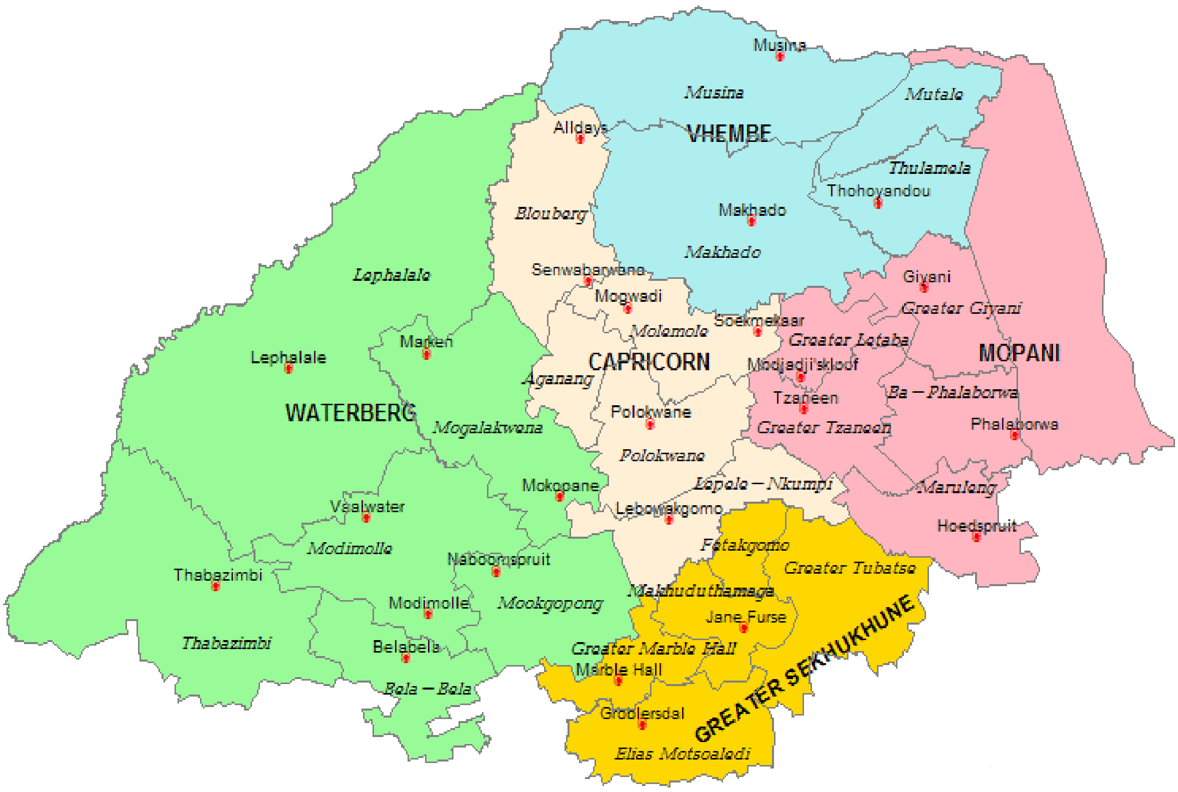

Figure 3.1 Map of Limpopo Province

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CHAPTER 4

THE NUTRITIONAL CONTENT OF THE ALTERNATIVE PROTEIN SOURCES FOR TRADITIONAL POULTRY PRODUCTION SYSTEMS

Abstract

The physical and chemical compositions of the crop contents and chemical composition of gizzard contents of scavenging chicken were assessed in this study. A total of 60 indigenous scavenging chickens, collected from rural farmers in Mukula Tribal land, Thulamela Municipality in Vhembe District of Limpopo Province of South Africa. Five chickens were slaughtered from each village in all seasons; their crops and gizzards were dissected, and crop contents were physically analysed. The crop and gizzard contents were then subjected to chemical analysis. From the physically analysed crop contents, the alternative protein sources were identified. The feed items observed from the crop ranged from grains (primarily white maize), kitchen wastes (maize meal scrap and cooked rice), green forages, and others which included worms, bugs, ants, stones and other unidentified items.

The pooled, ground crop and gizzard samples were subjected to proximate analysis to determine the dry matter, crude protein, ether extract, crude fiber, energy and ash contents. Calcium and phosphorus contents were also determined. Further analyses were done to determine the amino acid contents in both the crop and gizzard contents. The season influenced the contents of crude protein, crude fiber, ash, calcium, phosphorus and energy while village did not influence any of the variables measured.[1]

The amino acids profiles obtained in this study are very low as compared to those of a commercial layer. The energy, protein, fiber, calcium and phosphorus content in crop were significantly affected by season while village did not have any effect. The dry matter (DM g/kg) of crop content was 451.4 and the overall mean nutrient composition (g/kg of DM) of the crop contents were 59.6, 19.9, 13.4, 30.2, 2.9 and 1.2 for Crude protein, ether extract, crude fiber,

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[1]This chapter has been presented in the following conference:

Tshovhote N.J., A.E. Nesamvuni, I. Groenewald and F. Swanepoel. 2012. Nutrient concentration of the crop and gizzard contents of mature indigenous scavenging chickens in the Limpopo Province of South Africa. Proc. 44th Nat. Congr. S. African. Soc. Anim. Sci. 155, University of Stellenbosch, Cape Town, South Africa.

ash, calcium and Phosphorus respectively, and the energy content at 7.71 MJ/kg DM. The amino acid profiles from both crop and gizzard were slightly high in season two and four which are harvesting seasons. The following alternative protein sources identified from the crop contents: mopani worms, termites, sting bugs, pumpkin seeds, beans and bambara nuts were collected from the farmers and subjected to the proximate analysis. The crude protein content of mopani worms (586.5 g/kg) and sting bugs (548.3 g/kg) were similar but higher than that of pumpkin (351.1 g/kg) and legume seeds (196.5 g/kg and 188.1 g/kg for bambara nuts and beans respectively). All the potential alternative protein sources analyzed in this study provided large amounts of phosphorus (P) ranging from 2.6 to 3.6 g/kg but mopani worms and termites were the better sources of dietary calcium as compared to sting bugs, pumpkin and leguminous seeds (ranging from 1.09 to 3.2 g/kg .The AMEn of sting bugs (22.12 MJ/kg) and pumpkins (18.20 MJ/kg) is greater than that of mopani worms (11.34 MJ/kg), termites (9.30 MJ/kg) and legume seeds (10.2 and 9.1 MJ/kg DM for bambara and beans respectively).

Key words: Crop contents, gizzard contents, nutrients, scavenging chickens, season and village

4.1 Introduction

The rearing of indigenous chickens in rural areas in the world is generally considered as low input and low output production system (Guèye, 1998; Duguma, 2009). These chickens are of dual purpose in nature; that is, they produce both eggs and meat for household consumption at little or no cost to the producers. The rural or village chicken production in rural areas of Limpopo Province in South Africa is not an exception to this system and thus it depends mainly on household scavenging chickens (*Gallus domesticus*). The feeding regime of these chickens is basically through scavenging. Thus birds are left to depend on what nature offers and this means that the scavangeable feed resource base will never be constant. They rely more on worms, insects, larvae and snails but mainly on household scraps for food (Alemu and Tadele, 1997; Farrell, 2000). The chickens are of indigenous types and are kept in small flocks with or without proper shelter and better management practices. They constitute more than 70% of the country's chicken population (Huque and Paul, 2001).

The major feed sources for village chickens are mainly household scraps, earthworms, insects, seeds, larvae, snails, leaves, other plant materials found in household yards (Farrell, 2000).

Occasionally, they are given grains and always depend on what is being harvested by that time. The nutrients available to locally scavenging chickens are generally deficient. The availability also vary with the seasons of the year and the localities, as reported in studies carried out in some developing countries such as Sri Lanka (Gunaratne et al., 1993), Ethiopia (Dessie, 1996), Bangladesh (Huque, 1999), and Tanzania (Mwalusanya et al., 2002). Scavenged nutrients also vary to some extent by the foraging habit which may differ with the type of bird (genotype and physiological status) as observed for instance by Mwalusanya et al. (2002). These chickens provide protein in the two folds- that is, meat and eggs.

The use of equations to predict the energy and protein requirements of these birds are inappropriate as they are based on the high producing, improved and caged breeds whereas the foraging chickens travel an estimate of 1.5km for 26 weeks of the year (Farrell, 2000). The whole concept of chickens foraging from the food forest relies on their ability to select the feed items from the surrounding. Given a choice of various feed resources, individual birds in a flock are able to select a diet to suit their individual needs which is one of their survival or hardy character (Mtileni et al., 2011).

There is a need to intensify and improve the efficiency of livestock production practices in a sustainable manner that reduces the dependency on external inputs. However, that must be done while conserving the natural resource base and promoting biodiversity which has been widely recognised (Kudo, 2000) throughout the world. This call to move away from a dependency on external inputs makes much sense in this time of increasingly expensive fossil fuels. If the capacity of the scavenging feed resource base (SFRB) and the seasonal variations are known, more efficient strategies for production of scavenging village chickens can be developed. In this context, feed supplementation should be considered according to the probable nutrient requirements of the birds and what the birds get from the scavenging sources. Therefore, accurate estimation of the quantity of available feed and nutrient intake by the scavenging village chickens are important prerequisites for improving feeding systems and management, in terms of effective feed supplementation (Ajuyah, 1999). Another way of improving feeding is by upgrading the birds' SFRB through planting a collection of fruit-producing perennials (Samnang, 1998) and seed-producing perennials. Such a "food forest" of trees, shrubs and climbers should aim at yielding the quality and quantity of food (seeds, fruits, leaves, and attracted insects and other small creatures) that the birds need to eat.

In Bangladesh, the protein and fiber content of the scavenging feed at different locations were found to be too low and too high, respectively, in the light of required nutrients for high egg production (Huque, 1999). However, the study evaluated the nutrient contents of mixed ingesta of crop and gizzard, which may not reflect the true nutrient content of scavenged feed.

Thus, the present study was undertaken to assess the physical and chemical composition of the crop and gizzard contents of scavenging indigenous chickens separately, in order to estimate the nutritional value of the scavenged feed during four different seasons.

4.2 Materials and methods

4.2.1 Study area and seasons

The research was conducted in the Mukula tribal land, Thulamela Municipality in Vhembe District of Limpopo Province, South Africa. Mukula is situated about 20km on the North East of Thohoyandou. This area falls between latitudes of 30° 33' 00" and 30° 36' 00", and longitudes of between 22° 50' 00" and 22° 52' 30". It experiences mild to moderate winters (mean 8-15°C), hot summers (mean 23-27°C) and an annual rainfall of 750 mm-1000 mm per annum. The chicken population studied was comprised of indigenous scavenging flocks at three adjacent villages in Mukula which are Mukondeni (MK) as village 1, Phindula (PH) as village 2 and Satani (ST) as village 3. It is a shallowly flooded area of the river flood plains, which rises less than 10 meters above sea level. The chickens in the study area were left free to scavenge during daytime and confined in the evening following the procedure usually being practised.

4.2.2 Sampling, preparation of samples and chemical analysis

Five birds were collected directly from each of the five households in three villages in the evening between 4.00 p.m. and 6.00 p.m. when the birds were at the end of the day's scavenging in all the four seasons. The four seasons are described as Season 1: autumn (February to April – hot and wet), season 2: winter (May to July – cold), season 3- spring (August to October– warm and dry), and season 4- summer (November to January- hot and dry). They were weighed and slaughtered on the spot by cutting at the cervical region in all the four seasons. Each bird was eviscerated, the crop opened, and the feed items found in the crop of each individual bird were identified visually, and weighed. The gizzards were also opened, and the contents were collected, weighed. All samples were kept in the freezer (-20^{0}C) until preparation. Crop and gizzard samples from each household for each season were pooled to increase the sample quantity (n=12) irrespective of the type of chicken. After taking out the contents of crop and gizzard from the freezer, they were dried and weighed. The dried crop and gizzard contents were ground.

4.2.3 Chemical analysis of crop and gizzard contents

The individually pooled and ground crop and gizzard contents were analysed for the proximate components of dry matter (DM), crude protein (CP), and ether extract (EE), crude fibre (CF) and ash, according to AOAC (1990) procedures. Calcium (Ca) and total phosphorus (P) were determined by atomic absorption and spectrophotometry, respectively (FAO, 1980). Due to little sample availability, gizzard contents were only analysed for crude protein. For analysis of amino acids, samples (1 g) of crop and gizzard contents were pooled according to the household in each season, giving in total four samples. Amino acid profiles were determined by HPLC, according to AOAC (1990). True Metabolisable energy (TME) of the crop contents was determined by using the formula of Wiseman (1987): TME (kcal/kg DM) = 3951 + 54.4 EE - 88.7 CF - 40.8 ash. Apparent Metabolisable energy (AME) was then determined on the basis of TME by assuming that TME was 8% higher than the AME, since TME is noted to be 5-10% higher than AME (Wiseman, 1987). Moreover, samples of common feed supplements were obtained from farmers and pooled within ingredient source, and subjected to the analysis of proximate components, Ca and P.

4.2.4 Proximate analysis

The Mopani worms, stink bugs, termites, pumpkin seeds, sugar beans and Bambara nuts dried samples were ground to pass through the 1mm sieve before the chemical analyses were done. Dry matter was calculated from the analysed moisture content. Crude protein was determined with a LECO EP2000 Nitrogen Analyzer based on the DUMAS Combustion method. Amino acids concentrations were obtained using the AA Analyzer (Beckman System 6300, Palo-Alto, California, USA). For the digestibility trail, three groups of 12 adult cockerels were each fed different insect and leguminous seeds samples and the third group was fed glucose solution.

The precision feed technique as described by Mc Nab and Fisher (1984) was used to determine nitrogen corrected apparent and true metabolisable energy (AMEn and TMEn, respectively). The AMEn and TMEn values for each sample were determined in duplicate and each duplicate value represented a pooled determination from the six birds.

4.2.5 Statistical Analysis

The descriptive analysis was performed using the mean and standard deviation for each outcome variable. Data was analysed by a General Linear Model (GLM) procedure of SAS (1999) based on the following statistical model:

$Y_{ijk} = m + S_i + T_j + ST_{ij} + E_{ijk}$

Where Y_{ijk} is an observation for a given variable, m is the general mean common to all observations;

S_i is the effect due to the ith season (I=1, 2, 3, 4);

T_j is the effect due jth village (J=1, 2, 3);

STij is the effect due to interaction between the ith season and the jth village and

E_{ijk} represents the random effects peculiar to each observation. A 5% significant level was used.

4.3 Results and discussions

4.3.1 The physical and chemical composition of crop contents

The feed ingredients observed from the crop contents are presented in Table 4.1. The main components of the crop contents were visually categorised into grains, kitchen waste, green forage, insects and worms. The maize grains were observed as high proportion in crop contents and the hardened cooked maize meal formed a higher proportion of kitchen wastes. This is attributed to the fact that maize is the staple food in the villages where the study was undertaken.

Table 4.1 Physical composition of the chickens' crop contents

Categories	Feed items/ingredients
Grains	Maize, pumpkin seeds, beans, pieces of nuts, grass seeds
Kitchen wastes	Maize meal scrap from the kitchen, cooked rice
Green forages	Grasses and plant material
Others	Earthworms, Mopani worms, sting bugs, termites, ants, flies, sand stones and unidentified ingredients

4.3.2 Chemical composition of available potential protein feed supplements

In practice, free range or scavenging village chickens diets are based largely on vegetable matter and cereals. There are virtually few publications on alternative energy sources and none on alternate protein sources such as termites, worms and caterpillars in feeding these chickens. The visual observation of components in the crop contents suggested potential alternative protein sources that can be used to supplement the protein deficiency in the scavengeable feed resource base. As shown by Farrell (2000), the observation from this study had worms, insects, pumpkin seeds, beans and bambara nuts together with maize grains and household waste. These observations then gave us the opportunity to identify those alternative protein sources from local farmers to be able to analyse their nutrients profiles. The analysed nutritional values of potential protein sources in presented below (Table 4.2). The AMEn of sting bugs (22.12 MJ/kg) and pumpkins (18.20 MJ/kg) is greater than the one of Mopani worms (11.34 MJ/kg), termites (9.30 MJ/kg) and legume seeds (10.2 and 9.1 MJ/kg DM for Bambara and beans, respectively). The observation from the crop contents indicated that the most abundant feed resource is maize which is an energy source and the other feed ingredient classified as others are more of the protein source. Most of the energy ingredients have proximate analysis done by NRC (1994). Hence, the analysis presented below focuses on the protein sources only and this is justified by the fact that protein sources in rural areas are limited.

The crude protein content of Mopani worms (586.5 g/kg) and sting bugs (548.3 g/kg) were similar but higher than that of pumpkin (351.1 g/kg) and legume seeds (196.5 g/kg and 188.1 g/kg for Bambara nuts and beans respectively).

Table 4.2 Chemical composition of the available potential protein feeds commonly found in the area.

Protein source	Energy (AMEn, MJ/kg)	Crude Protein (g/kg)	Calcium (g/kg)	Phosphorus (g/kg)
Mopani worms	11.34	586.5	3.2	4.6
Sting bugs	22.12	353.4	0.9	3.7
Termites	9.3	548.3	1.8	3.8
Pumpkin	18.2	351.1	1.0	0.9
Beans	9.1	196.5	1.2	3.6
Bambara nuts	10.2	188	0.6	2.8

All the potential alternative protein sources analysed in this study provided large amounts of phosphorus (P) ranging from 2.6 to 3.6 g/kg but Mopani worms and termites were the better sources of dietary calcium as compared to sting bugs, pumpkin and leguminous seeds (ranging from 1.09 to 3.2 g/kg The chemical analysis of the potential alternative proteins indicated the same challenge of protein quality limitations. This then suggests that simple processing of these resources like drying of insects and steaming of leguminous seeds, milling or cracking of cereal grains may be required to improve the quality of these resources (Swatson et al., 2001; Tshovhote et al., 2003). Several researchers have indicated successful ways of culturing earthworms and termites (Farina et al., 1991) as other sources of protein for feeding chickens to reduce competition for high value crops with human for their own consumption (Swatson et al., 2001). Maggot meal contains crude protein at a range of 390 to 454 g/kg and 207 to 253 g/kg of lipid. It is possible to include a maximum of 3 percent of this meal in chicken diets as suggested by Atteh and Ologbenla (1993).

The chemical composition of crop and gizzard contents, for nutrients which showed the effect of either season or village is presented in Table 4.3 and 4.4 respectively. The mean DM % of crop content was 451.4 g/kg and the overall mean nutrient composition (g/kg of DM) of the crop contents were 59.6, 19.9, 13.4, 30.2, 2.9 and 1.2 g/kg for crude protein, ether extract, crude fiber, ash, calcium and phosphorus respectively, and the energy content was 7.71 MJ/kg DM.

Table 4.3 Chemical composition of crop contents (g/kg) summarized by season (mean ± sd)

Nutrient	Season				P value	Minimum requirements for layers*
	Autumn	Winter	Spring	Summer		
DM (g/kg)	432.0 ± 62.3	448.3 ± 107.9	335.9± 64.1	589.2± 64.2	0.508	na
CP	54.7 ± 7.5	55.8 ± 16.0	44.3± 4.2	83.7 ±10.9	0.021	165
EE	22.3 ± 4.7	16.7 ± 5.3	16.2 ± 2.2	24.4± 6.5	0.218	na
CF	14.0 ± 6.4	10.2 ± 2.2	7.0 ± 2.2	14.2 ± 0.8	0.076	na
ASH	41.4 ± 15.3	34.9 ± 14.0	26.2 ± 6.4	18.3 ± 3.5	0.222	na
Ca	6.1 ± 3.2	2.1 ± 1.0	1.2 ± 0.4	2.5 ± 0.5	0.066	36
P	1.0 ± 0.5	1.1 ± 0.3	0.9 ± 0.2	1.8 ± 0.3	0.067	2.7
AMEn (MJ/kg DM)	7.19 ± 1.40	7.67 ± 2.10	5.63±1.26	10.34±1.84	0.073	12.1

***NRC (1994), na = not available**

Crude protein, crude fiber, calcium, phosphorus and energy (AMEn) were significantly affected by season (P < 0.1). The fact that there were no significant differences in the nutrient contents amongst the villages may be attributed to the fact that these villages are adjacent to each other and the production systems practised may not be different. The crude protein intake (5.44 – 6.08 g/d) from scavengeable resources from this study was lower than 9.48 g/d reported by Tuitoek et al. (2000) but similar to the 6 g/day requirement as indicated by Farrell (2000). In contrast, Scot et al. (1982) reported the crude protein daily requirement of 11 g/day in confirmation of the protein limitation of scavengeable feed resources on protein supply especially on essential amino acids. Sonaiya et al. (2002) reported the daily protein and energy requirements which are lower than what was reported by Farrell (2000). The differences may be attributed to a lot of things ranging from evolution, the ability of the chicken to select better protein resources and natural genetic improvement of the chickens themselves and or it may be dependent on the region or the place of production.

Table 4.4 Chemical composition of crop contents (g/kg) summarized by village (mean ± sd)

Nutrient	Village			P Values	Minimum requirements for layers*
	Mukondeni	Phindula	Satani		
DM	399.6 ± 10.92	487.0 ± 10.94	467.5±15.06	0.361	na
CP	54.4 ± 1.55	63.7 ± 1.87	60.8 ± 2.23	0.508	165
EE	17.6 ± 0.51	21.1 ± 0.55	20.9 ± 0.66	0.565	na
CF	8.95 ± 0.38	11.6 ± 0.24	13.6 ± 0.57	0.174	na
ASH	28.8 ± 1.56	32.4 ± 1.72	29.4 ± 0.87	0.908	na
Ca	23 ± 0.08	36 ± 0.33	29 ± 0.28	0.625	36
P	1.2 ± 0.02	1.4 ± 0.04	1.1 ± 0.07	0.534	2.7
AMEn (MJ/kg DM)	6.80 ± 1.97	8.32 ± 2.24	8.01 ± 2.92	0.464	12.1

***NRC (1994), na = not available**

The crude protein contents presented in both crop and gizzard contents analyses (Table 4.3 and 4.5) confirms the results from previous studies which indicated the protein quality limitations in scavenged diets (Okitoi et al., 2009, Swatson et al., 2001).The observation made in this study is that the EE, CF and Ash content in crop and gizzard content, like all the other nutrients EE, followed the same trend but not affected by both season and village. The table above indicates that the nutrients intake of indigenous chickens is lower than the minimum requirements of a commercial layer chicken. These results concur with the report by Rahman et al. (2006). However, it is noted that calcium content of chickens from Phindula village was equal to the minimum requirements and from Satani is equal to the minimum requirements.

The observation made in this study was that ash, calcium and phosphorus contents were significantly influenced by season as indicated in Table 4.6 below ($P \leq 0.1$). This may be attributed to a lot of stones and bones observed in the crop contents which passed through to the gizzard from crop undigested. The crude protein content in gizzard was less than in crop contents. This may be attributed to the digestion of crude protein in the proventriculus on the way from crop to gizzard. The amino acid profiles of both crop and gizzard contents suggest that the contents were slightly higher in seasons two and four which are the harvesting seasons

(Table 4.5 and 4.6). However, none of the amino acids attained the required level of layers' or growers' diet as recommended by NRC (1994).

The results of crude protein in crop, gizzard contents and amino acids profiles (Table 4.7 and 4.8) clearly suggest that no matter how these chickens strive hard to balance their diets, the available resources available for them to feed on are limited in protein. This might be attributed to the fact that the feed resources available are mostly the energy resources such as maize and household waste. As most of the alternative protein sources scavenged such as insects and legumes might be covered with thick cuticles which may render protein to be indigestible, these sources may require some processing a bit to ensure that the protein and amino acids are readily available.

Table 4.5 Chemical composition of gizzard contents (g/kg) summarised by season (mean± sd)

Nutrient	Season				P values
	Autumn	Winter	Spring	Summer	
DM (g/kg)	629.0 ± 94.4	633.4 ± 29.9	705.5 ± 22.5	675.2 ± 26.2	0.367
CP	25.5 ± 8.0	22.6 ± 2.5	21.2 ± 4.2	24.1 ± 4.9	0.834
EE	9.1 ± 1.4	9.0 ± 4.6	5.8 ± 0.3	8.6 ± 2.5	0.269
CF	19.4 ± 7.6	17.3 ± 4.4	8.2 ± 3.8	18.6 ± 12.1	0.402
ASH	464.7 ± 96.8	472.9 ± 44.1	601.9 ± 46	525.6 ± 75.8	0.188
Ca	2.0 ± 1.3	1.0 ± 0.4	2.2 ± 1.4	2.1 ± 2.0	0.345
P	0.7 ± 0.4	0.4 ± 0.1	0.6 ± 0.5	0.4 ± 0.1	0.302
AMEn(MJ/kg DM)	2.08 ± 0.18	1.97 ± 0.50	0.86 ± 0.04	1.71 ± 0.94	0.136

In order for us to increase the production of these chickens, in addition to provision of proper shelter, disease management programs, extension support and capacity building; there is a need to look into feed supplementation (both protein and energy) as opposed to the current practice of providing them with household refuse and maize grains which are solely the energy sources.

Table 4.6 Chemical composition of gizzard contents (g/kg) summarized by village (mean ± sd)

Nutrient	Village			P values
	Mukondeni	Phindula	Satani	
DM	678.6 ± 58.0	639.3 ± 79.5	664.5 ± 23.5	0.628
CP	25.0 ± 1.0	22.4 ± 7.9	22.7 ± 3.8	0.792
EE	6.8 ± 0.9	7.1± 1.7	10.5 ± 3.4	0.078
CF	12.9 ± 8.4	16.7 ± 9.7	18.0 ± 7.4	0.692
ASH	547.3 ± 92.1	504.8 ± 101	496.7 ± 64.1	0.606
Ca	3.3 ± 1.4	0.9 ± 0.3	1.3 ± 0.2	0.012
P	0.8 ± 0.4	0.4 ± 0.2	0.4 ± 0.1	0.061
AMEn	1.64 ± 0.76	1.46 ± 0.60	1.88 ± 0.79	0.611

Rashid et al. (2005) also supported the findings by other researchers which indicated that a concentration of nutrients available to the indigenous chickens under rural environment was below the requirements of growers and layers and also limiting in protein supply and suggested the supplementary feeding is necessary to curb the deficiencies (Mwalusanya et al.,2002). However, this should not increase the inclusion of the highly nutritious feed resources to avoid competition with human consumption. Hence, the need to explore the potential of using by-products from agro processing industry such as feed mills and brewer mills to mention just a few.

Table 4.7 Amino Acid (g/100g) profile of the crop contents summarized by season and village

Amino acid	Season				P values	Village			P values	Minimum Required*
	1	2	3	4		1	2	3		
ARG	0.19	0.22	0.17	0.31	0.012	0.22	0.14	0.22	0.953	7.00
SER	0.17	0.21	0.15	0.27	0.050	0.19	0.22	0.21	0.748	na
ASP	0.25	0.3	0.21	0.37	0.017	0.27	0.21	0.3	0.586	na
GLUT	0.57	0.7	0.52	1.04	0.019	0.65	0.29	0.72	0.616	na
GLY	0.18	0.19	0.15	0.24	0.032	0.18	0.76	0.21	0.312	na
THRE	0.13	0.16	0.12	0.21	0.037	0.15	0.16	0.16	0.974	4.70
ALA	0.36	0.39	0.27	0.48	0.024	0.32	0.41	0.39	0.197	na
TYR	0.23	0.24	0.22	0.56	0.262	0.19	0.26	0.48	0.231	na
PRO	0.34	0.4	0.27	0.54	0.034	0.34	0.42	0.41	0.363	na
HPRO	0.02	0.02	0.02	0.02	0.454	0.02	0.02	0.02	0.096	na
METH	0.08	0.08	0.05	0.1	0.301	0.09	0.08	0.07	0.658	3.00
VAL	0.22	0.24	0.17	0.3	0.031	0.2	0.24	0.24	0.302	7.00
PHEN	0.19	0.23	0.16	0.32	0.014	0.2	0.24	0.24	0.395	na
ISOLE	0.17	0.19	0.14	0.24	0.038	0.16	0.20	0.20	0.298	na
LEU	0.45	0.54	0.36	0.76	0.028	0.46	0.57	0.54	0.451	na
HIST	0.19	0.24	0.16	0.26	0.276	0.19	0.20	0.24	0.531	na
LYS	0.20	0.20	0.18	0.24	0.274	0.18	0.20	0.24	0.126	6.90

***Layer minimum requirement (g/100g) , Season 1 Autumn , season 2 winter, season 3 spring and season 4 summer Village 1 Mukondeni, village 2 Phindula and village 3 Satani, na not available**

Table 4.8 Amino Acid profile of the gizzard contents summarized by season and village (g/100g)

Amino acid	Season				P value	Village			P value	Minimum Required*
	1	2	3	4		1	2	3		
ARG	0.16	0.17	0.16	0.12	0.488	0.18	0.14	0.15	0.306	7.00
SER	0.11	0.09	0.11	0.07	0.598	0.11	0.06	0.09	0.258	na
ASP	0.09	0.09	0.09	0.1	0.724	0.1	0.09	0.11	0.645	na
GLUT	0.23	0.22	0.23	0.17	0.131	0.22	0.18	0.22	0.103	na
GLY	0.14	0.17	0.14	0.09	0.619	0.15	0.08	0.1	0.263	na
THREO	0.07	0.07	0.07	0.06	0.629	0.08	0.06	0.06	0.059	4.70
ALA	0.12	0.17	0.12	0.09	0.076	0.12	0.09	0.11	0.026	na
TYR	0.06	0.11	0.06	0.08	0.474	0.08	0.11	0.08	0.664	na
PRO	0.23	0.16	0.22	0.12	0.336	0.22	0.1	0.15	0.193	na
HPRO	0.02	0.01	0.02	0.01	0.310	0.02	0.01	0.01	0.673	na
METH	0.09	0.03	0.09	0.02	0.593	0.08	0.02	0.03	0.389	3.00
VAL	0.09	0.08	0.09	0.07	0.396	0.09	0.07	0.08	0.121	7.00
PHENY	0.09	0.07	0.09	0.06	0.224	0.08	0.05	0.08	0.092	na
ISOLEU	0.08	0.06	0.07	0.06	0.253	0.08	0.05	0.06	0.082	na
LEU	0.17	0.14	0.17	0.12	0.045	0.16	0.12	0.15	0.048	na
HIST	0.12	0.06	0.12	0.06	0.208	0.12	0.05	0.06	0.338	na
LYS	0.11	0.08	0.11	0.07	0.529	0.12	0.07	0.07	0.091	6.90

***Layer minimum requirement (g/100g), Season 1 autumn, season 2 winter, season 3 spring and season 4 summer; Village 1 Mukondeni, village 2 Phindula and village 3 Satani, na= not available**

4.4 Conclusions

From the results of this study, it is apparent that the nutrient intake from the available scavengeable feed resources of the indigenous chickens was below the requirements of free ranging chickens. It was also evident that the scavengeable feed resource had limitations on the protein supply and hence amino acid supply will also be in deficit. The recommendations drawn from this study is that supplementary feeding is required for the chickens to can show their performance potential. Furthermore, the supplementation should look into both energy and protein thus offering two complementary feeds may be an effective method to allow birds to select and meet their requirements. It has also been shown that season had an effect on crude protein which then indicates that feed formulation for nutrient supplementation for scavenging chickens may even be more critical during certain seasons of the year. It may be practically recommended to make use of unconventional sources of protein rather than the conventional one such as fish and soybean meals which are expensive.

The scavengeable feed resource base has been observed to contain mostly the cereal grains such as maize; sorghum and millet commonly used to feed indigenous chickens are deficient in amino acids. The results of the unconventional alternative protein sources from this study gave an indication that they may be good sources of protein, calcium and phosphorus. However, simple processing may be required to improve the quality of the protein sources before feeding to make protein to be accessible to chicken, thus to overcome the protein limitation of the scavenged diets. The scope of novel feed resources can still be broadened by studying the effect of tannins in growth performance and determining the cost effective means of reducing their effect. The provision for supplementary feeds and improved husbandry conditions would lead to the improved production in indigenous chicken and consequently improving household food security, nutritional status and house hold incomes.

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CHAPTER 5

PREDICTION OF BODY WEIGHT OF MATURE INDIGENOUS CHICKENS IN LIMPOPO PROVINCE OF SOUTH AFRICA USING LINEAR BODY MEASUREMENTS

Abstract

Body weights and body measurements were collected from 254 mature indigenous chickens to investigate possibilities of using body measurements to predict body weight. Three villages were identified on the basis of a province wide survey of households that keep indigenous chickens. Body length (BL), chest circumference (CC), femur (F), crus (C), and tarsometatarsus (TM) obtained from 98 males and 156 females across four distinct seasons from March 2005 to March 2006 were recorded using weighing scale and a measuring tape. Summary statistics were computed, Pearson's correlation coefficients were estimated between BW and all body measurements and BW regressed to all body measurements for both sexes. Males showed higher BW and body measurements compared to females ($P<0.0001$). Body measurements were strongly correlated to the BW ($P<0.0001$). Body weight was correlated to the BL ($P<0.001$ in males and $P<0.01$ in females) and CC. The R^2 values indicated improvements of about 25 % to 50 % for males, and 37 % to 50 % for females when BW was regressed against BL and CC. Thus, CC and BL are body measurements most suitable for the prediction of the body weight. [2]

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[2]This chapter has been presented at the following conference:

Tshovhote, N. J., Nesamvuni, A. E., Nephawe, K. A., Groeneiwald, I, Swanepoel, F and Norris, D. 2008. Prediction of body weight of mature indigenous chickens in Limpopo Province of South Africa using linear body measurements. Poster presented at the World Congress on Animal Production held in association with the 42nd South African Society of Animal Sciences Congress. Cape Town ICC, South Africa, 23 – 28 November 2008.

Key words: Body measurement, body weight, indigenous chickens

5.1 Introduction

The contribution of poultry to family nutrition and income has been found to be substantial in developing parts of the world. In 1995, the chicken population in Senegal was estimated to be 40 million (Anonymous, 1996), and more than 70 % of it are constituted by the indigenous chickens (Guèye and Bessei 1997; Guèye 1998a). In Senegalese rural areas, indigenous chickens are generally raised in free-range and/or backyard systems, which are traditional extensive husbandry systems (Guèye, 1997). In Bangladesh, for example, poultry contributes 28% of the total protein supply and in Indonesia family poultry contributes 53% of the total income in rural households (Sonaiya et al., 1999). In Malaysia indigenous chickens in extensive production systems contribute over 60% of commercial slaughter (Aini, 1990). Huque (1999) reported that family poultry is the most important income generating activity for rural women, landless poor and marginal farmers in Bangladesh. The rural households in South Africa rear village chickens which contribute to their livelihoods, however, the depth of the information on this enterprise is lacking despite its contribution to the rural livelihoods. Nyoni and Masika (2012) also shared the same observation.

The relative importance of poultry in the Limpopo Province has been shown by Schuch, (1999), who indicated that 74% of farmers keep chickens compared to 15% that keep larger animals (cattle, goats, sheep and pigs). Poultry keeping is of great importance to Limpopo households. Outside the urban centers, and especially in non-coastal areas, family poultry provides the population with a vital source of protein and income, and plays a key role within the context of many social events (e.g. special banquets for family or for distinguished guests, cocks as alarm clocks for people, gifts, etc.) and / or religious ceremonies (e.g. cocks as offerings to the deities). The industry is largely based on domestic chicken production. Generally, rural chickens are perceived as poor producers and led to their replacement by commercial strains, hence the most information available for intensive broiler production (Dana et al, 2011). Tecklewold et al. (2006) indicated that the strategies to pursue increased production failed to bring sustainable improvement. The latter, however poses a threat to existing genetic diversity of indigenous chickens (Besbes, 2009). In contrast to the statement by Tecklewold et al. (2006), it has been shown that there is high genetic variation within ecotype which indicates the potential for genetic improvement in the chicken through selective breeding (Muchadeyi et al., 2007; Halima et al., 2009). Most farmers need improved growth as measured by body weight and egg production in the small holder poultry production system (Moreki, 2006; Dana et al., 2010). Despite the importance of this subsistence poultry sector in Limpopo, the marketing system is quite informal and poorly developed. The price of chicken largely depends on body weight. However, there is generally no weighing machine or scale available in poultry markets and in villages. The objective of this study was to investigate the possibilities of using body measurements to predict the body weight of mature indigenous chickens in the Limpopo Province with high level of accuracy.

5.2 Materials and methods

Data on body weight and body measurements were individually collected from 254 mature indigenous fowls with the objective to investigate the possibilities of using body measurements to predict the body weight of birds. Three villages were identified on the basis of a province wide survey of households in rural set-up that keeps indigenous chickens. Measurements were obtained from 98 males and 156 females across all four distinct seasons in a year from March 2005 to March 2006. The data of indigenous chickens were collected at Vhembe and Capricorn districts in Limpopo.

Using an electronic weighing scale and a measuring tape, information on body weight and body measurements was individually collected from chickens in each village during visits to the three villages from March 2005 to March 2006. Body measurements included body length (BL), circumference of chest (CC), femur (F), crus (C), and tarsometatarsus (TM), as described by Salomon (1996) and the definitions of the traits are as defined in Table 5.1. Measurements were carried out as follows:

Table 5.1 The body measurements description

Trait	Definition
Body Length	Length between the tip of the *Rostrum maxillare* (beak*)* and that of the *Cauda* (tail, without feathers). The bird's body should be completely drawn throughout its length
Chest Circumference	Circumference of the chest taken at the tip of the *Pectus* (hind breast).
Femur	Length between the mid region of the *Coxa* (hip bone) and that of the *Genu* (knee).
Crus	Length between the mid region of the *Genu* and that of the *Regio tarsalis*
Tarsometatartus	Length between the mid region of the *Regio tarsalis* and the outset of the *Digitus pedis IV*.

Summary statistics of the data was computed and Pearson’s correlation coefficients were estimated between BW and all body measurements to determine the phenotypic differences amongst the traits. Data was analysed using multiple regression procedure of SAS in two ways: (i) the overall data and (ii) data separated for each sex. This enabled us to estimate regression equation for the overall data as well as a separate regression equation for males and females. The most comprehensive model was as follows:

$$Y = b_0 + b_1 (BL) + b_2 (CC) + b_3 (F) + b_4 (C) + b_5 (TM) + e$$

Where;

Y = is the dependent variable body weight,

b_0 = the intercept

b_1 = the regression coefficient of body length (BL)

b_2 = the regression coefficient of chest circumference (CC)

b_3 = the regression coefficient of femur (F)

b_4 = the regression coefficient of crus (C)

b_5 = the regression coefficient of tarsometatarsus (TM), and

e = the residual

The stepwise multiple regression procedure in SAS was used to determine the best fitted prediction equation for BW based on the linear body measurements and results are presented in Tables 5.2, 5.3 and 5.4. Each variable was subjected to test to meet a 0.05 significance level for entry into the model (forward stepwise).

5.3 Results and discussions

The mean values for BW and body measurements with respect to the sex of Limpopo indigenous chickens brought for sale are presented in Table 5.2. In comparison with the males, more females (61.4%) were sold from indigenous chicken flocks.

The males showed higher values of BW and body measurements ($P<0.0001$) as compared to females. Males were 376 g heavier in BW, 4.27 cm longer in BL, 2.46 cm broader CC, 0.97 longer in F. The results agree with reports by Ngou Ngoupayou (1990) and Missohou et al. (1997) on indigenous chickens, and Hassan and Adamu (1997) on indigenous pigeons as cited by Guèye et al. (1998) who reported 1.37 and 1.12 BW for males and females respectively. Also, body measurements recorded in this study were high in males as compared to females.

Table 5.2 Least Square Means for body weight and body measurements

Traits	Overall Data	Males	Females
	N=254	N= 98	N=156
Body weight (g)	1493.92 ± 356.58	1724.54 ± 368.00	1349.04 ± 260.84
Body measurements (cm)			
Body length (cm)	38.89 ± 4.06	41.52 ± 3.69	37.25 ± 3.36
Chest circumference (cm)	32.47 ± 3.94	33.98 ± 3.97	31.52 ± 3.62
Femur (cm)	10.84 ± 1.96	11.44 ± 2.11	10.47 ± 1.75
Crus (cm)	13.20 ± 1.99	14.18 ± 2.02	12.58 ± 1.72
Tarsometatarsus (cm)	9.85 ± 2.62	10.51 ± 2.48	9.44 ± 2.63

Table 5.3 Correlation coefficients between body weight (BW) and body measurements (values for the overall data)

Trait	BW	BL	CC	F	C	TM
BW	-	0.69***	0.63***	0.48***	0.52***	0.27***
BL	0.69***	-	0.20**	0.11ns	0.57***	-0.15ns
CC	0.63***	0.20**	-	0.55***	0.21**	0.59***
F	0.48***	0.11ns	0.55***	-	-0.0006ns	0.70***
C	0.52***	0.57***	0.21**	0.21**	-	-0.094ns
TM	0.27***	-0.15ns	0.59***	0.70***	-0.094ns	-

ns = non-significant (P>0.05); * = P<0.01; ** = P<0.001; *** = P<0.0001

The correlation coefficients between BW and body measurements for both overall data are given in Table 5.3.The results indicate that all body measurements were strongly correlated to the BW of mature Limpopo indigenous chickens (P<0.0001). Highest correlation coefficients were found between BL and CC in the overall data. The results confirm the previous findings by Guèye et al. (1998) who reported the highest and significant correlation coefficients on BL and CC with regard to BW. Hassan and Adamu (1997) also observed body length as well as chest circumferences were strongly and significantly correlated to body weight in indigenous pigeons. The prediction equations consisting of body measurement variables are presented in Table 5.4. The comparison of R^2 values for such regression equations indicated that, when multiple regression techniques based on BL and CC were used instead of linear regressions, there were improvements of about 20 % to 50 % in R^2 values for males, and about 37 % to 50 % for females.

Further addition of body measurements in prediction equations did not make any substantial improvement in R^2 values. Body length and CC represent higher values in comparison with the other body measurements and are easier to measure. The accuracy level of between 73 and 77 % was recorded and thus giving error of 27 to 23 %. The results indicates that more work needs to be done before making the recommendation to use multiple regression techniques based on BL and CC

Table 5.4 Prediction of body weight (BW, g) on the basis of body length (BL, cm) or/and circumference of chest (CC, cm) for the overall data

Regression	b_0	b_1 BL	b_2 CC	b_3 F	b_4 C	R^2
BW	-872.30	60.83	-	-	-	0.48
BW	-2029.82	52.10	46.10	-	-	0.73
BW	-2095.80	52.05	36.60	34.71	-	0.75
BW	-2131.15	44.50	33.74	39.65	27.88	0.77

*** TM did not meet the 0.05 significance level required for entry in the model**

Table 5.5 Prediction of body weight (BW, g) on the basis of body length (BL, cm) or/and circumference of chest (CC, cm) for the males

Regression	b_0	b_1 BL	b_2 CC	b_3 F	b_4 C	b_5 TM	R^2
BW	-1285.38	72.49	-	-	-	-	0.53
BW	-2529.99	67.54	42.68	-	-	-	0.74
BW	-2544.39	67.24	33.49	29.64	-	-	0.76
BW	-2350.71	59.31	41.60	48.53	-	-33.88	0.78
BW	-2372.98	51.80	38.22	53.53	26.04	-31.76	0.79

Table 5.6 Prediction of body weight (BW, g) on the basis of body length (BL, cm) or /and circumference of chest (CC, cm) for the females

Regression	b_0	b_1 BL	b_2 CC	b_3 F	b_4 C	R^2
BW	-64.48	-	44.83	-	-	0.39
BW	-2029.82	52.10	46.10	-	-	0.73
BW	-2095.80	52.05	36.60	34.71	-	0.75
BW	-2131.15	44.50	33.74	39.65	27.88	0.77

*** TM did not meet the 0.05 significance level required for entry in the model**

5.4 Conclusions

This study was undertaken with the aim of using body measurements to predict the body weight of mature indigenous chickens in the Limpopo Province. Thus, only using a measuring tape, it is possible to predict the BW of these birds with high level of accuracy, BL and CC being body measurements that are most suitable for this purpose. The measuring tape is much more accessible than a weighing machine or a spring balance in poultry markets. These prediction formulas can help farmers, who generally are not indigenous chicken keepers, to have an accurate, easy, cheap and rapid estimation of the body weight of the birds.

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CHAPTER 6

AN EVALUATION OF RATIOS AS A MEASURE OF CARCASS TRAITS USING MATURE INDIGENOUS CHICKENS IN LIMPOPO PROVINCE OF SOUTH AFRICA

Abstract

Live weight and weight of body parts of 60 mature indigenous chickens were collected to investigate whether the use of ratios in poultry science may cause misinterpretation of data and misleading conclusions. Three villages from Mukula Tribal land in Thulamela municipality from Vhembe District in Limpopo Province of South Africa were identified for the purpose of this study. Five mature chickens were bought from each village, weighed, killed, dressed and cut to get the body parts using the standard procedures. This was done across the four distinct seasons from March 2005 to March 2006. The data was collected using a weighing scale with variables of interest being the sex, season and village. Summary statistics were computed and data was analyzed in two separate ways using the Statistical Analysis Software Packages as follows: Firstly, each individual body part was expressed as ratio of body weight and data analysed using a simple analysis of variance (ANOVA) procedure. Secondly, live body weight was used as a covariate in the analysis of other body parts using the ANCOVA procedures. Ratios suggested differences in gizzard, liver head and feet and body length due to sex and in gizzard, liver and body length due to village which were not apparent with ANCOVA. The results from this study suggested that ratios did not remove the variation due to differences in sex and village and may lead to wrong conclusions. From this study, one can draw conclusions that the use of ANCOVA gives us the exceptional method for interpreting the data correctly. [3]

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[3]This chapter has been presented at the following conference:

Tshovhote, N. J., Nesamvuni, A. E., Nephawe, K.A. and Groenewald, I. 2009. An Evaluation of Ratios as Measure of Carcass Traits using Mature Indigenous Chickens in Limpopo province of South Africa. 43rd SASAS Conference, Alpine Heath, KZN, South Africa, 28 -30 July. **Paper published** Tshovhote, N. J., Nesamvuni, A. E., Nephawe, K.A. and Groenewald, I. 2010. An Evaluation of Ratios as Measure of Carcass Traits using Mature Indigenous Chickens in Limpopo province of South Africa. South African Journal of Animal Science 40 (5), 467-470.

Key words: Ratios, ANCOVA, live weight, body parts

6.1 Introduction

Most morphological traits and physiological functions vary with body size. The ecological physiologists commonly divide individual values for variables of interest by corresponding measures of body size to adjust data that vary in magnitude or intensity with body size of the animal being studied (Packard and Boardman, 1988). In an attempt to remove this variation, the data are analysed as ratios of body size, for example ratio of a chicken breast divided by the mass of the chicken. (Wallis, 1999). These ratios are formed in an attempt to increase the precision of data gathered in planned experiments.

When a plot of a physiological variable (y) against a measure of body size (x) yields a straight line that passes through the origin, then the variable changes isometrically (Wallis, 1999; Mulaudzi, 2006). In this relationship, doubling the body mass also doubles the dependent variable. Functionally, isometry occurs when Y = Mx. Alternatively, allometry obtained whenever such a plot yields either a curved line or a straight line that does not intersect the Y-axis at zero. Most physiological variables change with body size and that is isometric relationships. Allometric relationships cannot easily be analysed as ratios and instead require other statistical methods like analysis of covariance (Packard and Boardman, 1987; Wallis, 1999).

The use of ratios may lead investigators to draw different (incorrect) conclusions than they would have reached by examining the data with Analysis of Covariance, a statistical procedure combining regression with the Analysis of Variance (Fisher, 1932, Cochran, 1957). The Analysis of Covariance is a statistical procedure that is superior to most statistical analyses on ratios (Anderson and Lydic, 1977). When ANCOVA is combined with a visual examination of data displayed in a bivariate plot, it affords an exceptional method for interpreting data correctly (Packard and Boardman, 1988). The ratios of body part to whole mass always lie between 0 and 1 and so their distribution cannot be normal. Distributions that can be used for ratios are distributions for continuous random variables with values between 0 and 1

(Mulaudzi, 2006). One of the basic assumptions of ANOVA is normality of error terms. Thus, ANOVA on ratios is not appropriate, even if data are normal, ratios are not.

Some of the general statistical properties of ratios of random normal variables have been known to statisticians for some time (Atchley et al., 1976). The majority of biological variables are not distributed as the typical normal distribution but rather as a truncated normal or related distribution. For example, body weights, heights, etc., do not exist below zero; however, the normal distribution extends from negative to positive infinity. In this case, one must look for methods of analysis that do not depend on the normality assumption.

Most authors indicated that the use of ratios may lead investigators to draw different or incorrect conclusions than they would have reached by examining data with other statistical procedures. The analysis of covariate and ratios were used in this study to compare the growth of chickens and body parts.

6.2 Materials and Methods

The research was conducted in the Mukula tribal land, in Thulamela Municipality of Vhembe District in Limpopo Province, South Africa. Mukula is situated about 20km on the North Eastern side of Thohoyandou. This area falls between latitudes of 30° 33' 00" and 30° 36' 00", and longitudes of between 22° 51' 00" and 22° 52' 30". It experiences mild to moderate winters (mean 8-15°C), hot summers (mean 23- 27°C) and an annual rainfall of 750mm-1000 mm per annum. This area has about 15000 inhabitants. Indigenous poultry keepers were selected from the three villages namely Phindula, Satani and Mukondeni. Five chickens were bought, weighed and sacrificed from each village in all the four seasons. Data on body weight and body parts were individually collected and weighed from 60 mature Venda indigenous chickens using an electronic weighing scale in a year from March 2005 to March 2006.

Measurements on live body weight, body length, crop, gizzard, small intestine, liver, head and feet were collected on individual chickens. The variables of interest were the season, sex and village. Data was analysed in two separate ways using the Statistical Analysis Software Packages (SAS, 2006). First each individual body part was expressed as ratio of body weight and data analysed using a simple analysis of variance (ANOVA) procedure of SAS (2006).

Secondly, live body weight was used a covariate in the analysis of other body parts using the ANCOVA procedures of SAS (2006).

6.3 Results and discussions

The summary statistics of the data were computed and presented in Table 6.1. The mean values for live weight and body parts as summarised in the table below did show slight difference when both ANCOVA and Ratio were used for all the body part. However, the difference is not significant for all procedures.

Table 6.1 Least square means for the body parts analyzed by ANCOVA and ratio

	ANCOVA		RATIO	
Variable	Mean	Std	Mean	Std
Small intestine	0.140	0.195	0.158	0.230
Crop	0.048	0.032	0.053	0.037
Gizzard	0.070	0.018	0.076	0.019
Liver	0.039	0.014	0.044	0.018
Head and feet	0.092	0.033	0.098	0.021
Live weight*	1.482	0.398		

***Is the same for the two analytical methods**

Table 6.2 presents the probability values for season, sex and village for various body parts. The results indicate that there is no difference in small intestines and crop when both ANCOVA and ratios were used. These suggest that forming ratios removed the variation in two of the six body parts presented (see column on LWT). These results support the findings by Packard and Boardman (1988) who reported that forming ratios effectively corrected the data for differences in body size from the hatchling turtles. In contradiction, Wallis (1999) reported that forming ratios failed to remove the variation in body mass for 10 of the 14 carcass parts that were used in his investigation. In four instances from study, that is gizzard, liver, head and feet and body length, ratios suggested differences between sexes which ANCOVA did not support. For gizzard, liver and body length, ratios suggested differences in village which were not apparent in ANCOVA.

Table 6.3 presents the coefficient of variation and root mean squares associated with the ANCOVA and ratios. From this table it is evident that the coefficient of variation and root mean squares for both ANCOVA and ratios did not differ significantly which may suggest same conclusions from both procedures.

Table 6.2 Probability (P) values for season, sex and village for various body parts analyzed by ANCOVA and ratios.

	ANCOVA				RATIO		
Part	Pseason	Psex	Pvillage	LWT	Pseason	Psex	Pvillage
SI	0.005	0.55	0.003	0.82	0.002	0.73	0.002
Crop	0.41	0.09	0.03	0.009	0.42	0.09	0.02
Gizzard	0.004	**0.32**	**0.48**	<.0001	0.002	**0.009**	**0.02**
Liver	0.007	**0.25**	**0.68**	0.05	0.009	**0.006**	**0.05**
H and F	0.35	**<.0001**	0.36	0.02	0.08	**0.004**	**0.73**
BL	**0.05**	**0.006**	0.52	<.0001	**0.001**	**0.09**	**0.0001**

The bold figures indicate P values where the two Analytical methods led to different conclusions. The column entitled LWT is the P values for the Regression of each body part against live weight

From the results of this study, analysis of body parts as ratios may be an unsatisfactory way of removing variation due to live weight when comparing differences in sex and season. Despite the reservations by many physiologists (Dinkel et al., 1965) and systematics (Wallis, 1999) regarding the use of ratios to scale data, ratios still continue to enjoy wide use (Mulaudzi, 2006).

The use of ratios to scale data will not lead investigators invariably to incorrect conclusions, in some instances in this data, ratios led to the same conclusions as did ANCOVA (when the level of significance was set at $\alpha = 0.05$). This was also evident in the studies of hatchling turtles as reported by Packard and Anderson (1988). From this study, it is evident that, ratios are adequate for scaling data when coefficient of variation for the numerator variable is substantially greater than the coefficient of variation for the denominator variable and also that treatment effects sometime are so pronounced that almost any analysis including ratios will reveal their existence.

Table 6.3 The Coefficient of Variation and the root mean squares associated with the Probabilities of ANCOVA and Ratio

	ANCOVA		RATIO	
Part	CV	Root MSE	CV	Root MSE
Small intestines	119.2	0.167	120.8	0.191
Crop	62.91	0.03	65.96	0.035
Gizzard	17.43	0.012	21.87	0.016
Liver	32.09	0.012	34.18	0.014
Head and Feet	22.56	0.020	19.31	0.018
Body Length	6.86	24.48	16.09	0.04

6.4 Conclusions

The results showed that ratio did not remove the variation due to body weight and that analysis of ratios led to incorrect conclusions. However, it does not mean that ratios cannot be used. If they are used and there is little variation in body weight, then expressing body parts in percentages matters little as it was evident in small intestines and crop. The results from this study suggest that we use ANCOVA as an exceptional method on analysing the data for variables which vary allometrically with body weight as it gives the correct conclusions. Hence, it affords an exceptional method for interpreting the data correctly. Likewise, for variables which vary isometrically with live weight ANCOVA will be an acceptable analytical method.

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CHAPTER 7

TOWARDS THE DEVELOPMENT OF A POULTRY SECTOR MANAGEMENT DECISION MODEL FOR LIMPOPO PROVINCE OF SOUTH AFRICA

Abstract

The study investigated poultry sector challenges in Limpopo Province of South Africa and using Congruence Model, proposed development of management decision model. Challenges entailed lack of (a) vaccination, (b) production skills, (c) extension, and (d) production input. Mean congruence for challenge and strategy was moderate (rating=2.00) resulting from high congruence (ratings=3.0) for challenges (a)-(b) and low for (c)-(d). Mean congruence for strategies and tasks was moderate-high (rating=2.50) resulting from high congruence (ratings=3.0) for (a)-(b) and moderate (ratings=2.0) for (c)-(d) components. For allocation and filling of posts, mean congruence was high (rating=2.58) resulting from ratings (2.9, 2.6, 2.6) for (a), (c) and (d) components and moderate for (b). High mean congruence (rating=2.75) also occurred for allocation and spending of budget resulting from high congruence (ratings=3.0) for (a)-(c) and moderate (rating=2.0) for (d) component. The management decision model should address areas of low and those of moderate congruence using commodity based approach focusing on poultry[4].

Key words: Congruence, poultry, vaccination, production skills, extension, production input, decision model

[4]This chapter has been presented at the following conference:

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7.1 Introduction, Congruence Model

Several researchers indicated challenges experienced by poultry farmers in Africa and the most prominent challenges identified were lack of (1) vaccination program, (2) production skills, (3) extension support, and (4) production inputs (Alders *et al.*, 1997). In order to successfully address the challenges experienced by the poultry farmers, an appropriate management decision model is required that takes into account the relevant capacity of service organisations. In order to be relevant, such a model should ensure congruence between the sector challenges and the capacity of service organisations. The Congruence Model (Nadler and Tushman, 1980) was therefore identified as a basis for development of the management decision model for the poultry sector.

The Congruence Model views organisations as made up of components that interact with each other (Figure 1). The components are categorised as **inputs** that include environment, resources, history and strategy; **transformation** that is influenced by tasks, human resources, financial resources and formal and informal organisational arrangements; and **outputs** that may be organisational, group or individual (Nadler and Tushman, 1980; Gill, 2000; Bezboruah, 2008; and Mertikas, 2008). The model provides for the flow of information and / or action from a source component to a recipient component and this information and / or action may be subjected to congruence rating to assess the degree of fit (Figure 1).

The congruence between two components is defined as the degree to which the needs, demands, goals, objectives, and structures of one component satisfy those of the other (Nadler and Tushman, 1980). The concept 'congruence' may be understood through illustration of the fit between units (1) across components and (2) those within components (Tshikolomo *et al.*, 2013). The main challenges experienced by poultry farmers were lack of (1) vaccination program, (2) production skills, (3) extension support, and (4) production inputs (Alders *et al.*,

1997) and are all human (person) related. Understanding of the concept 'congruence' in this study therefore focused on the fit between a person and the other components as described by Nadler and Tushman (1980). In this case, 'congruence' was illustrated for person-environment and person-organisation fit in recognition of the importance of environment (under input) and service organisation (transformation) in the model. Individual job performance is important for good performance of the poultry sector and hence person-job (P-J) fit was also used to illustrate the concept 'congruence'.

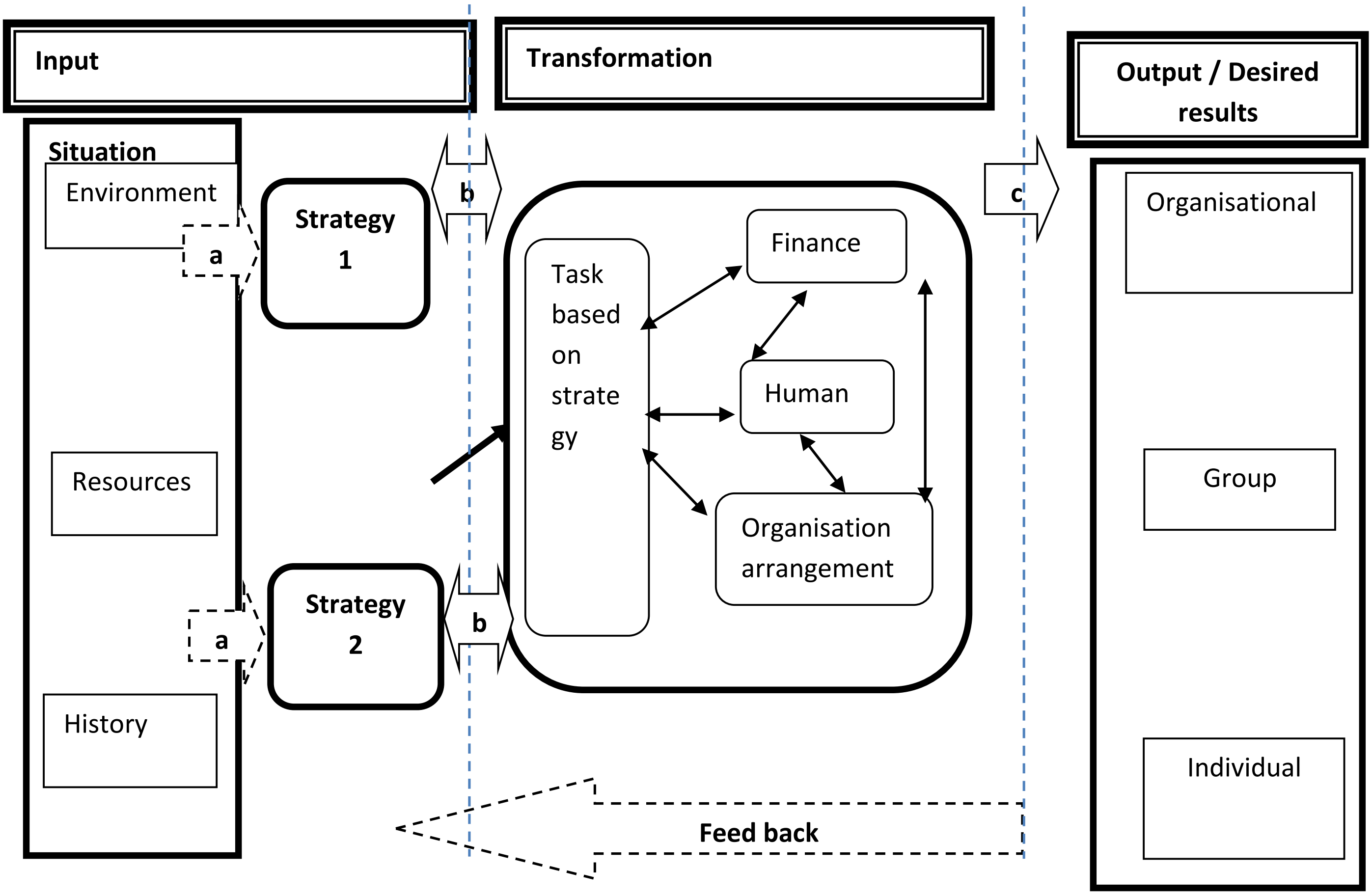
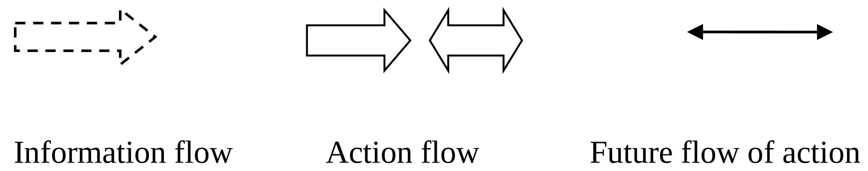


Figure 7.1 Adjusted Congruence Models of Nadler and Tushman (1980)

Key:



The concept 'person-environment (P-E) fit' refers to similarity between a particular set of person-related attributes and a set of environment-related attributes (Schneider *et al.*, 1992). It was indicated by Ostroff (1993) that organisations are more effective when the attributes of a person and those of environment fit or are highly congruent. The P-E fit was positively related to such issues as job satisfaction and career success (Bretz and Judge, 1994). A high degree of congruence between the unit of *environment* under input and that of *person* in service organisation (transformation) results in a more effective service organization. Similarly, high degrees of fit between pairs of other units across the two components of environment and transformation in poultry service organisations will make the organization to be more effective. The concept of 'person-organization (P-O) fit' was described as a fit between individual and organisational characteristics (Kristof, 1996). Organisational characteristics include such aspects as culture which informs people about the way things are done in the organisation (Balkin and Schjoedt, 2012). Some organisational cultures are rigid and do not provide for employees to make independent decisions while others are flexible and allow the employees to make decisions. Self-motivated employees would want to decide on their own goals, work schedules, methods of work and outputs (Sparrow and Daniels, 1999) and would therefore fit in flexible work situation (Jarvenpaa and Leidner, 1999). The organisations that offer a flexible work situation are often multicultural (Jarvenpaa and Leidner, 1999) and are therefore able to accommodate employees from different cultural backgrounds. The attainment of P-O fit is very necessary for poultry sector service organisation to be effective.

The concept of 'person-job (P-J) fit' refers to the degree of congruence between individual characteristics and job requirements (Edwards, 1991). The P-J fit commonly lacks where employees lack the competence that is critically required by the job. In situations where employees do not have the required competence for their jobs, attainment of P-J fit will require that organisations invest in reskilling interventions such as human resource development (Tshikolomo *et al.,* 2013).

The purpose of this study was to (1) highlight the challenges faced by the poultry sector in the study area, (2) analyse the degree of congruence between the challenges and the capacity of the major service organisation as reflected by strategies, tasks, and allocation and use of resources, and (3) to subsequently describe the issues of focus for developing a poultry sector management decision model. The Congruence Model was useful in analysing varying situations, reduced the complexity of organisational dynamics to manageable proportions, and helped leaders to predict important patterns of organisational behaviour and performance (Wyman, 2003). The Congruence Model of Nadler and Tushman (1980) was therefore used to analyse the degree of fit among the specified components and to subsequently identify the issues of focus for developing the management decision model.

7.2 Research methodology

7.2.1 Study area

Limpopo Department of Agriculture was sampled as the service organisation where the extent of capacity in all the 25 local municipalities was assessed. The Province is located in the north most part of South Africa and it forms borders with Botswana in the north-west, Zimbabwe in the north, and Mozambique in the east. Within South Africa the province forms borders with Mpumalanga Province in the south-east, Gauteng in the south and the North-West Province in the south-west. Limpopo Province has poultry farmers involved with broilers, layers and those involved with both broilers and layers (Figure 7.2).

It is evident that Mopani, Vhembe and Capricorn District Municipalities are the ones with high concentrations of poultry houses. It must be noted however, that only high technology infrastructure was captured with little emphasis on the small holder poultry structures and the family or household indigenous chicken farming.

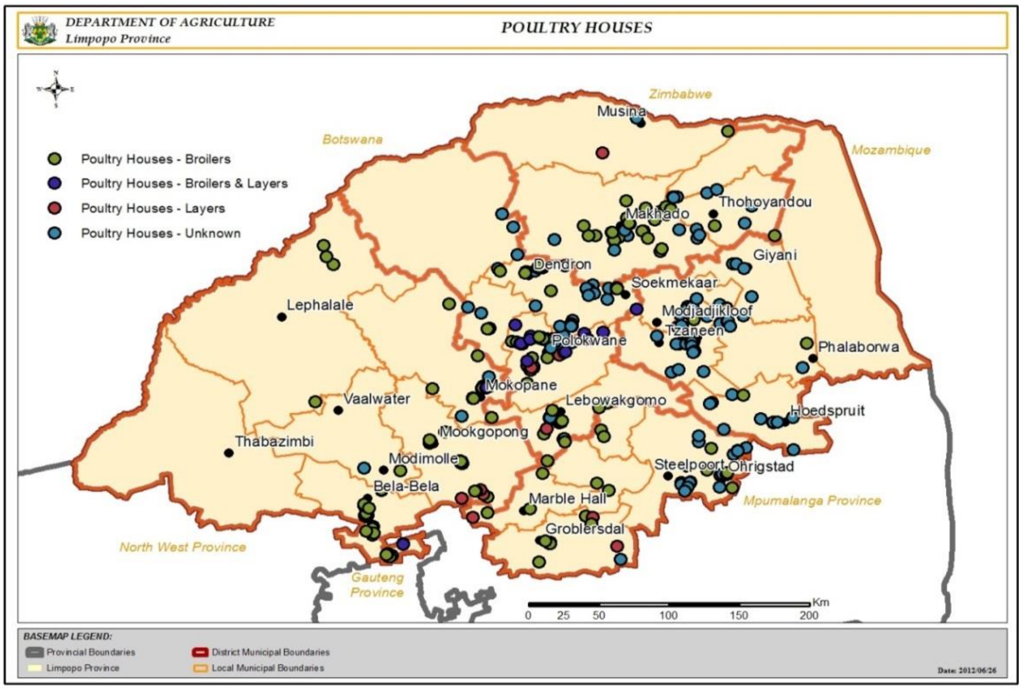


Figure 7.2 Map of Limpopo Province showing the distribution of poultry farmers in different areas.

7.2.2 Sampling procedure

Purposive sampling was used to select the poultry sector service organisation to be evaluated for development of a management decision model within the framework of the Congruence Model. The Limpopo Department of Agriculture (LDA) was selected as it is the custodian of agriculture services in the Province.

7.2.3 Data collection and analysis

Information on major challenges affecting the poultry sector in the study area was obtained from relevant literature studied to provide insight on the type and magnitude of the challenges. The study of literature was followed by case study where interviews of indigenous poultry farmers in Vhembe and Capricorn districts were conducted to confirm the applicability of the challenges in the sector. Data on capacity of the sampled LDA to address the challenges was obtained from the strategic and annual performance plan, organisational structure, staff placement and annual reports of the organisation (LDA, 2010; LDA, 2011).

The allocation of human resources was mainly based on professional disciplines and not on commodity to be serviced while the commodity based approach would be necessary. The assumption in this study was that Animal Scientists, Animal Production Technicians and Animal Health Technicians were competent to service the poultry sector. A fair amount of information with some degree of convergence on issues covered was obtained for the 2010-11 financial year and hence analysis was based on this year. Information was also obtained from other relevant literature.

In order to ensure relevance and consistency in the type of information collected, the major challenges experienced by the poultry sector were highlighted. The statements in the plans of the service organisation that proposed solutions to the sector problems were noted and used to assess the congruence between the capacity of the organization and the poultry sector challenge. The congruence analysis was based on the plans and reports of the LDA to assess the prospects of the Department to successfully address the poultry sector challenges.

Although the information was mainly qualitative, some quantitative data was used and that included data on the amount of resources allocated and those utilised by the organisation. The plans and reports of the LDA did not always reflect the exact financial resources allocated and used for the specific tasks and therefore financial resources were estimated by the goods and services budget of relevant programs where necessary. Based on quantitative data, objective rating of congruence between allocated and utilised human and financial resources was conducted. The qualitative information on different aspects of organisational capacity was properly summarised, organised and subjectively rated for congruence with the poultry sector challenges (Leedy and Ormrod, 2010).

Arbitrary numerical scores were decided upon and used for the rating of the degree of congruence between aspects of capacity of the LDA and the sector challenges. The scores were in a scale of 0-3 where 0 indicated no congruence, 1 indicated low, 2 indicated moderate and 3 indicated a high degree of congruence (Tshikolomo *et al.*, 2013). This type of research where both quantitative and qualitative data is collected and analyzed is described as a mixed study (Hurmerinta-Peltomaki and Nummela, 2006). The congruence scores were accordingly interpreted in the context of determining the prospects for the LDA to successfully address sector challenges. As stated by Tshikolomo *et al.* (2013), higher congruence scores for both quantitative and qualitative aspects suggested a higher degree of fit between the poultry sector challenge and the capacity of the LDA to address it and *vice versa.*

7.3 Results and discussions

7.3.1 Major challenges faced by the poultry sector

The challenges faced by the poultry sector were identified and the major ones include:

(a) Lack of vaccination program

Newcastle was described as a major disease that wiped out 85% of the poultry (Alders *et al.,* 1997; Moreki *et al.,* 1997; Mushi *et al*., 2000, Swatson *et al,* 2004). Contrary to situations with countries such as Bangladesh, South Africa had no vaccination program put in place by government (Swatson *et al,* 2001). According to Swatson *et al.* (2004), farmers used indigenous knowledge to try and control outbreaks of diseases such as Newcastle.

(b) Lack of production skills

The lack of skills on poultry production was one of the constraints faced by poultry farmers (Swatson *et al,* 2004) and this was also an issue in villages in the Mukula Chieftain area.

(c) Lack of extension support

The lack of extension support was recorded for production, veterinary, marketing and economic aspects of poultry farming (Swatson *et al.,* 2004) and this has presented itself as a challenge to the poultry sector.

(d) Lack of production inputs

The lack of production inputs was noted as a challenge for the poultry sector. It was indicated that village chickens freely roam around homesteads and scavenge for food (Moreki *et al.,* 1997; Mushi *et al.,* 2000) in order to meet their feed needs.

7.3.2 Congruence between poultry sector challenges and organisational strategies and among components of capacity of LDA

The effectiveness of LDA as service organisation in improving the performance of the poultry sector is influenced by the degree of congruence between the strategies of the organisation and the challenges faced by the sector.

7.3.2.1 Congruence between poultry sector challenges and LDA strategies

The strategies used by LDA to improve the poultry sector were shown in the strategic planning document of the organisation and those seek to address the major challenges faced by the sector

(LDA, 2010). The extent to which the strategies are relevant to solving the poultry sector challenges is illustrated by the congruence analysis between the two factors. Although the strategies of LDA were presented in the form of outcomes, there was a high degree of congruence (rating=3) between the challenge of lack of vaccination and the responsive strategy presented as safe and tradable animals and animal products. A high degree of congruence (3) was also noted between the challenge of lack of production skills and the responsive strategy presented as skilled and empowered farming community (Table 7.1).

Table 7.1 Congruence rating between poultry sector challenges and organisational strategies of LDA

Poultry Sector Challenge	Strategy	Rating
Lack of vaccination	Safe and tradable animals and animal	3
Lack of production skills	Skilled and empowered farming community	3
Poor extension support	Improved agricultural production	1
Lack of production inputs	Improved agricultural production	1

Congruence rating: 0 = None; **1** = Low; **2** = Moderate and **3** = High

The strategy of the LDA presented as improved agricultural production was rather broad and did not address any of the challenges of poor extension support or lack of production inputs at a reasonable level of specificity. Improvement of agricultural production could refer to commodities other than poultry and, even within the poultry sector, improvement could be achieved through interventions different from extension support and provision of production inputs. There was therefore a low degree of congruence (1) between each of the two challenges and the responsive strategy presented as improved agricultural production.

Although the LDA may not have clearly captured the issues of extension support and provision of production inputs, the two issues are included in the programs of the department. Improved extension support is provided for under a program referred to as Extension Recovery Plan (ERP) while provision of production inputs is through a program referred to as Production Input Support.

7.3.2.2 Transformation components and their congruence with strategies

According to the Congruence Model of Nadler and Tushman (1980), the transformation process for the poultry sector within LDA entails the use of inputs to produce a set of outputs. Important components influencing transformation within the Department include: (1) tasks (which could be in the form of performance indicators or projects), (2) human, and (3) financial resources (Nadler and Tushman, 1980; Gill, 2000; Ostroff, 1993; Wyman, 1998; Wyman, 2003). Congruence analysis of the transformation process assists in determining the extent to which the LDA is capable of addressing the sector challenges.

(a) Congruence between strategies and tasks

Tasks reflect the basic or inherent work to be performed by the LDA to address the challenges experienced by the poultry sector. Analysis of the congruence between strategies and tasks reveals the extent of relevance of the tasks in addressing the strategies set by the Department (Table 7.2).

A high degree of congruence (rating=3) was noted between the strategy presented as ‘safe and tradable animals and animal products’ and the task of controlling animal diseases (Table 7.2). Although there could be other tasks necessary for production of safe and tradable animals and animal products, the control of animal diseases is regarded the major task in the study area. The necessity of controlling animal diseases is critical because the Province co-hosts the Kruger National Park and therefore experiences outbreaks of diseases such as Foot and Mouth Disease (FMD). Also, the location of the Province in the periphery of South Africa makes it vulnerable to animal diseases from the neighboring countries (namely, Botswana, Zimbabwe and Mozambique).

Table 7.2 Congruence between strategies and the tasks for poultry sector within LDA

Strategy	Task	Rating
Safe and tradable animals and animal products	Control of animal diseases	3
Skilled and empowered farming community	Provide formal and non-formal agricultural Education	3
Improved agricultural production	Provide farmers with technical advice	2
Improved agricultural production	Provide farmers with production inputs	2

Congruence rating: 0 = None; 1 = Low; 2 = Moderate and 3 = High

There was also a high degree of congruence (3) between the strategy 'skilled and empowered farming community' and the task of provision of formal and non-formal education. The provision of the education is mainly through two Colleges of Agriculture that are under the LDA, namely: Madzivhandila and Tompi Seleka College of Agriculture. In response to issues of post-1994 transformation of the education system in South Africa, the two colleges stopped some of their training programs and provided more focus to farmer training mainly through short courses and skills programs. Research indicates that there is indigenous knowledge and other technologies that may be used to increase poultry production and these need to be explored and relevant target group trained on such innovations (Swatson *et al.*, 2001; Swatson *et al.*, 2004)

Although the strategy 'improved agricultural production' may not be entirely addressed by the task of providing farmers with technical advice, the task is one of the important initiatives for achieving the strategy and therefore the degree of congruence between the two was regarded moderate (rating=2). Technical advice for the poultry sector is mainly provided by extension officers for production issues and animal health technicians for disease and pest management issues.

Other than provision of farmers with technical advice, achieving the strategy 'improved agricultural production' is influenced by the extent to which farmers are provided with production inputs. The degree of congruence between the strategy (improved agricultural production) and the task (providing farmers with production inputs) was also regarded moderate (rating=2) as the task may not alone result in the achievement of the strategy. Production inputs provided by LDA are mainly the poultry production stock (broilers, layers and indigenous chickens), feed and medicines, and these are supplied under Production Input Support Programme and are funded through a conditional grant referred to as Ilima-Letsema. It was observed that the tasks performed in this strategy are more skewed towards broilers and layers with little activity on indigenous chicken production (LDA, 2010).

(b) Congruence between allocated and utilized organizational resources

With the congruence between strategies and tasks analysed, it is necessary to assess the capacity of the LDA to implement the tasks. Lack of capacity to implement the tasks results in the LDA not being able to achieve its strategies for addressing the poultry sector challenges and hence the Department will fail to render its important services. The study assesses the capacity of the LDA through determining the degree of congruence between availability and use of requisite resources. According to Nadler and Tushman (1980), human and financial resources are important determinants of the capacity of an organisation to successfully perform its tasks and achieve its strategies, and these resources were the focus of analysis.

(i) Congruence between allocation and use of human resources

The analysis of human resource allocation and utilisation was based at a local municipality level because this is where services are rendered (Table 7.3). The types of personnel required for the poultry sector are: (1) animal health technicians to support the task on control of animal diseases and that on providing farmers with production inputs such as poultry vaccines and medications, (2) animal scientists to support the task on providing formal and non-formal agricultural education and that on providing farmers with technical advice, and (3) animal production technicians to support the task on providing farmers with technical advice and that on providing farmers with production inputs. Each type of personnel has mainly two tasks to support. A limited number of veterinary doctors were placed in the districts to support the animal health technicians and those were not included in the congruence analysis.

The degree of congruence between the number of posts allocated and those filled was moderate (rating=2.2) (Table 7.3). Relatively more posts were allocated for animal production technicians where an average of 3 posts was provided for a municipality. Of the allocated posts of animal production technicians, 88.12% were filled and this translated to a high degree of congruence (rating=2.64) between the allocation and filling of the posts. As for animal health technicians, some seven posts were allocated for a municipality, more than twice the number of posts allocated for animal production technicians. Up to 93.32% of the posts allocated for animal health technicians were filled and this translated to a high degree of congruence (rating=2.9) between the number of posts allocated and those filled. The allocation and filling of more posts for animal health technicians suggests that the LDA regarded disease and pest management as priority in her services to the poultry sector.

Considering animal health technicians, it would be expected for municipalities lying along international borders and those next to the Kruger National Park to have more posts allocated and filled in order to provide for sufficient human resources to manage disease and pest outbreaks from the neighboring countries and those from the Kruger Park. These municipalities would include Lephalale, Blouberg, Musina, Mutale, Thulamela, Giyani and Phalaborwa. The allocation and filling of the animal health technicians does not seem to correlate with the geographic location of the municipalities (Table 7.3).

A high degree of congruence (rating=2.57) was noted between the average number of posts allocated in municipalities for the three types of human resources (animal scientist, animal production technician and animal health technician) and those filled. Some municipalities had filled all the posts allocated for the three types of officers and had a high degree of congruence (rating=3) between the allocation and filling of posts. The municipalities that filled all the allocated posts were Letaba, Tzaneen, Fetakgomo, Makhuduthamaga, Thulamela and Belabela. The rest of the municipalities had some allocated posts not filled and the Blouberg Municipality had the lowest (would be described as moderate) degree of congruence (rating=1.67) between the total number of posts allocated and those filled. Considering the allocation of posts for servicing the poultry industry, it would be necessary for the LDA to assess the demands of the sector and review the allocation of the posts. Posts should be allocated in accordance with the needs for services and should all be filled.

(ii) Congruence between allocation and use of financial resources

The allocation and use of financial resources are important indicators of the capacity for the LDA to effectively perform the tasks for servicing the poultry sector. The congruence between LDA allocation and spending of financial resources for achievement of tasks to support the poultry sector was therefore considered (Table 7.4).

Table 7.3 Congruence analysis for allocation and filling of posts by LDA to service poultry production

Municipality	Animal scientist				Animal production technician				Animal health technician				Mean
	Allocated	Filled	% Filled	Rate	Allocated	Fill	% Filled	Rate	Allocated	Filled	% Filled	Rate	
Aganang	3	1	33	0	3	3	100	3	7	6	86	3	**2.00**
Blouberg	3	1	33	0	3	2	67	2	7	7	100	3	**1.67**
Molemole	4	3	75	2	3	3	100	3	7	6	86	3	**2.67**
Polokwane	5	3	60	2	4	4	100	3	10	9	90	3	**2.67**
Lepelle-Nkumpi	2	1	50	1	3	2	67	2	7	7	100	3	**2.00**
Ba-Phalaborwa	1	1	100	3	3	2	67	2	5	5	100	3	**2.67**
Giyani	2	1	50	1	2	2	100	3	10	9	90	3	**2.33**
Letaba	1	1	100	3	3	3	100	3	6	6	100	3	**3.00**
Tzaneen	1	1	100	3	3	3	100	3	10	10	100	3	**3.00**
Maruleng	2	1	50	1	4	4	100	3	6	6	100	3	**2.33**
Fetakgomu	1	1	100	3	3	3	100	3	4	4	100	3	**3.00**
Tubatse	1	1	100	3	3	3	100	3	9	8	89	3	**3.00**
Elias Motsoaledi	2	2	100	3	3	2	67	2	5	5	100	3	**2.67**
Marble Hall	1	0	0	0	3	3	100	3	4	4	100	3	**2.00**
Makhuduthamaga	1	1	100	3	3	3	100	3	9	9	100	3	**3.00**
Makhado	1	1	100	3	3	2	67	2	18	12	67	2	**2.33**
Mutale	1	0	0	0	3	3	100	3	6	6	100	3	**2.00**
Musina	1	1	100	3	3	2	67	2	4	4	100	3	**2.67**
Thulamela	2	2	100	3	3	3	100	3	16	16	100	3	**3.00**
Bela-Bela	1	1	100	3	3	3	100	3	3	3	100	3	**3.00**
Lephalale	1	1	100	3	3	2	67	2	12	10	83	3	**2.67**
Modimolle	1	1	100	3	2	2	100	3	3	2	67	2	**2.67**
Mogalakwena	1	1	100	3	3	2	67	2	9	9	100	3	**2.67**
Mookgopong	1	1	100	3	3	2	67	2	3	3	100	3	**2.67**
Thabazimbi	1	1	100	3	3	3	100	3	4	3	75	2	**2.67**
Mean	**1.64**	**1.2**	**78. 04**	**2.2**	**3**	**2.64**	**88. 12**	**2.64**	**7.36**	**6.8**	**93. 32**	**2.9**	**2.57**

Congruence rating: 0=No congruence (<40% posts filled); 1=Low (40-59% posts filled); 2=Moderate (60-79% posts filled); 3=High (80-100 posts filled)

The plans and reports of the LDA did not reflect the exact financial resources allocated and spent on the top three tasks (control of animal diseases; provide agricultural education; provide farmers with technical advice). The financial allocations, spending and subsequent congruence rating for these three tasks were estimated by the goods and services budget of relevant programs.

A budget of R11.18 million was allocated for the task on control of animal diseases and the whole (100.0%) amount was spent resulting in a high degree of congruence (rating=3) between budget allocation and expenditure (Table 7.4). The spending of the entire budget would probably have catered for diseases such as Newcastle that is highly contagious. The budget allocation for the task on provision of agricultural education was R15.56 million with 85.1% of it spent still resulting in a high degree of congruence (3) between the allocation and spending of financial resources. A similar congruence rating (3) was noted for the fit between budget allocation and expenditure for the task on providing farmers with technical advice. Assuming that the budgets were allocated according to the demands of the tasks, the high degree of congruence between the allocations and the expenditures suggest that the LDA had good capacity to achieve the tasks during the 2010-11 financial year.

As for the task on providing farmers with poultry production inputs, the budget allocation was R1.44 million and the expenditure was R1.808 million constituting 125.5% of the allocated budget. A moderate degree of congruence (rating=2) was noted between the budget allocation and spending on this task. The additional spending (25.5%) was probably funded from other allocations within the production input budget, e.g. pesticides.

Table 7.4 Analysis of congruence between LDA allocation and spending of financial resources on poultry in 2010-11 financial year (LDA, 2011)

Task	Financial allocation (R'000)	Spending (R'000)	% Spending	Congruence rating
Control of animal diseases	11 180	11 180	100.0	3
Provide agricultural education	15 564	13 240	85.1	3
Provide farmers with technical advice	126 947	126 947	100.0	3
Provide farmers with production inputs	1 440	1 808	125.5	2

Congruence rating: 0=No congruence (≥ 60% under- / over-spend); 1=Low (40-59% under- / over-spend); 2=Moderate (21-39% under- / over-spend); 3=High (0-20% under- / over-spend)

This result of congruence analysis suggests that there was no perfect fit between the allocations and spending of the budget, instead the budget was overspent. The overspending could have been a result of (1) the allocation having been inadequate in the first place, (2) new demands for poultry production inputs having being received after budgets were allocated, or (3) prices for the production inputs having been higher than the estimates used at planning.

7.3.3 Congruence flow analysis

The purpose of congruence flow analysis was to assess the variation in levels of congruence along the input and transformation components (Tshikolomo *et al.*, 2013). The congruence for LDA was moderate (2.00) for strategies (compared to challenges) and was high (2.50) for tasks (compared to strategies). There was also a high degree of congruence (2.58) for allocation and filling of posts (human resources) and for allocation and spending of budgets (2.75) reflecting a good fit between the planning and use of resources to achieve the tasks (Table 7.5). These results suggest that strategy was the major constraint to successful implementation of poultry production in the study area. The moderate congruence rating for strategy was a result of its being broad and lack of focus on some of the sector challenges. For those areas where strategy was broad, focused activities were presented as tasks and this resulted in the high congruence rating for the tasks.

For the specific aspects of the components of the Congruence Model (Nadler and Tushman, 1980), a high degree of congruence was noted for the components linked to strategy on producing safe and tradable animals and animal products (2.98) and for the components linked to the strategy on skilled and empowered farming community (2.80). The degree of congruence was moderate for the components linked to strategy on improved agricultural production through providing farmers with both technical advice (2.15) and production inputs (1.90). These results suggest that the strategy on improved agricultural production was less achieved and was therefore a constraint to successful poultry production in the study area.

7.4. Proposed focus of a poultry sector management decision model

In accordance with the results of congruence analysis, an appropriate poultry sector management decision model for Limpopo Province should focus on the components (and specific aspects of components) with relatively lower congruence rating. As informed by the congruence flow analysis (Table 5), the management decision model should address the following issues.

(a) Strategy

There was an overall moderate degree of congruence (rating=2.00) between strategies and challenges suggesting that the strategy could still be improved. The major constraint was with the strategy on improved agricultural production (congruence rating=1) which was rather broad and not specific on the highlighted sector challenges. The management decision model should present some focus on the need for specific strategies to address sector challenges.

(b) Tasks

There was overall a moderate to high degree of congruence (rating=2.50) between tasks and strategies. The constraints were with the tasks linked to the broad less focused strategy on improved agricultural production, namely: (i) provide farmers with technical advice (2.0) and (ii) provide farmers with production inputs (2.0). Although the tasks were relevant, they were not sufficient to achieve the strategy. Focused strategies would be adequately addressed by the mentioned tasks.

(c) Human Resources

In overall, there was a high degree of congruence (rating=2.58) between the number of posts allocated and those filled. Assuming that sufficient posts were allocated for the different types of personnel, the main constraint to achievement of the tasks would be on the availability of animal scientists as only 78.0% of the posts were filled (mean rating=2.2). The sector management decision model should provide a focus on the need for posts to be filled, especially those for animal scientists.

Table 7.5 Congruence flow analysis of input and transformation components of LDA

Component of capacity	Specific aspect of component (congruence rating)				Mean congruence
Strategy	Safe and tradable animals and animal products **(3.0)**	Skilled and empowered farming community **(3.0)**	Improved agricultural production **(1.0)**	Improved agricultural production **(1.0)**	**2.00**
Task	Control of animal diseases **(3.0)**	Provide formal and non-formal agricultural education **(3.0)**	Provide farmers with technical advice **(2.0)**	Provide farmers with production inputs **(2.0)**	**2.50**
Human resource	93.3% of animal health technician posts filled **(2.9)**	78.0% of animal scientist posts filled **(2.2)**	88.1% of animal production technician posts filled **(2.6)**	88.1% of animal production technician posts filled **(2.6)**	**2.58**
Financial resource	100% of allocated budget spent **(3.0)**	85.1% of allocated budget spent **(3.0)**	100% of allocated budget spent **(3.0)**	125.5% of allocated budget spent **(2.0)**	**2.75**
Mean congruence	**2.98**	**2.80**	**2.15**	**1.90**	

(d) Financial Resources

A high degree of congruence (rating=2.75) was noted between the allocation and expenditure of financial resources. The constraints were with the strategy on skilled and empowered farming community with only 85.1% of the budget spent. This was the strategy with the constraint of relatively fewer posts filled (for animal scientists) and this could have contributed to budget under-spending. Although some posts were also not filled, the production input task under the strategy on improved agricultural production had the budget overspent by 25.5%. This could be indicative of the need for increased allocations and the sector management decision model should present some focus on this issue.

7.5 Conclusions

The major challenges faced by the poultry sector entailed lacks of (a) vaccination program, (b) production skills, (c) extension support, and (d) production inputs. The mean congruence between challenges and responsive strategies was moderate (rating=2.00) and this was a result of high degrees of congruence (ratings=3.0) for components associated with challenges (a)-(b) and low degrees of congruence (ratings=1.0) for those associated with (c)-(d). A moderate-high mean congruence (rating=2.50) occurred for strategies and tasks, and this resulted from high degrees of congruence (rating=3.0) for the components associated with challenges (a)-(b) and moderate degrees of congruence (rating=2.0) for those associated with (c)-(d). The mean congruence between the allocation and filling of posts was high (rating=2.58), and this resulted from high degrees of congruence (ratings=2.9, 2.6, and 2.6) for components associated with challenges (a), (c) and (d) and a moderate degree of congruence (rating=2.2) for component associated with challenge (b). As for the allocation and spending of budget, the mean congruence was high (rating=2.75), and this followed high congruence ratings (3.0) for components associated with challenges (a)-(c) and moderate congruence (rating=2.0) for the component linked to challenge (d). A responsive poultry management decision model should address the components with low and those with moderate degrees of congruence and should promote a commodity based approach with a focus on poultry. The purpose should be to increase the congruence among affected sets of components as this will effectively increase the capacity of the Department of Agriculture to address the challenges faced by the poultry sector in the study area.

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CHAPTER 8

GENERAL RECOMMENDATIONS AND CONCLUSIONS

The study illustrated that family chicken production plays an important role in the livelihood patterns of smallholder chicken producer of this study area. Moreover, village chicken production presents an important reservoir of genetic material which needs to be conserved. Management of the production processes ranging from hygiene, supplementary feeding, disease control and better housing could improve the productivity of these chickens.

It has been clearly indicated that the nutrient intake from available scavangeable feed resources were below the requirements of free range chickens. The most abundant feed resources available for supplementation are the cereal grains such as maize, sorghum and millet which are mainly the energy sources. The provision of both energy and protein supplementary feed resources and improved husbandry conditions would lead to improved production in indigenous chickens. There is still potential to research on the nutritive value of available alternative feed resources that could be used for ration formulation with simple processing to improve the availability of protein.

It is a well-known fact that body weight is the growth trait of critical importance in the poultry sector. Village farmers do not have the weighing scales to get the exact weight of the chicken but they rather look at the size to the chicken to tell that it is ready for slaughter. The prediction of body weight through linear body measurements of high accuracy level, BL and CC as measured by a tape measure could help farmers to have accurate, easy, cheap and rapid estimation of body weight.

Ratios if used may not necessarily bring significant variation in body weight. For small body parts it was evident that expressing body parts in percentages did not matter much. In that case ANCOVA will be the highly acceptable analytical method to be used to analyse the variables which vary isometrically with live weight. However, there is need to further study the different methods of expressing body parts such as wings, drumsticks and thighs as proportions of body weight.

A responsive poultry management decision model should address the components with low and those with moderate degrees of congruence and should promote a commodity based approach with a focus on poultry. The purpose should be to increase the congruence among affected sets of components as this will effectively increase the capacity of the Department of Agriculture to address the challenges faced by the poultry sector in the study area.

EXECUTIVE SUMMARY

Family poultry production plays a vital role in improving the livelihoods of rural communities in South Africa. The sector also serves as a reservoir of a genetic material which needs to be conserved before it goes instinct.

The low genetic potential in this input production system may be viewed as a limitation factor in increasing demand of free range products. However, if the number of households keeping these chickens could increase as well as the increase in the flock size within the households keeping the chickens, the supply will increase and the demand could be met.

The available scavenging feed resources available in the system are dominated by household waste, crop residues and the insects. It should be noted that the composition of the scavangeable feed resource base is determined by the agricultural practices in the region. Subsequently, the available alternative resources for supplementary feeding are also influenced by the type of grains planted in that region.

Village chickens grow slowly and keepers do not record performance. The price of the chicken is determined by seeing the size. Linear body measurements taken by a measuring tape showed positive correlation with body weight. It could be is concluded that using a measuring tape which could be easily accessed will give an estimate of body weight.

Slaughtering is happening at a substandard level. The use of ratio in eliminating variation of body parts in relation to the body weight may not necessarily give a positive response and they cannot enjoy the continuous use.

The sector is operating with little or no extension support. The Limpopo Department of Agriculture as the custodian of extensions services should work on improving the areas where the strategies and task are of low fit. The areas include provision of vaccination of notifiable

diseases such as New Castle, production advisory services and the financial support towards infrastructure. Policy Review should also include development of a multidisciplinary model that will assist decision makers to tailor made the necessary support to this sector to increase its contribution to food security.

Key words: Chickens, traditional, feed, nutrients, production, practice, growth, strategies, tasks, congruence