CHARACTERISATION AND PRODUCTION PERFORMANCE OF INDIGENOUS CHICKENS IN NORTHERN NAMIBIA REGIONS

A DISSERTATION SUBMITTED IN FULFILMENT FOR THE REQUIREMENTS

FOR THE DEGREE

OF

DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE

OF

THE UNIVERSITY OF NAMIBIA

BY

NDIILOKELWA PATRICIA PETRUS

MARCH 2011

SUPERVISOR: PROFESSOR G. P.KAAYA (Ph.D)

CO-SUPERVISOR: DR EMMANUEL LUTAAYA (Ph.D)

ABSTRACT

CHARACTERIZATION AND PRODUCTION PERFORMANCE OF INDIGENOUS CHICKENS IN NORTHERN NAMIBIA REGIONS

Farmers in all the studied regions regard poultry production as their primary source of domestic animal protein, with the domestic fowl being the most widely kept poultry species. Other uses are participation in socio - cultural ceremonies, selling for money and gifts. The extensive system of management is the most frequent. This system requires minimal costs, but mortalities due to disease and predation are very high, and chicken production is low and irregular. The study confirmed the use of local knowledge by some farmers (13.7%) in treating diseases. However, about (64%) of the interviewed rural farmers did not treat their chickens.

Numbers of birds per household in the entire region visited ranged from ten to fifteen per household. The adult body weights of females were found to range from 0.95 - 1.25 kg and adult males between 1.5- 2.0 kg. Scavenging system was the mode of feeding although birds were also supplemented with unknown quantities of pearl millet and it done ones. Rudimentary housing was available for indigenous chickens in 78% of the total households visited during rainy season only. The external characteristics of indigenous chickens in the four Northern regions showed the absence of autosomal dominant gene (I) that encoded for white plumage colour. Hence the study concluded that white leghorn might not have been introduced in Namibia. The single comb type was the commonest of the comb type observed in the chickens surveyed. 53.9% of the chickens had single comb, while 38.0% and 9.6% had rose and pea combs respectively. Average heterozygosity in the sub population was 0.0453 for Oshana, 0.1384 for Omusati, 0.0718 for Ohangwena a 0.221 for Kavango and these results indicated high level of inbreeding in the population. Principal component analysis was used to determine the genetic relationship of chickens between and within the four regions. Both scatter plot and phyllogenetic tree formed four major groupings and three sub-groupings with some overlapping. Based on this, the Kavango chickens were separated from the other Northern regions chicken populations. The same was also seen on the comb types where chickens from Kavango exhibited only a single comb type while the rest of the regions had the combinations of rose, pea and single combs.

The experiment on the production performance and growth response of growing indigenous chickens was done for 32 weeks using 3 dietary protein levels. The experimental chickens were offered diets and water *ad libitum* with high and low protein level whereas the controls were fed on locally- available feed materials. Feed intake and mortality were recorded weekly. Mortality of chicks aged between 1-8 weeks of rearing was (28%), those aged between 9-21 weeks (14.4%) and those aged between 21 -32 weeks (5.6%). There was no significant difference ($P>0.05$) between body weight of chickens fed on high and those that were fed on low protein diet. However, the body weight of chickens fed on low and high protein were not significantly ($P<0.05$) higher than those in the control group. The results of the analysis showed that varying dietary protein level had a significant effect ($P<0.05$) on nutrients deposited in chicken carcass especially a crude protein, energy and ash.

Key words: Characterization, Production system, disease, indigenous chicken, feeding and blood typing.

Table of Contents

Pages

ABSTRACT ii

ACKNOWLEDGEMENTS xviii

DEDICATION xix

DECLARATION... xx

CHAPTER ONE.. 1

INTRODUCTION.. 1

1.1. A brief description.. 1

1.2. Chicken population... 1

1.4. Problem statement and Justification... 5

1.5. Objectives... 6

1.5.0. General Objective.. 6

1.5.1. Specific objectives... 6

CHAPTER TWO.. 7

2.0. LITERATURE REVIEW... 7

2.1. Origin of chickens 7

2.2. Population of chickens 8

2.3 Characteristics of indigenous chickens 8

2.4. Importance of indigenous chickens 11

2.4.1. Genetic research 11

2.4.2. As a source of food and other functions 11

2.5. Flock ownership and management 18

2.7. Feeding and feed resources 21

2.8. Housing.. 28

2.9. Diseases of indigenous chickens 30

2.10. Poor management and mortality... 34

2.11. Weather condition 36

2.12. Disease control 36

2.13. Poultry farming systems 38

2.15. Marketing of local chickens 42

2.16. Breed and breeding of indigenous chickens 44

2.17. Identify gene types from physical characteristics 46

2.18. Importance of gene classification in chickens 47

2.19. Techniques for evaluating genetic biodiversity and biological performance........ 47

2.20. Current status of blood grouping in chickens 48

2.21. Variation in morphological characteristics in chickens................................ 50

CHAPTER THREE 54

3.0. Materials and Methods 54

3.1. Phenotypic characterization of indigenous chickens.. 54

3.1.1. Location of the survey 54

3.1.2. Sampling design and data collection 54

3.2. Statistical analysis 56

CHAPTER FOUR 62

RESULTS AND DISCUSSION.. 62

4.1. Distribution of indigenous chickens in Northern Namibian.................................... 62

4.2. Types of chicken breeds kept 63

4.3. Flock structure 64

4.4. Sources of stock and breeding criteria for replacement stock 65

4.4.0. Means of acquiring chickens in the rural areas 65

4.4.1. Breeding Practices 66

4.5. Roles of indigenous chickens 67

4.6 Consumption of chicken Products.. 70

4.7. Production performance 71

4.8. Chicken body weights 73

4.9. Feeds and feeding 74

4.10. Housing.. 80

4.11. Marketing of chickens and their products 83

4.12.0. Constraints for chicken production 84

4.12.1. Health status and disease management.. 84

4.12.2 Types of interventions made by farmers 85

4.12. 2. Inadequacy of extension services and veterinary support 91

4.12.3. Inadequate marketing system 92

4.12.4. Lack of quality feed.. 92

4.12.5. Chicken mortality 92

4.12.6. Predation... 93

4.12.7. Poor chicken management.. 94

4.13. Marketing of chickens and their products 94

4.13.0. Marketing of live chickens 94

4.13.1. Marketing of chicken products (meat and eggs) 96

4.14. Phenotypic characteristics of indigenous chickens in the four study areas........... 96

4.14.0. Plumage colour and feather patterns 97

4.13.9. Gene frequency for physical characteristic of indigenous chickens 107

CHAPTER FIVE 111

5.0. Study on the genetic variation of indigenous chicken population in Northern Namibian regions by blood typing method. 111

5.1. Introduction 111

5.2.0. Materials and Methods 113

5.2.1. Blood sampling and typing... 113

5.2.2.1. Washing of blood samples.. 114

5.2.3. Scoring based on agglutination 115

5.2.4.0. Genetic variation within the populations... 116

5.2.4.1. Gene frequencies 116

5.2.5.2. Genetic variability 116

5.2.5.3. Genetic distances 117

RESULTS AND DISCUSSION 117

5.3.0. Genetic frequencies 117

5.3.1. Genetic Variability 124

5.2.3. Average Heterozygosity 125

5.4.2. Genetic relationship of indigenous chickens in the four regions of Northern Namibia 126

CHAPTER SIX 133

6.0. Production performance of indigenous chickens under confined environment and fed four (4) dietary protein levels 133

6.1. Introduction 133

6.2. Hypotheses 134

6.3. Objectives 134

6.4. Methods and materials 135

6.4.1. Experiment procedure 135

6.4.2. Collection of experimental birds 135

6.4.3. Management 135

6.4.4. Experimental design 136

6.4.5. Measurements and sampling 137

6.4.6. Chemical analysis for the chicken carcasses 138

6.4.7. Statistical Analysis 138

RESULTS AND DISCUSSION 140

6.5.0. Comparisons of observed mortality of chickens across the three dietary protein levels. 140

6.5. 2. Feed consumption 143

6.5. 14. Growth performance of indigenous chickens in the confined conditions 149

6.5.15. Carcass characteristics 153

CHAPTER SEVEN 157

7.0. Conclusions and recommendations 157

7.2 Limitations of the study 159

7.3. Further research suggested 160

REFERNCES 161

APPENDIX --211

List of Tables Pages

Table 2.0.Egg numbers produced by indigenous chickens in various countries 10

Table 2.1. Chemical composition of chicken carcass of different genotype 16

Table 2.2. Major genes in local chickens and their side effects 24

Table 2.2. Contd.Major genes in local chickens and their side effect 25

Table2.2. Contd.Major genes in local chickens and their side effect. 26

Table 2. 3 Signs of poultry diseases observed in rural Indonesia 33

Table 2.4. Ethano-veterinary medicines from plants used for the treatment of diseases by rural farmers in different countries. 39

Table 2.4. Continued. Ethano-veterinary medicines from plants used for the treatment of diseases by rural farmers in different countries 40

Table2. 4. Contind.Ethano-veterinary medicines from plants used for the treatment of diseases by rural farmers in different countries 41

Table2. 5. Example of how to identify genotypes 46

Table 2.6. Major genotype associated with shank and foot colour inheritance in chickens 52

Table 2.6. contd. Major genotype associated with shank and foot colour inheritance in chickens 53

Table3.0. Example of computing gene frequency controlling the plumage colour 57

Table3.1 (a –c). Example of how to compute gene frequency of comb types 59

Table 3.1 (a).. 59

Table3.3 (c). Computation of a Peas comb type 60

Table 3.4. Calculation frequencies of dominant and recessive genes 60

Table 4.0. Body weight in (kg) (± s. e) of chickens from the four Northern Regions of Namibia. 75

Table 4.1. Names of the plants used as chicken medicine in the rural areas............... 909

Table4.2. Frequencies of comb type observed in the four regions.............................. 102

Table 4.3. Phenotypic distribution and gene frequency y of external traits of the indigenous chicken population in four Northern Regions of Namibia------------------- **Error! Bookmark not defined.**

Table 4.3. Contd . Phenotypic distribution and gene frequency of polymorphisms of external traits of the indigenous chicken population in four Northern Regions of Namibia.--

1101

Table 5.0. The degree of agglutination (clumping) of blood samples with different antisera.. 115

Table 5.1. Frequencies of 109 chicken antigens in Namibia local chickens from the studied areas 118

Table 5.1. contd. Frequencies of 109 chicken antigens in Namibia local chickens from the studied areas 119

Table 5.1. contnd. Frequencies of 109 chicken antigens in Namibia local chickens from the studied areas 1201

Table5.1. contnd. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas.. 121

Table 5.1. continued. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas 122

Table 5.1. continued. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas 1234

Table 5.1. continued. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas 124

T-able 5.2. Comparison of eigen values of first and second Principal components derived from the covariance matrix of 24anti sera. 128

Table5.2. contd Comparison of eigenvales of first and second Principal components derived from the covariance matrix of 175 indigenous chickens studied 129

Table 5.3. The frequency of occurrence of B and L system in the chicken from the four regions 132

Table6.0. Ingredients used in the experiment---137

Table6.1. Nutrient composition of the experimental diets-------------------------------139

Table 6.2. Chicken mortalities during 1-32 weeks of age 142

Table 6.3. Least Square Mean (± s.e) in kg for feed consumption based on different dietary protein levels fed to indigenous chickens.. 144

Table6.4. Regression coefficient of AWFI birds for the duration of 32 weeks of the experiment--145

Table 6.5. Regression coefficients of body weight on age of bird for chickens feed diets of varying protein levels 151

Table 6.6. Least of square means and standard error of difference in body weight of chickens fed on different level of protein 152

Table 6.7. Least Squares Means (± s.e) of nutrients composition of carcasses of chickens fed different diets.. 154

Table 6.7. contnd. Least Squares Means (± s.e) of nutrients composition of carcasses of chickens fed different diets.. 155

List of Figures Pages

Fig2.0. Marketing channels, players and flows for local chickens from producers to consumers--43

Fig 3.0. Map showing the four studied regions 55

Fig 4.0. Average number of chickens per household per region................................... 63

Fig4.1. Percentage of the purpose for keeping indigenous chickens-----------------------67

Fig 4.2. Two hens sitting in clutch 73

Fig4.3 A hen feeding together with her chicks in the crop field 76

Fig4.4 Supplements used by farmers.. 77

Fig 4.5. Chickens and ducks drinking from a broken plastic container 79

Fig4.6. A broken piece of a locally made clay pot used as drinker.............................. 79

Fig4.7. A chicken house made with Mopani poles 82

Fig4.8. Types of interventions used by farmers 888

Fig4.9. Greyish colour hen -- 99

Fig4.10. Mixture of white and black colour-- 99

Fig 4.11.Yellow and black colour-- 99

Fig4.12. Black yellow and white colour-- 99

Fig4.13. Black and brown colour---100

Fig4.14.Pur`-e black-- 100

4.15 Barred colour pattern ---100

Fig4.16. Yellowish colour type ---100

Fig4.17b. Single comb Fig 4.17b Pea comb Fig 4.17c Rose comb --------- 101

Fig4.18 Fig4.18 a. Frizzle chicken 4.18b.Naked neck chicken.................................... 103

Fig 4.19. Crested head without a comb 104

Fig4.20.Crested heads with a single comb 104

Fig4.21. Wild type (reddish, yellowish, black and greyish colour types 104

Fig4.22. Black shank 105

Fig4. 23. Yellow shank.. 105

Fig4. 24. Green shank.. 106

Fig4.25. Red shank with feather.. 106

Fig5.0. Genetic relationship among and between indigenous chicken populations in studied areas-- 131

Fig 5.1. Phyllogenetic tree for the chickens in the four Northern regions 131

Fig 6.0. Feeds consumption trend in rural chickens 145

Fig 6.1. Mean body weight versus the age of birds (9 – 32 weeks) for the three dietary treatments. 151

ACKNOWLEDGEMENTS

During all different phases of this research, I enjoyed plenty of support and co-operation. This contributed a great deal to the quality of the study results.

Those to be thanked include: The Almighty God for giving me strength and seeing me through this task successfully, my two research supervisors, Prof.G.P.Kaaya and Dr.E. Lutaaya, for spending their precious time and giving me constructive comments and advice, Prof. A. Abate, my first research advisor, for his invaluable support and constructive comments on my research proposal. I also appreciate the efforts of Prof.I. Mpofu, my head of department for his encouragement and positive attitude, Dr E. Musaba ,who willingly helped me any time possible. I would like to thank Mr. L. Samunzala for his assistance with field data collection and feed mixing, Mr.C.Mwaetako, Agricultural Extension Technician at Ongwediva Agriculture Development Centre, Mr.SP. Muteka, Prof. I Mapaure, Mr. N. Indombo, Mr.S. Kalundu, and all the farmers that participated in this research. Thanks to Dr. M. E Mizutani and his family, Mr. Suzuki, Ms. S. Kato, Prof.I. Takeda, as well as the Japanese Government through JICA Cooperation. I would like to thank the library staff Ms T. N. Andowa and Mr Taniseb for the assistant they render to me during preparation of the Dissertation.

I would also like to thank the University of Namibia for financial and logistical support, Danish Government through ASLIP Project, SANTED – project for the financial support. Lastly, I would like to thank all the colleagues who in one way or the other gave me moral support.

DEDICATION

This work is dedicated to my twin brother John, my two sons Chika, John and my daughter Helena for their love, patience and support.

DECLARATION

I, the undersigned hereby declare that the work contained in this dissertation is my own original work and that it has not previously in its entirety or in part been submitted at any University for a degree.

Name---

Signature----------------------------------- Date……………………………..

CHAPTER ONE

INTRODUCTION

1.1. A brief description of Northern Namibia region surveyed

Northern Namibia is bounded by the Kunene and Okavango rivers along the Angolan border. Although Windhoek is Namibia's capital, Northern central Namibia is the country's most densely populated region. The most prominent ethnic group in Northern central Namibia is the Owambos occupying the regions such as Omusati, Oshana, Ohangwena and Oshikoto. However, most Owambos practice subsistence agricultural system, growing staple crops and raising cattle and goats. In the northeast, the gently rolling Kavango region is dominated by the Okavango River and its broad flood plains where people cultivate maize, sorghum and green vegetables and supplement their diet with fish caught in woven funnel-shaped fish traps. Kavango people also produce Namibia's finest woodwork.

1.2. Chicken population

The indigenous chickens strains is a general terminology given to those animals or birds kept in the extensive system, scavenging in the free- range, have no identified description, multi – purpose and unimproved (Horst,1989). Elsewhere in Africa, they are also called family chickens, bush chickens, African hen, bush hen or Sahel chickens (Guèye and Bessei, 1997). These highly adaptable creatures are found throughout the Northern regions of Namibia and every culture owns them. Indigenous chickens form part of the agricultural farming activities among rural communities, although farmers regard them as secondary to the major farming activities such as crops, cattle, sheep and goat production and they are mostly under the management of women.

Indigenous chickens contribute significantly to the livelihood of the rural farmers by providing them with high quality animal protein in the form of eggs and meat for home consumption as well as for sacrifices.

Moreover, indigenous chickens through sales also provide some petty cash to the rural farmers. Native chickens are kept throughout the world and are the most widely utilized of all poultry species (Crawfold, 1984). Numbers of chickens per household varies from one house to another. Indigenous chickens are easily managed by all even the poorest of the poor including women and children. They require minimum input (husbandry) and adapt well to the rural conditions as compared to those of exotic chickens (Sonaiya, 1990; Guèye, 1998a). Unlike pork, indigenous chickens are known to have very few taboos attached to them (Taddle and Ogle, 2001) and in some instances, they have retained importance in religious and cultural rites (Crawford, 1984). Their meat is preferred because of its better texture and strong flavour as compared to those of commercial chickens (Guèye, 1998a).

Native chickens make best use of locally - available resources including household wastes and they do not compete with humans for grain (Sonaiya, 1990; Okoye and Aba – Adulugba, 1998; Tadelle and Ogle, 2001). However, they are faced with numerous challenges including poor health, poor feeding, improper housing, and low production rate in terms of eggs, slow growth, and mortality. Both chicks and adults are fed together as a group. Feed is broadcasted on the ground (sand) in the case where supplementation is done (Sonaiya 2004**).** Although they generally lay few eggs and grow very slowly, they have the potential to increase their productivity if they are given good care in terms of proper feeding, veterinary care and good housing.

Several reports from developing countries indicate disease as the most important challenge that affect the production of the indigenous chickens throughout the developing world. Newcastle disease is the most important disease for the indigenous chickens in the tropics. Other diseases reported are fowl pox, infectious coryza, internal and external parasites. Sonaiya (1990) reviewed reports from some African countries and concluded that mortality caused by Newcastle disease ranges from 50% to 100%. Sprabrow (1996) reported that Newcastle disease may cause mortality of entire flocks.

Apart from the disease, indigenous chickens are also faced with problems of predators due to absence of proper housing. Chickens are reported to sleep on top of trees, in and around the houses and in corners of the owners' dwellings (Akklobesi, 1990).

Despite their importance, information on genetic makeup of indigenous chickens in terms of their performances, adaptability, disease resistance, genetic variability and genetic relationships is lacking in Namibia. Elsewhere, indigenous chickens have been described to have unique genes which are important in adaptation to their agricultural production system and agro-ecological environments (Guèye, 1998a).

The genetic characterization of the domestic animals is also part of the FAO Global Strategy for the Management of Farm Animal Genetic Resources. This strategy places a strong emphasis on the use of molecular methods to assist in the conservation of endangered breeds and to determine the genetic status of breeds. Genetic characterization contributes to breed definition, especially populations which are not well defined and it provides an indication of their genetic diversity. It also has a potential to identify unique alleles in the breeds or lines studied. Conservation of farm animals including chickens will be important for future designing of sustainable breeding programs.

Throughout the world however, many methods of varying complexity have been developed that can be used either to assess or evaluate the structural biodiversity and biological performance in chickens in order to understand the relationship between the variation in biodiversity and biological performance. Their application in a particular situation depends on the degree of precision desired, practicality and cost.

Before the contemporary molecular tools were developed, researchers relied on methods such as morphological traits, protein polymorphisms, immunogenetic systems and microsatellites (Nickiforov *et al.*, 1998; Weigand and Ramanov 2001) and blood typing (Briles, 1952). Therefore, it is believed that, through genetic characterization, the information as to how unique or how different chickens are from each other may be revealed and also step in to design appropriate management and conservation programs on how best these strains can be conserved and suggest suitable breeding plans.

1.4. Problem statement and Justification

Although the rearing of indigenous chicken is of significant importance in the selected areas, there is paucity of information on production and genetic characteristics. Indigenous chickens are found everywhere in the rural areas of Namibia where 60% of the human population lives. They require low capital investment and little space for rearing and are consequently kept by all social groups including landless families. Although they grow slowly and lay fewer eggs per year as compared to improved commercial chickens, they are better adapted and survive well under harsh conditions.

There is little information and very little research has been done to determine the performance relating to productivity and reproduction performance of native chickens in these regions and in Namibia as a whole. The paucity of information is equally lacking with regard to survivability in the different production systems and at different stages of the growth cycle. Therefore the objective of this study was to characterize indigenous chickens' production system and their genetic potential in the four Northern communal regions of Namibia. The research strategy and layout of the study was as follows:

i) Phenotypic characterization of indigenous chickens through baseline survey,

ii) The genotypic characterization of the indigenous chickens by blood typing,

iii) Assessment of production performances of indigenous chicken under a confined condition,

iv) Characterization of the indigenous chicken production system

1.5. Objectives

1.5.0. General Objective

The general objective was to outline the phenotypic and genotypic characterization of indigenous chickens and production performance in the four Northern communal regions of Namibia.

1.5.1. Specific objectives

The specific objectives were to:

i. Characterize the systems under which native chickens are kept;

ii. Identify the available strains within the native chickens' population,

iii. Determine the feed consumption, growth rate and survival of native chickens under improved management.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Origin of chickens

The origin of domestic of chickens is well documented by many authors. Using the archaeological evidence, authors such as Carter (1971), Crawford (1984) Darwin, (1875) and Zeuner (1963) pointed out that chickens were first domesticated in Southeast Asia in the region called Indus valley by 2000 BC. The domesticated fowl (chicken) is believed to have descended from the wild Indian Jungle Fowl and the South East Asia Red Jungle Fowl (Mason, 1984; Moiseyeva *et al.*, 2003). This specie is one of the most common and wide-spread domestic animals with a population of more than 24 billion in 2003 and kept primarily as a source of food from their both meat and eggs (Mason, 1984, Ganabadi *et al.*, 2009).

In Africa Macdonald and Edward, 1993, quoted by (Van Marler – Koester and Cassey, 2001) stated that chickens existed since 332 BC and that the domestication of this species in South Africa was probably introduced by traders en route to India and European settlers in the early 15th and 16th centuries. Indigenous chickens vary greatly especially in morphological characteristics (Horst, 1991). Domestic fowl or chickens referred to as *Gallus domesticus* occur throughout the world and according to Mason, (1984), they are the most utilized species and the most popular of poultry kept under rural conditions.

2.2. Population of chickens

Indigenous chickens are the most abundant species of poultry that are kept in the rural areas and their reported number vary from one country to another. Their distributions out number that of other livestock and they are the only species that can be kept by the poorer section of the population in the rural areas. Guèye (2003) reported that they represent about 98% of the total poultry numbers kept in Africa. In Malawi, they constitute 83% (Gondwe, 2004), Nigeria 80% of 120 million poultry birds (Feyeye, 2005). Despite their popularity and potentials, Sonaiya (1990) pointed out that rural poultry are rarely accorded primary consideration in economic development activities. However, rural farmers often regard this sector as secondary to other livestock and crop farming activities.

2.3. Characteristics of indigenous chickens

Indigenous chickens are slow growers as compared to modern birds which grow very fast due to genetic selection, efficient production systems, improved nutrition, and regular veterinary attention. Variation in growth and productivity is highly genetically determined (Nordskog and Briggs, 1967). They are characteristically an integral part of the farming systems requiring low-inputs with outputs accessible at both inter-household and intra-household levels (Kitalyi, 1999). The production system is still very backward and suffers a serious setback such as poor management practice, malnutrition, disease outbreaks and predation (Permin and Hansen, 1998). Pousga *et al*. (2005) stated that the production output is low because of the poor genetic potential of the birds, inadequate feeding and management, and the harsh environmental conditions they subsist in.

Indigenous chickens are characterized as dual purpose birds due to their ability to supply both meat and eggs for human consumption. Indigenous chickens are broody, able to take care of their own chicks (Horst, 1989). When compared to exotic chickens they lay fewer eggs which weighed about 43grams (Ramlah, 1996). The reported numbers of eggs are presented in Table1. A maximum of four clutches per hen per year composed of up to ten eggs per clutch was reported by Awuni (1989).

As concluded by many authors, the low production in local chickens is caused by malnutrition, prevalence of diseases and lack of sound management and genetic factors (Musharaf, 1990). Farmers usually use all eggs for incubation but they usually encounter some problems in terms of hatchability and low chick survival rate. However, Awuni (2002) reported that factors such as predation (dogs eating eggs) and high ecto-parasite infestation which discourage brooding were the major reasons for the poor hatchability rate. At the same time, poor management practices such as provision of poor housing facilities, especially for chicks, exposed the newly hatched chicks to the adverse effects of weather (torrential rains) and predation Mwalusanya *et al.,* 2001; Kusina *et al.,* 2001; Pedersen, 2002).

Several authors have reported the production performances of indigenous chickens to be below that of standard commercial layers and broilers and with smaller bodies (Barua et al., 1998; Ebangi and Ibe, 1994; Safalaoh, 2001). Mature body weight of 1.02 kg in males and 1.00 kg in females at five months of age was reported by Barua and Yoshimura (1997). However, there is very little information about egg production for indigenous chickens in Namibia. Commercial strains for example can produce up to 300 eggs per year with an average weight of 63 - 65g (Faranisi, 1995).

Table2.0. Egg numbers produced by indigenous chickens in various countries

Country	number of eggs /hen/year	Source
Morocco	60 – 80	El Houadfi (1990)
Nigeria	30 – 128	Adene (1990)
Senegal	50 – 60	Boye (1990)
Somalia	100 – 144	Lul Said Ahmed (1990)
Namibia	100-150	Van Niekerk, 1998
Jordan	18 -30	Abdelqader . et al. (2007)
Togo	80 – 150	Aklobessi (1990)
Mali	20 -100	Guèye (1998)
Malawi	<50	Safalaoh (1992)
Ethiopia	> 80	Tadelle and Ogle (2001)
Kashmir	50-60	Iqbal and Pampori (2008)

2.4. Importance of indigenous chickens

The chicken has a proud history, both in genetic research, as a source of food and other functions.

2.4.1. Genetic research

Chickens have several merits as a model for understanding biology because they are rich in genetic diversity, command a huge population size, breeding is easy, and have high recombination rate (Siegel et al., 2006). History has also revealed that the chicken was the first animal species in which Mendelian's inheritance law was demonstrated and the first among farm animals to have its genome sequenced.

2.4.2. As a source of food and other functions

Literature and various presentations give ample evidence to support the impact of indigenous chickens in the livelihood of rural communities in terms of the nutrition, health status, income and socio - cultural aspects. Therefore, indigenous chickens are considered very valuable in the rural communities because they fulfil major functions and benefits in the livelihood of rural families. Farmers seem to keep chickens for several reasons which differ from one farm to another even within the same locality. However, Tadelle and Ogle (1996) reported that in the central highlands of Ethiopia, the main objective of keeping poultry was for production of eggs for hatching (51.8%), sale (22.6%), home consumption (20.2%), and sacrifice for healing ceremonies (25%), replacement (20.3%) and home consumption (19.5%).

Minh (2005) described indigenous chickens as efficient converters of leftover grains as well as insects into valuable protein, for example, meat and eggs. They are also viewed as controllers of weeds and insects and supplier of organic fertilizer for vegetable gardens and field crop fields. In ruminant nutrition, they provide nitrogen required in their diets. Chickens can serve as a unit of exchange in rural communities where there is no circulation of money. Mberema (1999) stated that a village in Kavango region pay their hospital bills with chickens which nurses replace with money by selling to other workers in that hospital or clinic.

Preference of chicken to other meat due to its taste and suitability to traditional ways of prolonged cocking, was reported by (Guèye, 1988; Aini, 1990; Safalaoh,1997; Kyvsgaard *et, al*.; 1999; Branckaert and Guèye, 1999).

Rural farmers in Jordan believe that by consuming meat of indigenous chickens, they are less prone to cancer and other diseases as compared to urban people. Farmers in this area also revealed that food produced from local livestock breeds, poultry in particular, is healthier and make them stronger (Abdelqadar *et al.*, 2007). Ganabadi *et al.* (2009) reported that indigenous chicken is always thought to be better in term of carcass composition than commercial broilers due to its low fat content. The diet of indigenous chicken consists mainly of kitchen left over, such as rice or used coconut pulp. Ramlah, (1996) stated that the indigenous chicken has low fat and muscle weight compared to broilers because they need to use energy to find food. Siegel *et al*. (2006) giving an example of the United State of America, said that consumers in that country prefer free range chickens to those that are reared indoors in battery cages. The reason for preferring indigenous chickens is because they are healthy. Survey by Latter-Dubois (2000), reported that the Canadian consumers also prefer grain-fed poultry because of the better flavour (34.16%), "raised without medicine/hormones (27.23%), less fat (15.84%), production methods more humane (12.87%), and higher protein (9.90%). Ganabadi *et al.* (2009) suggested that due to indigenous chicken’s carcass composition, it will be the best for consumption as it is healthier with medium level of fat, muscle and bone. The same authors further explain that even though broilers have the highest muscle composition, their fat level is also significantly higher and can be a risk factor for many diseases, such as heart disease and diabetes in humans. Indigenous chickens in some countries are valued differently. For example, people in Thailand believe that indigenous strains have traits that are very important for cock fighting (Wilson 1991).

The village chickens are free roaming and many studies have shown that rearing indigenous chicken is cost effective since very little financial input is needed (Ramlah,1996). Chickens have short reproduction cycle of 21 days (Lough, *et al*. 2001). Economically eggs also play an important role, for example about 98.5 % and 99.2% of the national egg and poultry meat production in Ethiopia are contributed from the traditional poultry production respectively (AACMC, 1984), with average annual output of 72,300 metric tons of meat and 78,000 metric tons of eggs (ILCA 1993).
Indigenous chickens also have been reported to contribute to food security and help to spread production risks and contributing to gender equity in many developing countries

(Lebajoa, 2001; Wilson, 2007). Indigenous chickens also play a crucial role in households where there is lack of able bodied especially those households affected by HIV/AIDS among the rural populations (Haruna, 2001).

Similarly, indigenous chicken products are cherished because they are a source of many nutrients required by humans and also provide income to rural farmers (Mwalusanya, *et al.* 2001). Van Marle-Köster *et al*. (2008), in their study also stressed the importance of local chickens throughout Africa as contributing significantly to household food security and socio-economic value. White meat such as chicken is considered superior in health aspects to red meat because of comparably low fat and cholesterol content. Consumers also acknowledge the relatively low price, the typically convenient portions, and the lack of religious restriction against its consumption (Jaturasitha, *et al*., 2004)

In terms of nutrients composition of chicken meat, the comparisons of carcass and meat quality traits as well as muscle fiber characteristics in Blacked-boned and Thai chickens as opposed to Bresse and Rhode Island Red chickens, confirmed the unique features of indigenous strains as presented in Table 2.1. Kansci *et al.* (2004) also reported that the indigenous chicken is superior to exotic chickens in terms of protein content and also high in water retention capacity but low in lipid content. They also concluded that meat from indigenous chickens has some unique features and seems to have more advantages over imported breeds, especially when determined for a niche market serving consumers who prefer chewy, low-fat chicken meat. Native chickens are also important for other activities e.g. colours of the plumages are reported to be very important in various religious and socio - cultural life of many African people. For instance, Sonaiya *et al.* (1999), reported that red cock is used for sacrifice to ask for rain and good harvest, a white cock is used for thanks giving and black cock is for protection from evils e.g. diseases, war or quarrel.

According to Ojo (2003), a lot of social and traditional values are placed on frizzled and naked neck chickens due to their roles in rituals and sacrifices. In Senegal, Guèye et al. (1997) reported that outside the urban centres and especially in non-coastal areas of that country, family poultry provides the population with a vital source of protein and income. Other roles poultry plays include social events (eg: special banquets for family or for distinguished guests, cocks as alarm clocks for people, gifts, etc.) and/or religious ceremonies (eg: cocks as offerings to the deities).

Other reasons why scavenging chicken has been valued are that, they provide much needed animal protein at minimum cost (Msoffe *et.al.,* 2001), suited to very limited input that poor producers can provide (Guèye, 1998) and provide eggs and meat at a little or no cost to their owners (Farrell, 2000). Thus, the birds are left to depend primarily on what nature offers.

Table 2.1. Chemical composition of chicken carcass of different genotype

	Chicken genotype					
Item	Black-boned	Thai	Bresse	Rhode	SEM	P-value
Breast muscle						
Chemical composition (g/100g)						
Moisture	72.1	72.9	73.3	73.7	0.05	0.210
Protein	24.4	24.7	23.6	24.8	0.06	0.561
Fat	0.53^{ab}	0.51^{b}	0.76^{a}	0.72^{ab}	0.006	0.013
Energy (mJ)	184^{ab}	225^{a}	139^{ab}	118^{b}	2.0	0.040
Thigh muscles						
Chemical composition						
Moisture	74.1^{ab}	75.7^{a}	73.7^{b}	72.8^{b}	0.05	0.003
Protein	21.7^{a}	20.4^{ab}	20.6^{ab}	20.1^{b}	0.04	0.053
Fat	2.81^{b}	2.94^{b}	4.21^{b}	6.04^{a}	0.041	0.001
Energy (mJ)	-	-	-	--	-	-

Source: Jaturasitha *et al.* (2008)

Poultry meat and eggs accounts for more than 30% of the animal protein consumption globally and the share is increasing steadily (Guéye, 1998). Local chickens provide cash; create employment opportunities for rural women and for landless and marginal farmers (Dessie and Ogle, 2001). Furthermore, rural poultry are reported to be associated with few religious taboos. However, Jorge *et al*. (2007) pointed out that chickens meat is one of the important source of animal protein without any major dietary restriction, unlike pork which is avoided by Muslims and Jews or beef which is not consumed by Hindus. Chicken products are sold to meet essential family needs e.g. medicines, clothes, school fees (Mack, *et al.,* 2005). Mopate and Lony (1999) on the other hand reported some taboos associated with consumption of chickens, especially in circumcised women and first born children. Moreover, in some cultures, children under the age of three and girls in general are traditionally forbidden from eating eggs (Guèye and Bessei, 1997). Apart from taboos, indigenous chickens are described by Barua and Yoshimura (1997) as having the ability to protect themselves and their chicks from predatory animals. According to (Sonaiya *et al.*, 1999; Tadelle, *et al.,* 2000), indigenous chickens have the ability to utilize resources that cannot otherwise be used for human consumption to maximum and also are reared and survive under different types of production systems without much difficulty. Adaptability to a wide range of environmental conditions facilitated the emergence of the chickens as the leading domesticated avian species (Siegel *et al.*, 2006)

2.5. Flock ownership and management

Indigenous chickens are widely distributed species in many rural areas and according to (Guèye, 1998), about 80% of chicken in some African countries are owned and controlled by women assisted by children. Badubi (2006) reported that in Botswana, about 98% of chickens in rural areas are managed by women and only the remaining 2% are owned by men.

In Western Kenya, Okitoi *et al.* (2007) reported that there is division of labour among family members in rural poultry management as far as construction of sheds, cleaning of chicken houses, feeding and treatment of sick chickens, showing that all family members provide labour, although women and children dominated the activity profile. What is interesting from a gender perspective is that, men are said to dominate both in selling and buying of chickens in village markets (Kitalyi, 1998) in Kenya. However, Abubakar *et al.* (2007) observed that in Nigeria in most households, chickens belong to the entire family with women owning the majority of the birds, followed by children and then men last. The same author also reported that in Nigeria, Borno state in particular, majority of chickens are owned by men, follow by women and lastly the children.

Division of labour among the households is demonstrated by the fact that women are assisted by children and children are assisted by their mothers in feeding and watering chickens. According to Losada *et al.* (1997) in Iztapalapa (East of Mexico City), the management of poultry is largely the responsibility of the women and children and represents only a secondary activity for men. The indigenous fowl is also extremely well adapted to the tropics and its tolerance to poor management and feed restrictions, Oluyemi *et al*. (1979).

2.6. Improvement of indigenous chickens

A number of approaches aimed at increasing the productivity and improving the economic production profile for poultry farmers have been conducted in some part of Africa and elsewhere in the world. The genetic improvement program in a number of African countries did not achieve sustainable result and this has been attributed to various factors. These include operational and financial problems of state-owned farms or stations maintaining the parent stocks, which resulted in failure to deliver the pullets as planned (Minga *et al.,* 1989; Kaiser, 1990); inability to maintain higher management level of improved stock in the villages (Adegbola, 1988); lack of adequate extension support (Kaiser, 1990); and inadequate or poor institutional and organizational support (Kaiser, 1990). Some of the failures experienced for improving productivity are related to breeds unsuitability to the environment, diseases challenges, bad management, lack of supplementary feeding and predator problems (Bagust, 1994). Hence, in the face of these problems, therefore, it becomes imperative to explore interventions that may increase productivity through increased number of clutches per year and reduction of losses due to predation. The interventions to improve the productivity were mostly made through cockerel exchange and egg distribution to rural farmers.

Safalaoh (2001) reported that the government of Malawi provided cockerel of Australop breed to farmers in order to crossbreed with their local chickens. Vaccination of local chickens against Newcastle diseases was done in Mozambique (Alders, 2002) aimed at improving indigenous chicken production. These past attempts at improving livestock productivity in developing countries have focused largely on importation of exotic breeds. This approach was taken in order to achieve increase in production of meat and egg in the shortest time possible with limited success in the communal areas. Hence, Mack *et al.* (2005) suggested that to improve performance of indigenous chickens, a combination of effort needs to be examined at. For example there is need to provide an enabling environment that allows vulnerable and disadvantaged people access to credit, improve husbandry practices, good services, improved genotypes and better market opportunity.

Guèye (1998) suggested that there is a need to protect and conserve the indigenous chickens because they represent an important gene reservoir. Indigenous chickens constitute a variable genetic reservoir that make them well adapted to the extensive management system, a condition which prevails in African rural areas as presented in Table 2.2. An improvement through supply of proper inputs such as feed supplements, vaccination, treatment, house cleaning and disinfection and provision of proper housing and nesting places were suggested to improve hen performance, particularly egg production and egg weight (Abdelqader *et al.*, 2007).

2.7. Feeding and feed resources

The major feed sources for village chickens are earthworms, insects, seeds, green leaves and other plant materials found in household yards. The nutrients available to locally scavenging chickens are generally deficient; not only does their availability 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 (Tadelle and Ogle, 1996), Bangladesh (Huque, 1999), and Tanzania (Mwalusanya, *et al*. 2002). But the scavenged nutrients also vary to some extent depending on 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 authors reported that the commonest source of chicken feed was through scavenging with little supplementation and irregular supply of water. Permin *et al.* (1999) reported that lack of protein and vitamins weakened the chicks and made them vulnerable to diseases and predators that led to mortality. According to (Roberts and Gunarantne, 1992), chicks tend to be the weakest among chicken flocks and as such, cannot compete with adult birds for feed available from the scavenging feed resource base. Moreover, Tadelle and Ogle (2001), without specifying the type of nutrients, identified feed deficiency and malnutrition that weakened the birds as one of the contributing factors of the birds becoming vulnerable to predators and also increasing their susceptibility to diseases

The results of the study of Huque (1999) in Bangladesh concluded that the nutrients obtained by hens from scavenging around the homestead in a range of locations did not have enough protein, or were too high in fibre, or were imbalanced in calcium and phosphorus when considered in the light of known nutrient needs for high egg production. The availability of nutrients was differed among seasons with summer being most favourable and the rainy season least favourable in terms of nutrient availability. Protein appeared to be the most limiting of the nutrients. The amounts of nutrients consumed are however not known and this has made the improvement of the diet of the indigenous chickens impossible (Sonaiya, 2000; Tadelle and Ogle, 1996) also reported that due to the limited supply of nutrients, the productive potential of local birds is very much restricted, thus any attempt to supplement local poultry should take into consideration the estimates of what the birds actually consume.

However, the uncertainty of what the local poultry consumed in their environment has led to several authors researching on the nutrients composition and the amounts of scavenge-able feed resources base consumed by indigenous chickens. Attempt to determine the nutrients composition of feed consumed by scavenging chickens has been documented by (Sonaiya, 2004; Minh, 2005; Goromela, *et al.,* 2006). However, Roberts and Gunaratne (1992) stated two methods for estimating the capacity of the scavenging feed resource using data collected in Sri Lanka. The first method was based on measurement of household refuse and chemical composition of crop contents using the formula:

SFRB = H/P * n(n/n-x),

Where;

SFRB = scavenging feed resource base;

H = amount of household waste per family per day (kg dry weight);

n = number of families in the community;

x = number of families in the community that do not keep chickens;

P = proportion of the crop content that is household refuse, determined by visual inspection.

The second method suggested by the same authors used production levels of the flock. In this method, the daily consumption of the SFRB was described by the formula.

SFRB = $\sum$ Ej /Es.

Where;

j = the average number of birds in the family flock obtained in a survey; Ej = the metabolizable energy(ME) requirement for the daily maintenance and production of each bird per day (kcal/kg dry weight), calculated from production data of growth rates and egg production such as that given by the National Research Council (1984) and Es = the ME in the scavenging feed (kcal/kg dry weight) from crop content measurement. These scavenge-able feed materials have been observed to be mainly consisting of household left - over, green materials, insects, earthworms, residual grains (Ndegwa *et al.,* 2001; Tadelle and Ogle, 2000), and young grass shoots and fruits (Aini, 1990).

Table2.2. Major genes in local chickens and their side effects

Gene	Mode of inheritance	Direct effect	Indirect effect
Dw: dwarf	Recessive, sex linked, multiple allelic	Reduction on body size 10 – 30%	Reduced metabolism, improved fitness and disease tolerance
Na: Naked neck	Incomplete dominant	Loss of neck feathers, reduction of pterlae width, reduction of secondary feathers	Improved ability for convection reduced embryonic liveability (hatchability), improved adult fitness
F: frizzle	Incomplete dominant	Curling of feathers and reduce feathering	Decrease fitness under temperate conditions, improved ability for convection.
H: silky	Recessive	Lack of humuli on barbules, delicate shaft, long barbs at contour feathers	Improved ability for radiation from shank and skin

Table2.2. Contd. Major genes in local chickens and their side effect

Gene	Mode of inheritance	Direct effect	Indirect effect
K: slow feathering	Dominant, sex linked, multiple allelic	Delay feathering	Reduced protein requirement, reduced fat deposition during juvenile life, increase heat loss during early growth, reduced adult viability.
id: non-inhibitor	Recessive, sex linked, multiple allelic	Dermal melanin deposition in the skin and shank	Improved ability for radiation from shank and skin
Fm: fibro-melanosis	Dominant with multi factorial modifiers	Melanin deposition; all cover the body; sheath of the muscles and nerves; tendons esenterium; blood vessel walls	Protection of skin against UV radiation, improved from the skin, increased pack cell volume and plasma protein.

continued

Table2.2. Contd. Major genes in local chickens and their side effect.

Gene	Mode of inheritance	Direct effect	Indirect effect
P: pea comb	Dominant	change skin structure, compact comb size; reduction of pterlae width; development of breast ridges	Improved ability for convection, increased frequency of breast blister, sex limited (o) improvement of late juvenile growth
O:blue shell	Dominant, sex limited	Deposition of blue pigment (bilivrbin iv) into egg shell	Improved egg shell stability

Source Horst (1988)

The household materials are reported to form a major proportion of the total diet consumed by chickens per day which range from 69% in the rainy season to 90% in dry season (Goromela *et al*. 2008). The same authors, however, reported smaller proportion of 10% to 31% of the diet in dry season and in the rainy season, respectively, come from scavenging in the environment.

According to Rashid *et al*. (2004), scavenge-able materials are dependent on the availability of feed from the surrounding environment and household refuse.

Quality and quantity of scavenge - able feed resources (FSR) can be significantly affected and influenced by seasons, breeds as well as social habit in different location and by the life cycle of the insects and other invertebrates (Minh, 2005). Native chickens are hardly supplemented, but where it occurs, chickens are supplemented with unbalanced feed resource which is often very limited quantities thrown on the ground every day. Some figs obtained by other authors also showed that more than 70% of the feed intake was household refuse roughly composed of 27% cooked rice, 30% coconut residue, 8% broken rice and 36% other scraps. The remainder was from the environment (13% grass shoots, 8% small metazoans and 7% paddy rice).

However, Sonaiya (2004) indicated that SFRB contained 8.8 gram crude protein and 2864kcal of metabolizable energy. These values are said to be below the estimated 11g/bird per day protein required for free ranging local hen in the tropics to meet maintenance needs. The energy and protein intakes of the birds as a function of breed, season, temperature, physical state of the birds, composition of the food and previous experience in scavenging has been observed. Gunaratne *et al*. (1993) reported that the average amount of scavenged feed per household flock per day was 550 g dry weight with approximate composition of 9·4% crude protein, 9·2% ether extract and 5·4% crude fiber and this led the authors to conclude that feed consumed by chickens from scavenging is critically deficient in crude protein, calcium and phosphorous.

Farrell (2000) recommended that a laying hen requires apparent metabolizable energy of 689KJ and protein requirement of 6 gram per day. Due to seasonal variation of

SFRB, birds in the rural areas are said to be experiencing some deficiencies of some nutrients. In dry season, for example, birds will develop deficiency of vitamins because of scarcity of succulent vegetable in the range Sonaiya *et al*. (1999). Ndegwa et. al., (2000) reported that rural farmers offer supplements in the form of kitchen left - overs and small amounts of grains are usually provided by housewives assisted by children. Other sources of supplement reported are small amounts of cereals which include millets, milo and maize (Pousga *et al.,* 2005). Supplements may be given in the morning or in the afternoon (Kitalyi, 1999; Ndegwa *et. al.,* 2001). In Botswana, supplements are reported to be offered once a day (Badubi, 2006).

2.8. Housing

In rural areas, housing occupies a low priority in the management of all poultry including chickens under extensive management system. Although there are some indications that farmers at rural level do not provide houses for chickens, this scenario seems to vary from one household to another, economic situation of a particular farmer, the way farmers value the importance of housing and also the purpose of production (Badubi, 2006). Tadelle and Ogle (2000) in their study in central Ethiopia, reported that 88.5% of the respondents had proper houses for their birds, while 11.5% only provided simple shelter. The study carried out in Botswana by Badubi (2006) also indicated that most farmers did not provide housing for their birds in a total of 230 respondents, 64.2% did not provide any housing whereas 35.8% did provided housing of some kind.

Similarly, Kusina *et a*l. (2001) in Zimbabwe reported that 94 % of the households kept chickens in houses although they were poorly constructed. However, 3% of the farmers in the same study left them to stay on trees or in open space and the remaining 3% only provided housing to those chickens that were laying eggs. In Kavango, chickens were reported to sleep either in house dwellings or on top of the trees that are within the household boundaries (Mberema, 1999). However, Khalafalla *et al*. (2001) reported that 48.3% of the households provided overnight housing, 20.6% kept chickens overnight within the main house, and the remaining 30.9 % of the farmers did not provide houses, hence chickens sleep on trees or roof tops. Seventy nine percent (79%) of rural families shared shelter with their chickens and other domestic animals like cats and goats. In summer, however, the same authors indicated that only 8.3% of the farmers sheltered their chickens for one or two weeks during planting to prevent their crops from being destroyed and during winter when they plant agronomic crop such as vegetables in the garden. Similarly, in Malawi three types of housing were used for sheltering local chickens namely; (1).Humans' dwelling 84.5% of flocks, (2). Households' kitchens (8.05% of flocks), and (3) built for chickens separated from the main house (7.45%). Traditional house built poultry in Malawi is known as"khola" (Gondwe and Wollny, 2007).

Elsewhere, reports from researches done in many developing countries have also indicated that where chickens are provided with houses or shelter, these are said to be rudimentary. However, rural farmers in Lao People's Democratic Republic make use of various scrap materials or split bamboo and palm leaves to construct houses for their chickens (Wilson, 2007). Some locally available materials used by farmers for the construction of chickens' houses in Morocco include bamboo, wood, stones and plastic screens (Benabdeljelil and Arfaoni, 2001). Kumerasan *et al*. (2008) also reported the use of Bamboo and wood in India.

2.9. Diseases of indigenous chickens

Disease is defined as departure from health and includes any condition that impairs normal body functions (Damerow, 1994). Diseases result from a combination of indirect and direct causes. Indirect causes are those conditions that reduce resistance while direct causes are those that produce diseases (Domerow, 1994).

Numerous research reports have shown that disease outbreak is one of the main constraints in to poultry production many developing countries. The impact of disease on the poultry industry has both economic and genetic dimensions. Economically, losses are a direct result of mortality, medication costs, veterinary services costs, downgrades, depopulation, lower production, and poorer feed efficiency (Lamont, 1998). Furthermore, an outbreak of disease can have an implication on the difference between sufficient food stocks and food insecurity, between having a secure income to the loss of key household assets and the presence of livestock disease. This makes it difficult for the low resource farmers to participate in local and even the national livestock economy (Sonaiya and Swan, 2004)

Equally importantly, animals and human health is intricately related. Zoonotic diseases can have a major influence on the health and wellbeing of the households involved. Zoonotic diseases are those that can be cross -transmitted between humans and animals. Hence, livestock diseases have a major influence on poverty outcomes (Sonaiya and Swan, 2004).

Horst (1998) noted that indigenous chickens have low resistance to diseases such as New Castle disease, fowl pox and coccidiosis. In Nigeria, a study by Okoye and Adulagba (1998) revealed that indigenous chickens are susceptible to diseases such as Busal infectious disease as compared to commercial broiler chickens. Other diseases such as typhoid, diarrhoea, coryza have been reported in chickens (Sonaiya, 1990).

However, it has been reported that when New Castle disease appears it can often kill almost all the flocksat ones (Spradbrow, 2001). For instance, Sonaiya (1990) after summarizing other reports from six African countries indicated that 50 – 100 % of mortality of indigenous chickens is due to New Castle disease. This disease is caused by paramyxovirus and it is known to be a serious and commonly fatal disease of chickens when compared to other avian species. In Botswana, Badubi *et al*. (2006) and Mushi *et al.*, 2000), in their separate studies also reported New Castle as a major disease that causes mortality in indigenous chickens.

Hefez (2005) explained two ways by which New Castle disease can be transmitted; namely through direct contact between healthy and infected birds and secondly through mechanical means such as vaccination and de-beaking equipment. The same authors further explained that the course of the disease varies according to the virulence of the strain involved, age of chicken and immune status, as well as the general condition of the particular birds.

Another disease of poultry which is, by far not of major consequence to the local scavenging chickens is the avian influenza. Avian influenza is notifiable disease caused by viral infection of the family Orthomyxoviridae, genus influenza virus (Branckaert, 2007). According to literature, the disease depends on the age of the birds, species and the type of bird specific characteristics of the viral strains involved and the environmental factors (Mabbett, 2006). The clinical signs presentations of the disease include; respiratory signs, such as ocular and nasal discharge, coughing, swelling of the head, sneezing and dyspnoe, apathy, reduced vocalization, reduction in feed and water intake, cyanosis of un-feathered skin, wattles and comb, in-coordination, nervous signs and diarrhoea. Additional clinical feature is a marked drop of eggs production. These types of diseases were reported in Nigeria and according to (Mabbett, 2006), it infected 46 000 birds (chickens, geese and ostrich) in a farm in Jaji area of Kaduna state.

Rural farmers describe diseases by the symptoms the chickens' exhibit and the most common symptoms include noisy breathing, and coughing accompanied with discharge and watery eyes which is regarded as chronic respiratory disease (Okitoi *et al.*, 2007a).The same authors also included symptoms such as swollen head, sharp coughing, sneezing, and gasps culminating in difficulty in breathing especially among young birds and this is interpreted to be infectious bronchitis. Bloody diarrhoea is regarded as coccidiosis. List of signs of diseases are presented in Table2. 3 as cited by FAO,2004

Table2. 3. Common signs of poultry diseases observed in rural areas

Signs	Frequency **%**
Chickens huddle together	16.1
Coughing, sneezing, rapid breathing	13.2
Discharge from mouth and nostrils	10.9
Dullness, no appetite, closed eyes	10.9
White droppings	8.6
Turned or twisted neck	8.0
Dark red colour of head and comb	6.9
Greenish or yellow droppings	4.6
Bloody reddish droppings	4.0
Swellings of head and comb	2.9
Pale comb	1.7
Worms in faeces	1.7
Eye worm	1.1

Source: Adopted from FAO 2004

2.10. Poor management and mortality

According to McAinsh *et al*. (2004), predators, limited feed supply, low level of management and diseases are the causes of mortality among indigenous chickens. The results of the study by Pedersen (1998) showed 55% mortality among chicks in Sanyati, Zimbabwe. According to farmers in that area, 27% of these deaths were due to predators, 18% due to diseases, 17% due to external parasites, 9% due to rains, 15% due to accidents and 14% were unspecified factors (Pedersen 1998).

Maphosa *et al.* (2004**)** reported that 12% of losses among local chickens was due to accidental stepping on by human or animals, which is as a result of people or animals steeping on them, crushed under objects children beating them or chickens getting drowned in water. Kusina *et al*. (2001) also reported that monkeys, hawks, baboons and crows causing mortality among local chickens. Haruna and Messango (1991) reported predators like dogs, wild cats, rats, squirrels, hyenas, eagles and thieves as significant in reducing village chickens production. The same author also reported mortality in chickens resulting from being exposed to heat and therefore called for better management through the provision of water so that the effect of heat stress can be reduced. Furthermore, Mwalusanya, *et al*. (2001) reported high mortality of chicks in their early weeks of age and concluded that this problem was associated with low inputs as regards to health care. The author recommend that the protection of chicks from predators should be done up to 8 weeks of age in order to reduce losses by providing proper housing and feeding. Mopate and Lony (1999) in their study observed that chicken mortality was a result of unsuitable husbandry practice, predation and accidents. Mortality due to diseases can be enhanced by contacts between flocks of different households, the exchange of birds as gifts or entrusting, sales and purchases are the main sources of infection transmission at the village level. Permin *et al*. (1999) reported that lack of protein and vitamins weakened the chicks and made them vulnerable to diseases and predators that in turn led to high mortality rates. Several investigators have reported that increased dietary content of protein resulted in improved growth performance (Jackson *et al.,* 1982; Smith and Pesti, 1998; Temin *et al*., 2000). The young chicks were found to be more sensitive to dietary levels than the older chicks.

Information obtained on the direct assessment of nutrient resources in free range scavenging systems by Sonaiya (2004) revealed that the protein content is more critical during short rain and dry seasons, while energy supply is more critical during the drier months (Ndegwa *et al.,* 2001). Predators include fox, hawks, cats and dogs, were reported by Maphosa *et al.* (2004**)** as critical for chicken survival in Zimbabwe. Dessie and Ogle (2001) described predators such as vultures, wild mammals like cats and foxes as one of the major causes of mortality among village chickens in Ethiopia.

In Chad, wild cats, and snakes are indicated as the main predators which hamper the growing of village chickens under village conditions (Mopate and Lony, 1999). Mortality among local chickens can be as a result of parasites. The most common ectoparasites observed in chickens included lice, fleas, mites (feather, body and leg mites), and *Argas persicus* (Gordon and Jordan, 1982**;** Soulsby, 1982; Permin *et. al.,* 2002).

2.11. Weather condition

Chickens especially the normal feathered ones are said to suffer at high ambient temperatures due to the fact that their feather coverage hinders internal heat expulsion. A study comparing the performance of naked neck and normal feathered broiler chickens in hot, warm and temperate climates by Yalcin and Ciftici (1996) revealed that, the reduction in feather coverage renders them relatively heat tolerant, whereby naked neck was superior especially in hot climate to their normally feather counterparts. The authors therefore suggested that naked neck would be suitable in hot climate.

2.12. Disease control

Absences of diseases control in many rural areas are well recognized and strongly believed to be contributing factors to high mortality among the indigenous chickens. Chickens in this sector are never vaccinated against any type of disease with Western standard vaccines; rather farmers use a variety of ethno – veterinary practices in treating their birds (Guèye, 1998). The limited use of the modern or conventional vaccines in indigenous chickens is as a result of factors like cost, dose format, and lack of thermo-stability (Okitoi *et al*., 2007a). Dose format was reported to be difficult due to the fact that flocks were small in number per household, scattered, multi – aged and under minimal condition and are relatively expensive and produced in large dose units suitable only for large commercial flocks **(**Haruna and Massango, 2001)

Tamboura *et al.* (2000) reported that 95% of the medical recipes used to treat affected animals in the villages are from plants origin. Ethano-veterinary medicine (EVM) by simple definition means the use of local or indigenous knowledge and methods for caring, healing and managing livestock. EVM practice is believed to be the custody of older people both women and men which they pass on from one generation to another. EVM practice at rural level is well recognized as valid method used for both preventive and curative measures against various diseases of chickens and seems to be appropriate for circumstances of many, if not the majority livestock owners in the tropics.

Guèye (1999) reported that there are many plant products that rural farmers in developing countries believe to improve productivity or rather reduced the impact of diseases on their chickens.

Preparation of the solution used in the treatment and controlling poultry diseases by farmers is reported to be a mixture of more than one plant and the amounts of each of the ingredients are not known (Okitoi *et al.,* 2007a). Tables 2.4 below shows a list of several plant products used to treat diseases of chickens in the rural areas as reported by various authors. Another advantage of EVM practice is that it does not require refrigeration compared to modern vaccines or medicines.

2.13. Poultry farming systems

Free range system is one of the most common production systems by which indigenous chickens in developing countries are reared (Aklobessi, 1990; Revelonson 1990; Guèye, 1998; Sonaiya *et. al.*, 1999; and Minh, 2005). However, Sonaiya (1995) reported two types of management systems in Nigeria, namely; extensive and intensive. Extensive system is describes as a low- input low output system (Safalaoh, 1997). Indigenous chickens have been described by many authors as having better genetic materials due to their ability to survive in a little input environment in terms of feeding and they require low capital, and labour inputs (Gunaratne e*t. al.*, 1993; Guèye, 1998; and Minh, 2005). In the free range system however, chickens are believed to spend most of their time of the day searching for food or scavenging (Kitalyi, 1989; Guèye, 1998; and Minh, 2005). A study by Ramlah and Shukor (1987) showed that rural farmers in Malaysia mainly practice the free-range system (82.8%), followed by the semi-intensive system (15.9%) and the intensive cage- system (1.3%). Most studies on feeds scavenged by chickens described theses feeds as feed resource base (FRB) Tadelle and Ogle (2001) while Sonaiya, (2004), described it as scavenge-able feed (SF). Goromela *et al*. (2006) have defined the Scavenge-able Feed Resources base or scavenge-able feed (SF) as those feed resources available at farm level which consist of households and all materials available in the immediate environment that the scavenging birds can use as feed.

Similarly, Gunaratne *et al.*, (1994) and Robert *et al.* (1993), in their separate studies also defined (SFRB) as total amount of food products available to all scavenging animals in a given areas and that their availability depend on the number of households, the types of food crops grown and their crop cultivating and the types of processing methods as well as on the climatic conditions that determine the rate of composition of the food products.

Table 2.4. Ethano-veterinary medicines from plants used for the treatment of diseases by rural farmers in different countries.

Diseases	Plant products	Application form	Country and sources
Eye infection	Leave of shrub *pseudogonalium leteo* album and roots. Powder of *Diospyros lyciodes*	Exudates used as eye drops	Botswana, Moreki (1997)
Eye trouble	Leaves of Voniumadonense	Deccotion to newly hatched birds to open gummed up eye	Zimbabwe, Chavunduka, (1976)
Sore eyes	Bulb of Adenium multiforum	Juice used as eye drops	Zimbabwe, Chavunduka (1976)

Table 2.4. Continued. Ethano-veterinary medicines from plants used for the treatment of diseases by rural farmers in different countries**.**

Diseases	Plant products	Application form	Country and sources
Poor growth, low production	Fruit of Cucumis pustulatus	Mixed with bran and placed in drinking water	Nigeria Nwuda and Ibrahim (1980)
	Fruit of Cyprus articulate	Soaked in drinking water	Nigeria,Nwuda and Ibrahim (1980)
Coughing,Diarrhea and leg weakness	Citta species(ginger) , pepper	Put in drinking water	Maigadi and Usman(1996)
All diseases	Leaves of Euacalyptus spp.	Put into drinking water	Ethiopia Dessie (1996)
	Hot pepper(Capsicum frutescens)	Soaked in drinking water	Ethiopia, Dessie (1996)
Cough, cold Worms	Fruit of Salanum *nodiflorum*	Soaked in drinking water	Nwude and Ibrahim (1980) Nigeria

Continued

Table2. 4. Contid. Ethano-veterinary medicines from plants used for the treatment of diseases by rural farmers in different countries

Diseases	Plant products	Application form	Country and sources
Coughing cold and Pneumonia	Tuber of Colocasia *esculenta*	A whole tuber tube (about 0.5 k Washed and ground in a mortar, 2 litres of water added and the mixture served. Three drops are given once in the nostrils of each.	Kenya, Anonmymous (1996)

Guèye and Bessei, (1995)

2.14. Growth performance

Teketle (1986) reported that the productivity of birds under the rural production system in Ethiopia is very low and this was expressed in terms of low egg production, small sized eggs, slow growth and low survivability of chicks. This low production potential was attributed to lack of improved poultry breeds, the presence of predators, high incidence of diseases, poor feeding and management which farmers practiced (Alemu, 1995**;** Alemu and Tadelle 1997**).** Similarly, Musharaf *et al*. (1990) reported that slow performance is caused by malnutrition, lack of sound management and prevalence of diseases. Indigenous chickens do also vary widely in body size and in growth performances. However, a comparative study conducted by Van Marle – Koester and Cassey (2001) revealed that Owambo chickens from Northern Namibia grow better as compared to the South African breeds, namely Koek and Naked neck. The average weight of the Owambo chickens at mature age was 1.81 kg, while that of Koe koek and naked neck were 1.1 and 1.06 kg, respectively. The same study also revealed that Owambo chickens are an efficient users and attained sexual maturity at the age which is between 16 and 22 weeks as compared to Labowa -Venda at 77days of age. Halima et al. (2007) observed native chicken lines named Mello-Hamusit, Guangua and Mecha were the fastest growers as compared to other seven chicken populations found in northwest Ethiopia. The same authors also reported that the growth rate of the indigenous chicken line under good management is comparable with Rhode Island Red which is an exotic breed of chickens.

2.15. Marketing of local chickens

Marketing is an issue which is of less importance to subsistence farmers because chicken keeping is a way of tradition. However, farmers only sell their birds whenever there may be a need for money. Some farmers barter their free-range local chickens for food and household items (Andrew, 1990). In Senegal for instance, six local chickens can be exchanged for one goat (Missohou *et al.,* 2002). Several authors have also reported that the greatest reason why farmers sell their chickens is for income generation (Safalaoh, 1997; Guèye, 1998; Sonaiya 1999; Ekue, *et al.,* 2002 and Missohou, *et al.,* 2002). Chickens are both sold at households within the villages, on road sides, during entertainment ceremonies and even in local and city markets. The market channel where chickens are sold in many developing countries have been described as informal and poorly developed Branckaert and Guèye 1999; Dessie and Ogle 2001; Dessie and Ogle 2000; Mlozi, *et al.* (2003). Figure 2.0 describes the marketing channel according to Gondwe, *et al.* (2005).

Chickens are either sold live or as cooked meat. Selling of free-range chickens is positively influenced by size of chickens and by the time of the year especially during festive seasons (Guèye, 1998). Consumers are said to prefer brown birds and pay higher price as compared to white and black birds which are considered to be agents of transmission of human diseases between households and also bring bad fortune.

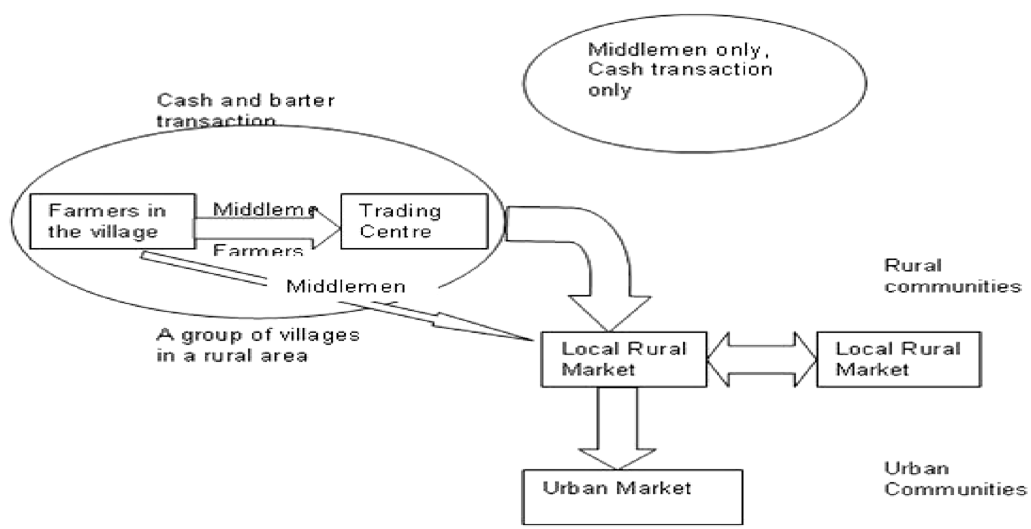

Fig2.0. Marketing channels, players and flows for local chickens from producers to consumers. Sources: Gondwe *et al.* (2006

2.16. Breed and breeding of indigenous chickens

Breeding and selection of indigenous poultry has been largely left to nature and to date no differentiation into broiler or layer strains has occurred. Lots of names have been used to describe the indigenous chickens. The following are some of the examples; African hen, bush hen, or sahel (Guèye and Bessei, 1997). In other reports, names like, Family poultry, local chickens, deshi chickens have also been used to describe indigenous chickens (Sonaiya, 1995).

There is a great variety of indigenous chickens in the rural areas and as such they cannot be called breeds in the same sense as the European breeds. In most cases, the variations among local chickens are due to indiscriminate breeding practiced at farm level, both male and female chickens run together and are also housed together (Guèye, 1998b; Barua and Yoshimura, 1997). The variations mostly are found in body size, plumage colour, shank colour, comb types and feather patterns. Furthermore, local chicken populations in literature are often grouped and described according to their phenotypic characteristics or geographical location. For examples, the Owambo chickens originate from Owambo land in Northern Namibia and the Lebowa-Venda from Venda in the Limpopo Province in South Africa (Van Marle – Koester *et al.,* 2008). Studies on diversity have revealed that classification into breeds or types of indigenous chickens in many developing countries is very limited. Studies that have been conducted thus far have classified few of them into ecotypes based on the plumage colours, feather structures and patterns as well as body sizes and length. Work in Cameroon resulted in the classification of indigenous chickens into breeds like Dzaye, Tsabathi, Dongwe and Zorwa (Ngou Ngoupajou, 1990). The same can be said of the Beldi or Roumi of Marrocco (El Houadafi, 1990) and Baladi and Betwil of northern Sudan (Musharaf, 1990). Similarly, in Mali, the native breeds like Kolochie, Kolokochie , Toulouchi, Centrichrochie, are the names of some breeds which have been identified (Sonaiya, 1990; Guèye, 1998a). Another breed identified is the Koekoek in South Africa. According to Viljoen (1986), koekoes came from a cross between the Black Australorp and White Leghorn during the 1950's, followed by crosses with Plymouth Rock to produce a Black and White speckled bird carrying the sex-linked bar gene called Koe koe.

In Tanzania, Msoffe *et al*. (2001) classified the local chickens into five breeds namely: Morogoro – medium, Mbeya, Kuchi, Ching'weke and Singamagazi. In Uganda names given to native chickens are: Tilili Gellilia, Debre-Ellias, Mello-Hamusit, Gassay, Guangua, Mecha (Halima *et al.*, 2006). The study of biodiversity has also made it possible to distinguish some genes carried by indigenous chickens that are of economic importance which local farmers preferred. Horst (1988) reported that some local breeds such as the Assel breed of India is preferred for meat, whereas Fayoumi of Egypt as well as Deshi chickens of Bangladesh are preferred for egg production. Tadelle and Ogle (1996), reported that farmers in Ethiopia preferred birds with light colour plumage for large eggs which they produced, whereas birds with black and red feathers are preferred for meat production. Naked neck on the other hand is preferred for high meat yield as compared to dwarf village chickens in Malawi (Safalaoh, 2000).

2.17. Identify gene types from physical characteristics

Gene types can be identified from the physical characteristics of chickens Table 2.5. The following are a few examples of how to identify the genotypes. Alleles are indicated with capital or small letters for dominant/recessive relationship.

Table2. 5. Example of how to identify genotypes

Characteristics	Gene type
Comb type	single (pprr) pea (P _) rose(R _)
Feather colour	white (I _) black (E _) wild (e^+ _) silver (S _) gold (ss)
Feather pattern	barring (B _) non-barring (bb)
Shank colour	white or yellow (Id _) black or willow (idid)

Stevens,1991. *Superscript '+' means the wild type. The wild type is the type close to the ancestor, a red jungle fowl.

Wild (e^+) in male: black breast, wing bar and tail; red neck, saddle, wing bows and feathers.

Wild (e) in female: Salmon breast, brown darkly stippled body.

Terms definition:

Comb type=Rose (*R)*

Feather colour=Wild(e^+)

Gold (*ss*)

Feather type=Barring (*B_*) and Shank colour=Yellow (*Id*)

2.18. Importance of gene classification in chickens

Formal knowledge about genetic diversity of traditional free-range chicken production in tropical countries is increasing but still limited. Quantitative trait loci (QTL) mapping studies in the chicken have identified chromosomal regions that contribute to variation in economically- important traits. The results of the primary QTL studies enabled identification of basic information on the genetic architecture underlying complex traits in the chicken.

2.19. Techniques for evaluating genetic biodiversity and biological performance

Genetic diversity within a given farm animal species refers to the variety of genetic variants evolved during domestication and displayed by the existence of structural variation among genomes of individuals, families, strains, and populations (Lamont *et al.*,2006). The aim of the techniques used are therefore to identify chromosomal regions contributing to variation in traits related to growth, disease resistance, egg production, behaviour, and metabolic parameters and this enables researchers to have better knowledge of the genetic architecture underlying QTL that are needed for successful application into breeding programs and conservation (Abasht *et al*.,2006). Conservation of animal genetic diversity over the long-term will enable countries and their farmers to better respond to changing environmental conditions and consumer preferences, to pursue new economic opportunities and to reduce their vulnerability to food shortages Campbell, *et al.*, (2006). Many methods of varying complexity have been developed that can be used either for study, assessments or evaluation of the structural biodiversity and biological performance in chickens in order to understand the relationship between the variation in biodiversity with biological performance. Their application in a particular situation depends on the degree of precision desired, practicality and cost. Before the contemporary molecular tools were developed, researchers relied on methods such as morphological traits, protein polymorphisms, immunogenetic systems and microsatellites (Nickiforov *et al.*, 1998; Weigand and Ramanov, 2001) and blood typing (Briles, 1952).

2.20. Current status of blood grouping in chickens

The old method used in classifying chicken populations into different groups and studying their economic importance was first used by Briles *et al*. (1950) by blood typing. Through this method, 13 blood groups were discovered and an alphabetical letter was designated to each of them as A, B, C, D, E, F, G, H, I, J, K, L, N (Dietert, 1992). By blood typing, individual genes were isolated and those that were associated with inheritance in relation to animal health and productivities were discovered. Of the 13 groups or systems, B system or major histocompatility (MHC) which was first reported by Briles *et al*. (1950), has long been the subject of intense investigation for its role in disease resistance.

Since then, response to a wide range of pathogens or diseases have been demonstrated to be associated with the MHC genes and those that are associated with production traits for example, body weight, juvenile survival, adult survival egg production, hatchability ,embryonic mortality and fertilization rate (Gilmour,1960). MHC is also known to make a crucial contribution in immune response (Weigend and Lamont,1998).The confirmed MHC genes in chicken that influence resistance to disease include; autoimune, viral, bacterial and parasitic diseases (Quereshi *et al.*,2000).

Many other candidate genes like cytokine gene, CD encoding genes, T cell receptor, Nrampl, immunoglobin genes were also reported to be associated with disease resistance (Lamont, 1998). Another study has also revealed that L-system and P non major histocompatibilty alloantigen system have potential to influence immune responses by modulating phagocytic functions in chickens (Quereshi et al., 2000). The MHC genes show associations with response to diseases as diverse as virally - induced neoplasia, bacterial, parasitic and auto – immune diseases (Lamont, 1998). The MHC is thought to play an important role in disease resistance. Briles *et al.* (1977), reported that the chicken MHC has been implicated in conferring resistance or susceptibility to several bacterial, parasitic, and viral diseases, the most notable of which is Marek's disease. The chickens MHC (B complex) is comprised of three classes of highly polymorphic loci, namely class I (B-F), class II (B-L) and class IV (B-G)

(Fulton *et al.*, 2001). Among the three classes of MHC class II genes has been reported that chickens with B21 were resistant to avian influenza, while chicken with B12, B14 and B19 were susceptible to Avian Influenza (Boonyanuwat *et al.*, 2006).

The principal technique for identifying blood groups of avian species is known as hemagglutination essay and was applied before 1985 (Dieter, 1992). The study of blood groups on Chinese native chicken breeds and cluster analysis revealed that of the eleven Chinese native chicken breeds investigated, there were some similarities amongst them and it was suggested that the breeds could be divided into four groups (Cheng *et al.*, 1991). In addition to the previous blood group identification, there are several other methods which have recently been developed including the molecular probe. Using this method allelic difference within blood groups could be detected at the level of the DNA through the use of restriction fragment length polymorphism (RFLp).

2.21. Variation in morphological characteristics in chickens

All native chickens in developing countries are said to be descendants of the red jungle fowl, *Gallus gallus* (Crawford, 1984) and that they often have no defined phenotypic pattern (Hoffman, 2005). All modern breeds were, however, developed in northern hemisphere many years ago. Varieties of modern breeds that exist today came as a result of manipulation and modification of the habitant of jungle fowl for the advancement of human beings’ own comfortable existence and for the sake of accomplishing desires of mankind. The products from man’s manipulation gave rise to many varieties of poultry breeds which the world knows to be incredibly efficient and highly productive with no comparison at all with their ancestor jungle fowl.

The variability in morphological characteristics within the local population in all continents where indigenous chickens possess a similar appearance has been reported by many scholars. These similarities are observed in parameters such as plumage colour pattern, skin, adult body size, body conformation, comb types, shank colour and feathering of shank and many other phenotypic characteristics. Due to this complexity in nature of the native chickens or strains, several scholars have described them as non - descriptive type of breeds (Kitalyi, 1998a). This is so because one single chicken can possess a mixture of characters such as multicolour type and feathers on the shanks at the same time. Many of these differences are genetically- controlled and science has proved them to have a bearing on some production traits. For example a study conducted in Nigeria revealed that feet feathering has an effect on length and girth of local chicken breast, number of eggs laid and hatchability per hen per year (Ikeobi et al., 1996). Genetic of feathers colour however has been studied by several authors among them are Smyth 1990; Coquerelle 2000. Feather colour is the major element of the phenotypic standard used to defined breeds. In rural areas famers use feather colour to identify their chicken. Various traits possessed by chickens are said to be influenced by certain genes (Table 2.6) among them are feather pattern and plumage colour, shank colour and skin colour (Stevens, 1991). Furthermore, the phenotypic expression of shank and foot colour is dependent on the cumulative and interaction effects of several major genes too. For example the effects of the *Id* and id^+ alleles are confined to the dermis while E is primarily associated with the epidermis In addition, the absence of or presence of yellow carotonoid pigment due to the W^+ and w alleles respectively, interacts with the melanin status of the dermis resulting in either blue or green shank colour Smyth (1990).

Table2.6. Major genotype associated with shank and foot colour inheritance in chickens

Pigment status			Genotype	Phenotype
Carotene	Dermal melanin	Epidemal melanin		
W+	Id	E	W+W+Id/Id/E/E	Near-black with white sole
		e+	W+/W+Id/Ide+/e+	White shank and feet
Carotene	Dermal melanin	Epidemal melanin		
	Id+	e+	W+/W+id+/id+e+e+	Blue shanks with white soles
		E	w/wId/Id E/E	Near back with yellow soles

Table2.6. contd. Major genotype associated with shank and foot colour inheritance in chickens

Pigment status			Genotype	Phenotype
Carotene	Dermal melanin	Epidemal melanin		
	Id	e+	w/w Id/Id e+/e+	Yellow shanks and feet
		E	w/w id+/id+E/E	Black shanks with yellow soles
	Id+	e+	w/w id+/id+e+e+	Green shanks with yellow soles

Smyth. (1979)

CHAPTER THREE

3.0. Materials and Methods

3.1. Phenotypic characterization of indigenous chickens

3.1.1. Location of the survey

This survey was carried out in the four regions of Northern Namibia Fig.3.0 to describe the village-based chicken production systems and constraints. The study also aimed at identifying genetic differences among and between chicken populations in different villages and regions through blood typing.

3.1.2. Sampling design and data collection

A total of fifty two (52) households were surveyed. The respective numbers in each region were: Omusati (n = 13), Oshana (n=13), Ohangwena (n=14), and Kavango (n =12). From the four regions, 175 chickens of mixed age groups were investigated. Households were randomly selected through the assistance of agricultural extension technicians in their respective regions. A structured questionnaire (Appendix 1 and 2) was administered using face to face interview to the fifty two households at their homesteads. Although questionnaires were written in English, farmers were interviewed in their vernacular languages. Data collected in the questionnaire included chicken management practices such as: housing, feeding, diseases and marketing.

Production data such as clutch size, clutch number per year, number of chickens per household, breeds kept, chickens acquisition, duration of keeping chickens and importance of keeping chickens was collected.

Fig 3.0. Map of Namibia showing the four studied regions

Each of the 175 chickens was physically examined and blood samples were also collected. Plumage colour and patterns, comb shapes were recorded as well as live weights. The survey was conducted during July 2003 and August2004. Other information gathered included sex of chicken and weight of individual birds. The determination of colour of plumage, shank colour, comb types, feather pattern were done through visual and direct observation on the birds. This also included structures like chicken houses and equipment used. All the information observed was recorded on a designed form and individual birds were photographed.

3.2. Statistical analysis

Survey data was analysed by the Chi - Square test in SPSS (2007). Descriptive statistics (means, variance) were obtained for qualitative data Gene frequency estimation for plumages, shank and comb types were calculated by the counting method of Yasuda (1968). The gene frequency and standard errors of the plumage, shank colour and comb types in Table 3.0 - 3.4 were computed as follows:

At a locus on autosomal chromosomes including comb type (rose and pea) and plumage colour (black and wild) gene frequency of the recessive allele (q) comb types was calculated using the formula

$q = \sqrt{}R/N$

Variance

$$V(q) = (1- q2)/(4N)$$

$$= (1- R/N)/(4N)$$

$$= (N- R)/(4N^2)$$

$$= D/(4N^2)$$

Where: D: the number of individuals showing a dominant trait

R: the number of individual showing a recessive trait

N= D+R

The standard error was calculated as:

$$\sqrt{}V(q) =\sqrt{}D/(2N)$$

Gene frequency of the dominant allele (p) was calculated as:

$p = 1- q$

The Variance was calculated as :

$V(p) = p(2- p)/(4N)$

$= (1- q)(1+q)/(4N)$

$= (1- q2)/(4N)$

$= V(q)$

Standard error

$\sqrt{V(p)} = \sqrt{V(q)}$

$= \sqrt{D}/(2N)$

For frequency for plumage in case of multiple alleles such as E, e^+ and e, the following information in the table below was used to compute gene frequency.

Table3.0. Example of computing gene frequency controlling the plumage colour

Phenotype	Genotype	Observed number
E	EE, Ee^+, Ee	A
e+	e^+e^+, e^+e	B
E	Ee	C
Total		N

Gene frequency (q) in each case was computed as:

E : $q1 = 1 - \sqrt{[(b + c) / n]}$

e^+ : $q2 = \sqrt{[(b + c) / n]} = \sqrt{(c / n)}$

e : $q3 = \sqrt{(c / n)}$

Variance (V) was computed as:

E: $V(q1) = q1 (2 - q1) / (4n)$

e+: $V(q2) = [q2 (2 - q2) + 2 q1 q2 /(1 - q1)]/ (4n)$

e: $V(q3) = (1 - q3 \times q3) / (4n)$

Standard error（$\sqrt{V}$ was computed as:

$E = \sqrt{V(q1)}$

$e+ = \sqrt{V(q2)}$

$e = \sqrt{V(q3)}$

There are at least 8 alleles for the ‘E’ locus. These are: E (Extended black), ER (birchen), e^+ (wild), eb (brown), es (speckled), ebc (buttercup), ey (recessive wheaten), and eWh (dominant wheaten). The approximate dominance relationship is E > ER > e^+ > eb > es > ebc > ey, with eWh probably lying below ER (Stevens, 1991).

E, e^+ and e are used for the sake of field identification, and e represents the alleles indicated by e other than e^+.

For comb three phenotypes can result: Pea(R/Rp/-; rose (R/_,p/p) and Single r/rpp)

Table3.1 (a –c) . Example of how to compute gene frequency of comb types

Table 3.1 (a).

	Sample size Locality A	Sample size Locality B	Sample size Locality C
P	1	4	12
R	25	14	28
Pr	26	24	23
Total	52	42	63

P (pea) locus and R (rose) loci are known to be in different positions. Therefore, the above Table will be written as follows;

Table3.2 (b). Computation of a single comb type

Alleles	Sample size Locality A	Sample size Locality B	Sample size Locality C
P-	1	4	12
Pp	51	38	51
Total	52	42	63

and for rose comb

Table3.3 (c). Computation of a Peas comb type

	Sample size Locality A	Sample size Locality B	Sample size Locality C
R-	25	14	28
Rr	27	28	35
Total	52	42	63

.

For example for locality A frequency of P = 0.018, and frequency of p=0.0185.

Frequency for Sex-linked traits include feather colour (silver and gold, barring and shank colour Table 3.4.

Table 3.4. Calculation frequencies of dominant and recessive genes

Gene type	Gene	Number (sample size)	
♂ (ZZ)	Dominant	A	A+B = m
	Recessive	B	
♀ (ZW)	Dominant	C	C+d = f
	Recessive	D	
Total		N	2m+f = G 2b+d = H

The frequency of the recessive gene q was calculated as:

q= $c + \sqrt{(c\times c + 4\times G\times H)}$

2G

where G =frequency of both dominant gene (male and female)

H= frequencies of recessive genes for both male and female

Variance was then computed as:

Variance was then computed as:

$$V(q) = \frac{1}{\dfrac{4m}{1-q^{2}} + \dfrac{f}{q\,(1-q)}}$$

The frequency of the dominant gene: p was computed as:

$p = 1-q$

Standard error was given as:

$\sqrt{V(q)} = \sqrt{V(p)}$

Where applicable Chi-square test were done to test significant differences tests in distribution of the different morphological characters across the four regions

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Distribution of indigenous chickens in Northern Namibian

The results obtained in the current study showed that indigenous chicken is an integral part of mixed farming system because in all households visited, none of the farmers farmed with chicken alone. Farmers in the study regions practiced mixed farming in a crop – livestock system.

Apart from farming activities they were also involved in a variety of non - agricultural activities like weaving of traditional baskets and making clay pots. Although chicken were found in all the households visited, the numbers observed in individual households varied as shown in Fig 4.0. Farmers interviewed did not keep records hence they did not know the number of chickens they keep and more often only adult chickens are counted. The problem associated with record keeping experienced in the study is in line with what was reported by Sonaiya (1990) who pointed out that rural people often regard poultry as secondary to livestock and crop production activities, and hence they pay little attention to them. The observed average number of chickens per household was 12.5 and this was in agreement with what was recorded from the countries with comparable production systems. For example, in Malawi, Gondwe and Wollny (2004) recorded 12.9 birds per households but in Senegal Missohou *et al*. (2002) recorded high number of numbering birds per households. Muchadeyi *et.al.*, (2004) reported that chickens kept house in Rushinga district of Zimbabwe are thirty (30) and above.

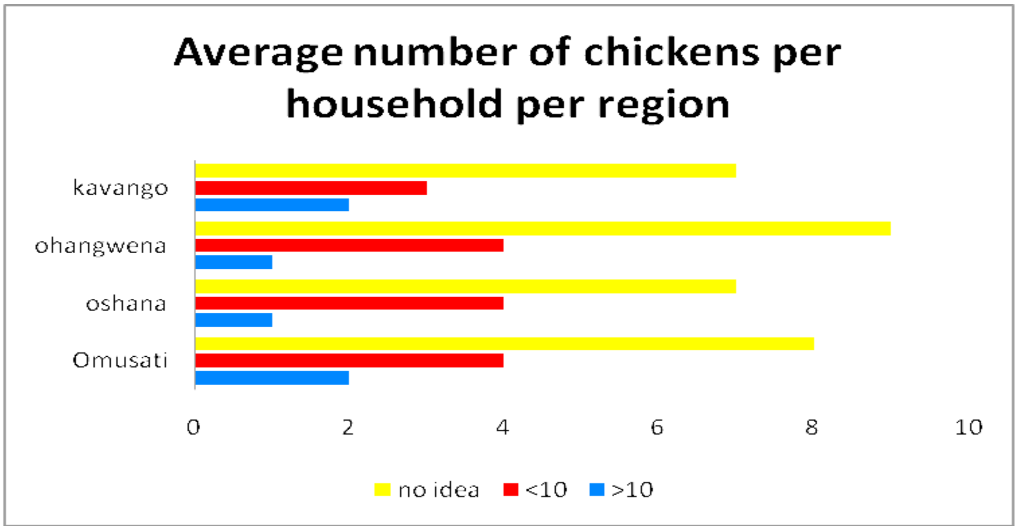

Fig 4.0. Average number of chickens per household per region

It is important to emphasize the fact that the number of chickens kept as indicated the by the farmers varied due to continuous culling of chickens through slaughtering for home consumption, offering chicken out as gifts to visitors, sale of live chickens for cash or direct barter, providing or exchanging breeding stock with other farmers and, mortality due to predators and diseases among other things.

4.2. Types of chicken breeds kept

The current study observed that in all households, chicken production is mainly based on indigenous types. This is n line with the report of FAO (1998) which stated that rural chicken production is based on indigenous chickens (*Gallus domesticus*). Similarly, Gondwe *et al.* (2004) reported that almost 83% of the total chicken population in Malawi in the rural households was indigenous chickens. In Nigeria, Fayeye (2005) reported that there are 120 species of poultry in that country out of which 80% were indigenous chickens. Similarly, Guèye (1998) reported that indigenous chickens constituted 98% of the chicken population in the whole of Africa. All interviewed farmers indicated that they preferred them because they are easy to manage and are readily available to them. This finding is similar to what was reported by Mukherjee (1992) that, indigenous chickens are widely distributed in the rural areas of tropical countries where they are kept by a majority of the rural farmers for various reasons.

To the question of how long they have been rearing chickens, 92.3% (n= 48) of the interviewed farmers indicated that they had been keeping chickens for more than 10 years and only few of them 7.7 % (n= 4) had kept chickens for less than ten years. The respondent farmers contended that keeping chickens was a way of life among the rural community and it is a trend that is passed on from one generation to another. This explains the reason why chickens were found in every household.

4.3. Flock structure

The study observed few numbers of cocks in all the households visited. Farmers said that males are often culled as compared to female chickens. This continuous culling of male chickens was for home consumption and income generation as required. Other reasons why farmers slaughtered cocks are to keep a reasonable ratio of cocks to hens and also to prevent cock fighting. The exploitation of cocks for home consumption and selling observed in this study is comparable to what was reported by Kurmaresan *et al*. (2008) in India. Farmers also reported slaughtering hens which laid fewer eggs or small sized eggs. Pullets are also slaughtered for home consumption and offered as gift to visitors and relatives for breeding purposes. About 80% of the farmers in all the regions said that hens are mainly kept for breeding. Ninety percent (90%) of households visited kept at least 1 cock while 56% of the farmers keep four to six females. These results are almost similar to what was reported by Mwalusanya *et al*. (2001) in Tanzania. Less male chickens are kept in individual households in Nigeria and this is due to regular culling of males especially during festivity periods (Feyeye *et al.*, 2006).

4.4. Sources of stock and breeding criteria for replacement stock

4.4.0. Means of acquiring chickens in the rural areas

Farmers in the study areas acquired their stock through a combination of two or more of the following ways: Most of the respondents (38%) said that they bought their first stock (17%) of the farmers disclosed that they got their first stock as a gift, which they received from friends and relatives during weddings or when the newly- wedded couples visited their friends and relatives. Fifteen percent of the respondents (15%) said that their first stock was from both gift and purchases. The remaining thirty per cent of respondents (30 %) did not specify the sources of their first stock. Similarly the result of this study agreed with Kugonza *et al.* (2007) who reported that in most of the households in Uganda chickens were acquired through a combination of two or more ways which include purchased (65.6%), given as a gift (26.3%) or exchanged for labour (8.1%)

4.4.1. Breeding Practices

The science of animal breeding is defined as the application of the principals of genetics and biometry to improve efficiency in production of farm animals. Most breeding programs that aimed at improving the productivity of indigenous chickens made use of cross – breeding. For example, the system used in Bangladesh often referred to as Bangladesh model (Jansen and Dolberg, 2002), which was designed to fight and alleviate poverty among the vulnerable people was based on cross between Fayoumi and Rhode Island Red chicken. In the current study however, (55.8%) of the total 52 farmers interviewed responded they practice selection, while 44.2% respondent did not practise it. Farmers who practice breeding, select and use the birds that suite their goals. Farmers in the study areas identified a number of traits that are of importance in selection of chicken replacement stock. For example (51.6%) of the respondents ranked hatching as the first selection criterion. Hen mothering ability was considered second by 13.8% of farmers as the most important trait for selection. Meanwhile 24.4% of the respondents considered body weight and colour of the plumage as being the most important criterion for selection. Only small proportion (11.1%) of respondents indicated that they did not practice any selection with their chickens.

Although all farmers indicated that natural hatching of eggs by a hen is the only means they used to replace old stock, some also reported that they buy from their neighbours or from the market. Using the latter option depends on the situation when the whole flock is wiped out by diseases or predators. With respect to breeding, none of the farmers practiced controlled breeding. Farmers in all the households allowed both males and females to run together thus indiscriminate breeding was practised.

4.5. Roles of indigenous chickens

In all the study regions, it was observed that indigenous chickens have multiple roles, the most important being and the most frequent consumption as relish meat either for family, visitors or during ceremonies 46,1% (n=24) in all the regions. Income generation counted for about 9.6%, while keeping as a custom counted for 42.3% (n= 22) and only a small proportion 1.9% (n=1) indicated that chickens are kept and used for sacrifices by traditional healers as shown in Fig4.1 below.

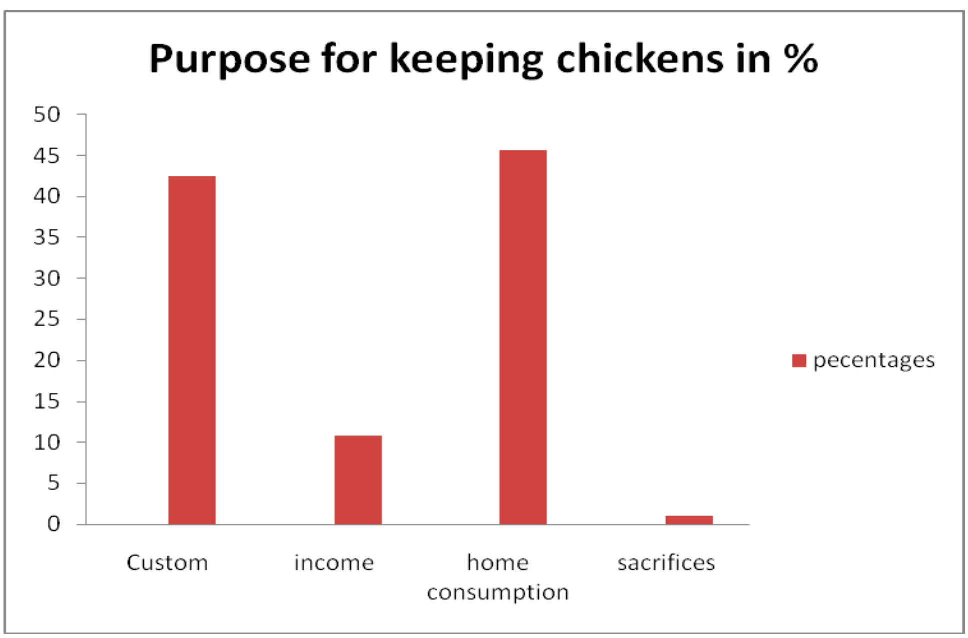

Fig4.1. Percentage of the purpose for keeping indigenous chickens

The keeping of chickens for variety of purposes as reported in this study is in line with what was reported in several reports by various scholars including (Katalyi 1998;

Sonaiya, 1990; Guèye, 2002; Tadelle e*t. al.*, 2003; Halima *et al*., 2007). According to Aini (1990), village chickens are important because they survive on minimal resource inputs which rural farmers can readily provide. Local consumption include eating chicken products within the home, food for visitors, gifts to friends and the church and used for cultural functions and rituals as reported in Uganda by Kugonza *et al.* (2008) Furthermore, Aklilu *et al.* (2006) reported that poultry in Ethiopia are used for strengthening marriage partnership whereby in the local culture, preparation of 'doro wot' (chicken dish) is taken as a major way of assessing how much a (future) wife cares for her husband. Serving with 'doro wot' is also a symbol of best hospitality and respect to guests (e.g. in-laws),

During the discussion with individual farmers in all the study areas, it was mentioned that the sale of live chickens is always high during festive seasons especially Christmas and Easter holidays. Although the majority of farmers in the study areas did acknowledge the use of chicken for sacrifices, only very few of the respondents (5%) were open and willing to share detailed information on the issues of rituals or sacrifices using chickens. Farmers reported that if there is a need for a chicken to be sacrificed, the herbalist demands for a certain colour or sex (male or female chicken) from the sick person and in most cases is either a cock or a hen with a white or a black plumage colour. Similarly Aklilu *et al.* (2007) indicated that some farmers in Ethiopia especially in areas such as Tigray believed that spirits that target a family member can be diverted with white feathered chickens. Masuno, (2008) classified rituals in Northern Thailand as small or large according to whether the participation is done on a households or village level or whether or not they are annual ceremonies.

According to Muchadeyi *et al*. (2005); Cuc *et al.* (2006), household food supply was generally the greatest reason as to why rural farmers keep chickens in their respective countries. According to Muchadeyi *et al.* (2004) farmers in Rushinga District of Zimbabwe used chickens to strengthen relations with in-laws or maintain contact with their families by entrusting the other family members with their chickens. The same authors also reported that farmers in the same district sell chickens also sold to pay for school fees, medical costs and paying village taxes. The issue of food security was also reported to be part of the reasons why farmers keep chickens in the visited regions. The contribution of indigenous chickens to food security was also emphasized by Alders et al (2000) who stated that village poultry make a significant contribution to poverty alleviation and household food security in many developing countries. The same authors further stated that the advantages of keeping indigenous chickens were that they can also support HIV/AIDS mitigation protein nutrition programs and can fund wildlife community conservation initiatives. Ahlers *et al*. (2009) pointed out that village poultry play an important role in households where there is a lack of able-bodied workers, such as those affected by HIV/AIDS or which have a disabled family member. Chicken owners said that serving a chicken dish as part of payment for labour during, for example, crop weeding time was an important motive for keeping chickens.

Very few households however, reported that they sell eggs during hot season i.e. during the month of August – October; Northern regions experience high temperature up to 37 to 40^0 degree Celsius. Literature it says that High temperature causes embryos to die at early stage, hence lower hatchability (Antwi, 1993). Generally, indigenous chickens are used for both eggs and meat production in all the houses visited.

4.6 Consumption of chicken Products

Although consumption of chicken meat was rated the highest priority (Fig 4.1.) as to why rural farmers keep chickens, variation of answers given by farmers regarding the question of how frequently farmers slaughter chickens for both home consumption and for visitors in the households across the study areas defeated that purpose. About 75% of the respondents from across the regions said they consumed chicken two times a month and the remaining 25% said they slaughter when the need arose. In terms of slaughtering for visitors, all the farmers said that it depended on the importance of the visitor and the availability of chickens at the time of the visit. People in Northern Thailand, have classified consumption of chickens as for; home consumption, rituals, and gift (Masuno, 2008).

The results of this study show that consumption of chickens, especially for home consumption depends on the number of chickens in a household. Thus, there is a need to increase the number of chickens through good husbandry management to allow the continuation of protein supply to improve the living standard of the farmers. For example, availability of quality breeding stock at reasonable price that would provide an opportunity for rural farmers to produce more chicken products is very important. Provision of proper marketing facilities in the rural areas will go a long way in expanding the rural poultry sector in Namibia.

4.7. Production performance.

As reported by several authors, indigenous chickens are generally known to lay fewer eggs as compared to exotic chickens. In the current study, majority of the respondents (about 64 %) said that their chickens laid 3 clutches of eggs per year and each clutch was estimated to contain 10 – 15 eggs (30-45) eggs per year and corresponding to the number of eggs per clutch observed during the survey. However, some respondents (10.4%) estimated that their chickens lay between 3- 4 clutches per year with estimated number between 8-15eggs per clutch totalling 32-60 eggs per year. The number of clutches reported in this study is similar to those reported by other authors (e.g Abdelqader *et al*., 2007; Guèye, 1998). However, lower numbers of eggs were reported in countries like Togo 20 eggs per year per hen (Aklobessi, 1990) and Ethiopia 25 eggs per hen per year (Tadelle and Ogle, 2001). About 25.2% of the respondents said that they had no idea of how many eggs were laid. As mentioned earlier in the current study there is lack of recording among the rural communities as per the exact number of eggs and clutches per hen per year.

During the study, some hens were seen sharing incubation episodes for their eggs in one nest Fig4.2**.** To the question as to why the two hens incubated on one nest, farmers said that the two hens laid their eggs together. One farmer explained that there are great advantages when two hens lay their eggs on one clutch because usually it gives very good result up to 100% hatchability and chick survivability. Poor hatchability was also reported especially during the rainy seasons. Farmers explained that when it rained clutches got filled up with rain water and this prevented the affected hens from sitting (incubating) on the eggs. This problem can also be blamed on the lack of proper housing infrastructures. Some chicken houses were constructed without the roof allowing the rain to fall into the houses and on the eggs. Sometimes hens did lay eggs in unsafe places like bushes. The absences of laying nests were also observed in the study. This means that farmers do not provide nests where chickens can lay their eggs on. As to the question of which time of the year chickens laid their eggs 44.2% of the respondents said that chickens lay mostly during summer because this is the time when there is more food such as green leaves, grasses and insects. In contrast 43.3% of the respondents said that their chickens lay mostly during winter because after harvesting there was always more food for the chicken to feed on. The rest of the respondents about (12.5%) reported that their chickens lay throughout the year. Farmers in these areas understood the importance of sufficient feeding in reference to egg lying. According to reports of various researchers in most countries and regions, the very large proportion of eggs (>80%, Sonaiya *et al*.,1999; Ekue *et al*., 2002; Njue *et al.,* 2002; Khalafalla *et al.,* 2002; Henning *et al.,* 2007) are set under the hen to produce chicks, a large proportion of which regrettably die before 6 weeks of age (Aini,1990; Cumming 1992; Spradbrow, 1993: Guèye, 1998; Sonaiya *et al.*,1999; Farrell *et al*., 2000). The above studies reported that in a typical clutch of about 10 to 16 eggs, only about 2 to 4 eggs per clutch are kept for consumption or sale.

Fig 4.2.Two hens sitting in clutch

4.8. Chicken body weights

Body weight of indigenous chicken populations throughout the world is generally characterized as having small body weight in comparison with exotic chickens. Body size of mature chickens from the four northern regions of Namibia is presented in Table 4.0.

The study showed a significant ($P<.05$) difference in body weights between females and males. This means that females had smaller body size compared to males. Greater disparity was observed in body weights of males compared to female chickens, as observed in other studies (Guèye *et al*.,1998 ; Mwalusanya *et al*., 2001) and according to the finding of (Yakubu *et al.,* 2009), sex- related differences between male and females chickens might be attributed to the usual between- sex differential hormonal effects on growth. Equally in the study of, Baeza *et al*, (2001) attributed the differences between male and female ducks to sexual dimorphism

4.9. Feeds and feeding

The chickens were managed traditionally based on free range scavenging management system. Respondent farmers in all the 4 regions revealed that their chickens depended on whatever the environment offers therefore, feed resources base for indigenous chickens was obtained through scavenging. A variety of feed resources scavenged by chickens include; insects, grasses or some leftover crop residues like; millet, sorghum left after harvest. Farmers also said that the availability of feed resources was dependent on the seasons and that, scavenged feed resources varied. For example, during rainy seasons, there were more feedstuffs as compared to winter and dry seasons.

During rainy season, farmers reported that there are lots of green grasses and abundance of insects as well as other invertebrates which chickens could feed on. The results obtained from this study are comparable to those of other scholars (Aini, 1990; Tadelle *et al.,* 2000; Ndegwa, 2000; Minh, 2005; Goromela *et al.,* 2008).

Feed supplementation was done (45.5%) in both seasons (rain and dry seasons) of the year. It was mainly the responsibility of women (52.1%) to feed and offer water to village chickens while a lesser role (6.5%) was played by children. This trend was more observed in Oshana, Omusati and Ohangwena region. Non-participatory role of men in taking part in giving supplement was due to that man caring more for large stock e.g. cattle.

Table 4.0.Body weight in (kg) (± s. e) of chickens from the four Northern Regions of Namibia.

Region	Sample size (N)	Females	Males
Oshana	42(males=11, females =31)	1.25 ±0.6	1.39±0.14
Omusati	35(males=15, females =37)	1.26±0.04	1.56±0.14
Ohangwena	62(males=19, females =43)	1.06±0.04	2.09±0.11
Kavango	28(males=6 females =22)	1.35±0.70	1.69± 0.31

During the study, both old and young chickens could be seen roaming in search of food in and around the homestead and scratching on the bare ground as shown in Fig 4.3 below.

Fig4.3. A hen feeding together with her chicks in the crop field

Apart from scavenging there are farmers who reported that they supplemented their chickens by giving them millet, maize, sorghum, and small melon seeds. The varieties of supplements used by farmers are never processed but given as whole grains. Most n=46 (88.5%) of the farmers supplemented their chickens once or twice a day; while n= 6 (11.5%) farmers did not supplement at all. Both adult and chicks as young as day old are supplemented together. Although one may assume that this is the way chicks are taught by their mothers how to scavenge, the problem is that chicks may have a little feeding rate as compared to adult and can place chicks at a disadvantage in terms of the quantity and quality of feed to be consumed. According to Kugonza *et al.,* (2008) poorly fed birds may lead to low immunity to diseases and also housed chickens are expected to survive predator attacks better during the night. The most used supplements in order of frequency of usage by farmers was pearl millet grains, followed by maize and then a combination of pearl millets, small melon seeds and bran of pearl millets as shown in Fig 4.4**.** None of the farmers indicated the exact quantity which they give as supplement to their chickens. The reason for the frequent use of pearl millet by majority of farmers was that, it is a staple food and the most cultivated crop in all the regions studied, hence it is readily available as compared to other grains such as maize. None of the farmer provided feed troughs because to the majority of the farmers interviewed, feed troughs are not important. One farmers in Omusati region said that providing feeders to chickens is a waste of time because even though feed are put in feed trough chickens still pour them out and start eating from the ground. The most common feeding practice employed by farmers was to broadcast whatever supplements offered on the ground where birds could feed from.

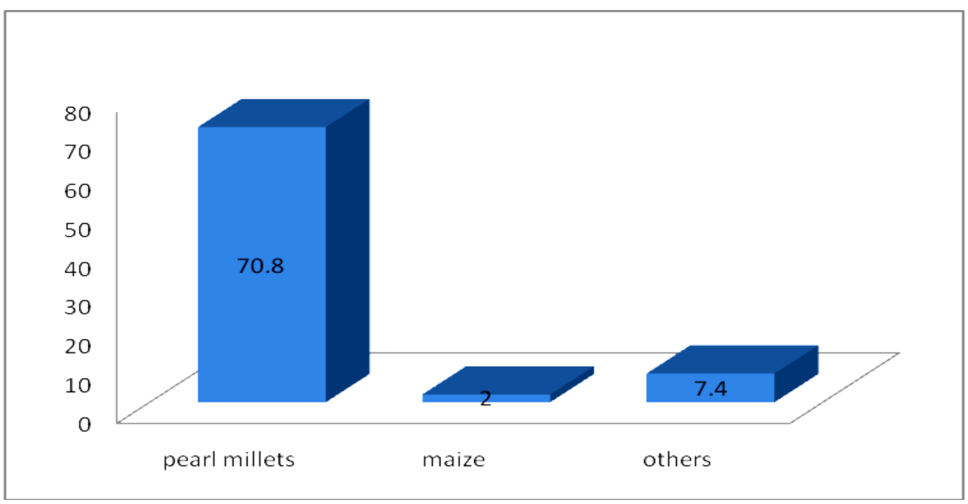

Fig4.4. Supplements used by farmers

The study found the method of spreading grains on ground as having some problems, especially to the young chicks. It was observed that it is difficult for the chicks to feed because most of the grains were buried in ground by the bigger birds through scratching. This observation was consistent with Cuc *et al.* (2006) who reported that the method of broadcasting chicken feed on the ground is a problem because birds do not make best use of the limited resources. It is therefore suggested that a better a way of feeding is by providing feed in troughs. Feed in troughs made from locally-available materials could be used to minimize wastage of feeds and optimize the utilization of the limited resources farmers provide.

Farmers in the study areas claimed to provide water to their chickens each and every day, especially during the dry season but during the rainy season, birds were sparingly offered water. Materials used by farmers for providing water to their birds include pieces of calabash, clay pots and broken plastics. During the time of the survey in the study regions, there was no evidence that chickens were provided with water. Water is critical in the life of birds because it is a major component of blood and plays a major role in transporting nutrients to the cells and disposing metabolic body waste. Water also plays a primary functions in two of the most important processes that occur in chickens, that is digestion and respiration, which is key to thermoregulation. Therefore, farmers should be made to understand that if they want to optimize their flock performances, they must provide their chickens with clean water regularly. Although some few farmers claimed to provide water to their birds, in the households, during the survey both ducks and chickens were seen drinking from the same container which is used as water trough Fig 4.5. In most households (65%), no drinkers were seen, 35% of the households had drinkers but they were empty and dirty as shown inFig4.6.

Fig 4.5. Chickens and ducks drinking from a broken plastic container

Fig4.6.A broken piece of a locally made clay pot used as drinker

4.10. Housing

The survey took place during dry season and none of the farmers housed their chickens during this season. Chicken were seen roaming around the houses and in all crop fields close to the homestead and some were seen in bushes close to the homestead.

Housing is essential to chickens as it protects them against predators, theft, inclement weather (rain, sun, cold wind, dropping night temperatures) and to provide shelter for egg laying. In some households, housing of chickens never occurred. From the total of 52 households interviewed, only 26 farmers (50%) indicated that they provided shelter to their birds during cropping season. These findings are similar to those (Gondwe and Wollny, 2007) in Malawi.

Chicken houses were traditional type, made from locally - available materials like poles from Mopani trees, scrap metals and old wire mesh. Example of the chicken houses constructed with locally available materials is shown in Fig4.7. The use of locally-available materials to construct chicken houses were also reported by other investigators (Benabdeljeil *et al.,* 2001; Wilson, 2007; Kumerasan *et al.,* 2008). Farmers who provided shelter reported that roofs of the houses were made up of metal sheets or poles of Mopani and crop straws, depending on what an individual farmer could afford. These houses were too small and dirty as compared to standard houses for chickens. None of the houses that were constructed could protect the bird from rain or cold. Cleaning of houses was not done and some of the houses were so small that only chickens could enter. The housing situation observed in the current study did not differ from what has been reported in other African countries (Zimbabwe: Kusina *et al.*, 2001; Ethiopia: Tadelle and Ogle, 2000; Botswana: Badubi, 2006; Malawi: Gondwe and Wollny, 2007).

Chickens were housed together irrespective of their ages. As to why they house chickens of different sex and ages together, almost all the farmers (99%) claimed ignorance about the issue. This means that farmers do not know that chickens can be housed according to sex and ages hence need to be trained. Although some farmers said they provided houses to their birds, what was observed was that these were generally inadequate and inappropriate and this partly explains why farmers experienced heavy losses and high mortality of their chickens. The situation can be corrected by appropriate extension support services for farmers' education and training in poultry production. According to Smith (1992), proper housing must not only provide an environment that moderates environmental impact but also must provide adequate ventilation for birds to lay eggs in nest boxes, as well as to feed and sleep in comfort and security.

Fifty per cent (50%) of the farmers said that they did not house their chickens; instead they kept them overnight on top of the poles that made up the homestead, while some slept overnight on trees. None of the farmers in the study areas provided nests neither for laying eggs, nor for brooding, therefore in the majority of cases were the eggs were laid and brooded wherever the hens could find suitable places. Hens naturally did the hatching and brooding. Once chicks hatched, they stayed with their parents until weaning time.

As to why chickens were not housed, only a few farmers indicated that they fear their chickens would die due to snakes attacks or parasites. Houses were made of poles and these do not prevent snakes from getting into the house and the traditional chicken houses are never clean hence a suitable breeding place for parasites. Reasons for not housing chickens were ranked as follows: lack of construction materials (64.4%); lack of manpower (34.2%); and some said they had only a few chickens hence no need to construct houses for them (1.4%). Through observations and from what the farmers said, it is suggested that there is a need for educating the farmers on the importance of proper housing and cleaning to attain high productivity from their chickens. Farmers should also be advised that lack of proper shelter exposes chickens to predators, especially for newly hatched chicks.

Fig4.7. A chicken house made with Mopani poles

4.11. Marketing of chickens and their products

Compared to the broiler and layer chickens, marketing of indigenous chickens observed in the current study is traditional. In all the visited regions, there were no specific markets where farmers could sell their chickens and chicken products. When need arose, however, farmers carried their chickens to traditional markets to sell. Rural farmers said that they sell their chickens in two ways: firstly at the homestead level, where farmers sold only live chickens, to their neighbours and secondly was at the village level, especially during pension days when old people come to receive their pension from the government, or at "Kuka" shops where people come on daily bases to socialize. Similarly, the selling of chickens in an informal way was reported by Mlozi *et al.* (2003) and Branckaert and Guèye (1999) in Tanzania and Senegal, respectively.

Dessie and Ogle (2001) stated that the market places where indigenous chickens are sold in developing countries are generally informal and poorly developed. Eighty percent (80.4%) of the farmers in the study areas indicated that they sell live chickens mostly to the neighbours and others (19.6%) said they also sell to the retailers who resell to people in urban areas. The selling of cooked chicken is only done at "Kuka" shops. Male chickens were reported to be the most sold and had a higher sale value than female chickens because of their sizes (weight). Farmers had the criteria for judging of chicken price and causes of price fluctuation of chicken. For example respondents in Omusati, Oshana and Ohangwena gave high value for body weight 54.6% and 56.9%, respectively.

Respondents from Kavango gave high value (45.7%) for plumage colour. Season of the year also influence the price; for example in December, they had higher prices as compared to other months. The highest demand for local chickens coincided with the major social and religious festivals of the year which include weddings and Christmas (August and December). Farmers attempted to increase flock size either by buying pullets or cockerels from their neighbours. No weighing scales were used and therefore chickens and their products are sold without grading. Chickens were priced based on the size and the weight of chickens as gauged by visual appraisal.

4.12.0. Constraints for chicken production

Although indigenous chickens were found in all the visited households, problems confronting the development of this sector are many and diverse. As detailed below, many of these problems are common to all the regions.

4.12.1. Health status and disease management

The interviewed farmers acknowledged that disease outbreaks were the biggest constraint to their flocks. Clinical symptoms were regarded as diseases themselves. Disease symptoms indicated by interviewed farmers were numerous and included, shivering, coughing, head swelling, diarrhea, sudden death, blindness and crouch down. Some of these symptoms reported in current study are similar to what was documented by Food Agriculture Organization (FAO) (2004). Though the actual routes cause of diseases reported by farmers are not known, the likely situation is that since the domestic birds are not contained in houses, they sometimes mix with other animals during scavenging and this situation may create an opportunity of spreading disease pathogens between species. Through observation animals that readily mix with chickens are pigs, cattle, goat and dogs. Mixing with other livestock was observed in Oshana, Ohangwena, Omusati (86%) followed by Kavango (14%). It was also observed that there is extensive interaction between humans and their chickens, since chickens were seen scavenging all over the houses even in places where households' food is prepared. This again in a way poses dangers of exchanging disease pathogens between humans and domesticated birds. Mixing of wild birds with chickens during scavenging was found to be common among all regions. Chicken movements through gift could also be a way of spreading of diseases in the rural areas. Apart from diseases, the issues of ecto parasites such lice were mentioned in Omusati 46%) and Oshana 34% and none in Ohangwena and Kavango regions. According the interviewed farmers, higher rates of infestation of ecto - parasite occurred during the rainy seasons. The study observed that houses constructed for chickens were too small and cleaning become difficult. Similarly, Zaria *et al.* (1993) reported that ecto-parasites of domestic fowls in Nigeria mainly lice (*Menacanthus straminen)* were the major problem in rural areas.

4.12.2. Types of interventions made by farmers

Farmers in the study areas treat their chickens using the indigenous knowledge they acquired over a long period of time. However, this existing indigenous technical knowledge inherited from past generations reported to have sustained the local poultry production system and farmers regard the indispensable source of medicine for indigenous poultry production systems (Okitoi *et. al.,* 2007). However, farmers in these areas depend on plant parts and herbal remedies for indigenous chickens' health management. For example, in the absence of modern treatment, farmers in the studied areas reported that they used traditional herbs (plant herbs) and in some cases others used human medicine as remedies in an attempt to control and treat the symptoms/ disease outbreaks. Farmers in all the study areas consider the use of Ethano-veterinary medicine as sustainable, economical and culturally- acceptable. This is because some farmers stated that there is no money involved to acquire the herbs; farmers get them freely from the bush. According to famers the leaves were harvested, cleaned with water, and crushed before they were mixed with drinking water for chickens. These findings are in line with the reports by other authors including (Guèye, 1999) in Senegal and by (Tamboura *et al.,* 2000) in Burkina Faso. The effectiveness of herbs as a way of disease treatment was reported in Simbabwe by Mapiye and Sibanda (2005). These two authors observed that rural farmers who used traditional medicine (herbs) in that country had large flock sizes in comparisons with those who did not use any form of treatment. However, the results of the current study together with those found in literature about the use of herbs is an indication that traditional medicines in some instances have potential to improve the health status of rural household flocks.

The types of herbs in developing countries by rural farmers differ greatly for example, (Kugonza *et al.,*2008) reported that farmers in Uganda make use of *aloe vera,* pepper and sisal leaves for the treatment and control of indigenous chickens' diseases . In addition Okitoi *et al*.(2007) reported that the use herbs plants like ***aloe*** *vera*, pepper, sisal and neem were the most used medicinal plants by rural farmers in Western Kenya. Interventions reported and carried out by rural farmers in the study areas are presented in Fig 4.8. However, 7.9% of respondent said that they intervene by slaughtering for home consumptions, 5.9% slaughter and sell the meat, intervene by the use medicine from veterinary shops 3.9%. It is also reported that some farmers in the study areas use leftover from their own or their children prescription in treating their chickens. The used use of human medicines in the treatment of chickens was also reported by (Sofowora, 1993) who said that most of the developing countries including Nigeria rely wholly or partly on traditional herbal medicine for treatment and control of animal and human diseases.

However, thirteen per cent (13.7%) of the farmers make use of herbs they get from the bushes. Those who did not intervene at all were the majority and accounted for 64.7% Musa, *et al.* (2008) reported that the major medicaments used by the rural chicken farmers for the treatment of rural chickens against Newcastle disease (ND) in Nigeria are those from plants origin and they include mahogany (*Khaya senegalensis*) bark/roots (25.1%), wild garden egg (*Solanum nodiflorum*) (20.3%), bitter leaf (*Vernonia amygdalina*) (7.8%) and pepper (*Capsicum frutescens*), as the main sources of remedies. It was also revealed that 7 (2 %) of the respondent employed the use white maggi (*Monosodium glutamate*), which they usually soak in water and administer to chickens orally for the treatment of New castle disease.

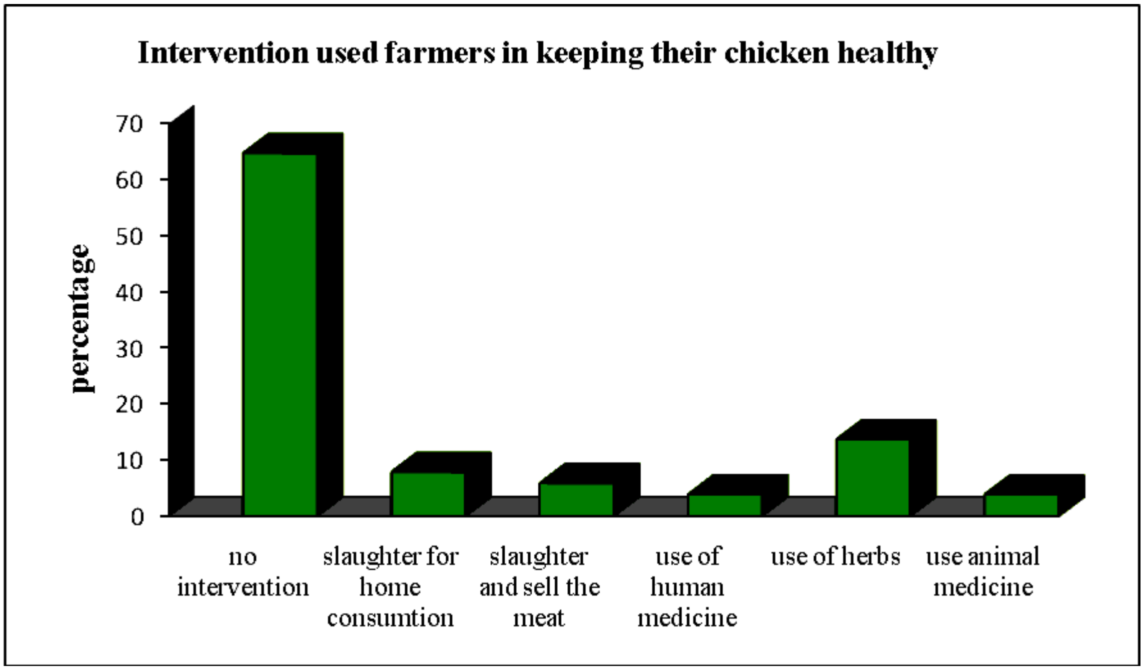

Fig4.8. Types of interventions used by farmers

Treatment of indigenous chicken diseases was based mostly on concoction of plant materials where farmers mixed different plants or single plant parts depending on the knowledge of the individual farmer as shown in Table 4.1**.** The amounts of ingredients contained in these plants used as medicines were not analyzed hence dosage levels were not known. This means that birds may be receiving over dose or under dose. This observation is similar to that of Okitoi *et al.,* (2007) who reported that farmers in Western Kenya did not know the amounts of ingredients contained in concoctions given to birds and that treatments were not for any specific disease. In most cases, they were offered in drinking water irrespective of whether the birds were sick or not. The present study also found out that ash was used as means of eradicating ecto – parasites from chickens. Farmers did not also consider the age when giving the concoctions therefore, what is given to the adult chickens is also applied to chicks. These specific interventions made by farmers in the study areas could in a way be blamed for the mortality rate farmers experienced in their flocks. The use of traditional medicine by farmers in the study areas may be due to its low cost, availability and ease of application compare to modern veterinary medicine.

Table 4.1. Names of the plants used as chicken medicine in the rural areas

Region	Name of the plants in local languages	Scientific name	Parts used	Disease treated	Mode of administration
Oshana	• Omazimba	-	Stems and leaves	Diarrhea, shivering	Drinking water
Omusati	Endombo	Aloe	Exudates	Eye infection	Exudates squeezed into the eye
	Omazimba	-	Stems and leaves	Diarrhea, shivering	Drinking water
	Endombo	- Aloe	Exudates	Eye infection	Exudates squeezed into the eye

Table 4.1. Names of the plants used as chicken medicine in the rural areas

Region	Name of the plants in local languages	Scientific name	Parts used	Disease treated	Mode of administration
Ohangwena	Ediba	-	Stems and leaves	Diarrhea, shivering Eye infection	Drinking water
Kavango	Muhuzi	White bauhinia	Exudates	Eye infection	Exudates squeezed into the eye squeezed
	Muhuzi Usizi	Large false mopani	leaves	Eye infection	Exudates squeezed into the eye

The unavailability of drugs and lack of veterinary services in the rural areas will have contributed to low utilisation by farmers in sourcing drugs for treatment of sick chickens. However, more interventions are needed and the Ministry of Agriculture Water and Forestry should pay more attention to subsistence poultry farming in general and consider it as one of the programmes that would ensure food security and income generation in the rural community.

Currently, the provision of both extension and veterinary services on issues concerning poultry husbandry and health is lacking in the rural areas. However, the only consolidated intervention that exists in the areas is that of diseases and it is only geared toward large and small stock animals. Farmers also need to be informed and educated on the dangers of eating sick animals as it was pointed out as one of the intervention. Farmers in this situation can easily be exposed to zoonotic diseases which are transmitted from sick animals to healthy humans such as anthrax.

4.12. 2. Inadequacy of extension services and veterinary support

Based on these results one can conclude that there is lack of veterinary knowledge by rural farmers as far as rural chickens are concerned. It is also possible that high disease levels were probably enhanced by exposure of chickens to the natural environment, interaction between different chickens within and among flocks such as flock contacts during scavenging, uncontrolled introduction of new stock from relatives and sale of live chickens. Farmers never isolated sick chickens from the healthy ones. Disease situation is made worse by the failure of vaccination program and general lack of adequate disease diagnostic and control services. It is therefore recommended that a close coordination between extension and veterinary services as well as rural farmers for adequate supply of essential inputs including training facilities and proper system of marketing. Farmers benefit through the supply of protein and other socio- cultural activities, cannot be underestimated, therefore there is a need for the improvement of the sector in terms health control. It is clear that greater productivity and profitability will result from such interventions. Although disease condition was mentioned as one of the important factors that affect indigenous chickens in rural areas, there was a problem in identifying the real causes of diseases that led to the chicken deaths in the present study. This is so because farmers only described symptoms they observed in their chickens.

4.12.3. Inadequate marketing system

Marketing of chickens and chicken products is a serious problem confronting indigenous chickens in all the regions. In the absence of a proper marketing infrastructure in the rural areas, chicken trade is still done at homestead level in all the regions visited.

4.12.4. Lack of quality feed

Lack of quality feed has detrimental effects on rural chicken production in all the regions visited. Farmers explained that lack of feeds is more severe during dry season and when chickens depend on their owner for survival. The observation is consistent with what was reported by Rashid et al. (2005), who reported that during dry season there is shortage of chicken feed due to the absence of insects and green material including grasses.

4.12.5. Chicken mortality

Respondents also indicated the age at which most of their chickens die. Mortalities in chicks were highest (85%) followed by adults (40%). Farmers explained that mortality was highest in the chicks, especially during the first and second weeks of their life. Based on the ways which chickens are reared in rural areas, high mortality rates in chicks could have resulted from starvation because chicks as early as a day old were left to scavenge together with their mothers. In this situation, young chicks do not have enough experience and competency in searching feed hence they mostly depend on their mothers for food. Another factor that might lead to high mortality among young chicks is the inadequate nutrients to meet the chicks' requirement, resulting in chicks' with low physical defensive mechanisms, weak and under-developed immune system. The results in the current study are similar to the findings of Mwalusanya *et al.* (2002) who recorded a survival rate of 59.7% in village chicks (1-10 weeks old) in Morogoro, Tanzania. Guèye (1998) attributed losses, especially chicks, to several factors, among them, low, protein and energy in the feed consumed by local chickens, low hatching weight of chicks, high ambient temperature and other associated factors. Mushi *et al.* (2005) pointed out that the most likely causes of chick mortality were inability of chicks to survive the cold winter temperatures and starvation due to lack of feeds which made the chicks weaker.

4.12.6. Predation

Predation was the other economically - important constraint to village chicken production system of the study areas. Halima *et al.* (2007) also reported predation as one of the major constraints to village chickens production in North-West Ethiopia. According to Bell and Abdou (1995), large proportion of village birds were being lost due to predation in some African countries. Kusina *et al.* (2001) also reported that chicken predators were prevalent in Zimbabwe.

4.12.7. Poor chicken management

According to the respondent farmers and visual observation in various villages, production losses are due to poor chicken management especially feeding and watering. The study took place during dry season when green grasses or insects which chickens presumably feed on during rainy season were scarce. Chickens were seen scavenging, scratching and picking from the bare ground. Water containers were empty. It is concluded that poor feeding and water supply were also contributing factors to mortality among chicken in rural areas.

4.13. Marketing of chickens and their products

4.13.0. Marketing of live chickens

Although selling is not the main aim why farmers keep chickens, all interviewed farmers agreed that they sell their chickens from time to time even though not in large numbers. Farmers sell their chicken mostly when there is an instant cash need in the house (25%) to neighbours and retailers or other people who may need to slaughter during weddings and other important occasions, slaughtering for home consumption and visitors (75%). Cash generated from chickens are used to support children school fees and other households' necessities. Lack of established marketing structures in the villages has led them to sell their chickens to neighbours and at the "Kuka" shops. Apart from that small numbers of readily disposable chickens, farmers would prefer to sell in the villages. Of the 52 number of interviewed 61.5% of them said selling at the "Kuka" shop (sheabens) was a problem because, the owners in many occasions after selling used up the money for alcohol instead. While the remaining farmers 38.5% prefer to sell their chickens in the households arguing that the main purpose of keeping chickens is for home consumption. Majority of the respondent farmers indicated that there is a need to have a market within their villages because lack of the proper marketing avenues sometimes forced them to sell their chicken at a rip-off price. Some chicken buyers bargain for very low prices so as to maximize profit when they get to the open market. In some situation farmers are frequently compelled to sell their chickens on credit and in many a time the money is never recovered on time or never recovered at all.

The cultural value that chicken meat has on weddings and other occasions helps to ensure sustainable marketing of live chickens in the regions. This observation is in line with (Guèye, 1998) who reported that local consumer generally preferred indigenous chickens and that the high consumption associated only with holidays resulted in the largest off take rates from the flock to occur particularly during holidays and festivals and during the onset of disease out breaks. However, at local *Kuka*-shops some farmers cooked chicken meat for sale to people drinking. One woman in Oshana region indicated that she makes between N$40 and N$70 in a month from selling of live chicken.

4.13.1. Marketing of chicken products (meat and eggs)

Although farmers in the studied areas have reported that they sell chicken products mostly to people that come to *Kuka*- shops. Eggs are not commonly sold at the open market. However, at local *Kuka*-shops important they are sold cooked to people drinking. Prices for a chicken ranged from N$40 to N$60 for a cock and N$ 20 to N$ 30 for a female chicken depending on the place because the price is higher with the urban farmers. Overall 3.5% of farmers sell chicken eggs in hot period that is during the month of October to December. Farmers explained that in hot period they experienced poor hatchability due to excessively high temperature. This finding is in line with some researchers including (Romanoff, 1960). However, high temperature is a very factor in the embryo development and post-hatch performance according to (Lundy, 1969; Wilson, 1991) as well for hatchability (Deeming and Ferguson, 1991; Wilson, 1991). During the months of October and December in these regions, temperatures usually range between 28 -38^{0}C. Most poultry species have an optimum incubation temperature of 37 to 41^0 C and small deviations from this optimum can have a major impact on hatching success and embryo development.

4.14. Phenotypic characteristics of indigenous chickens in the four study areas

The results of the study indicated the existence of great variations in qualitative traits among the indigenous chickens population in the study areas. Phenotype variation refers to the variation of the physical traits, or phenotypic characters of the organism, such as differences in anatomical, physiological, biochemical, or behavioural characteristics.

Phenotypic variations represent an important measure of the adaptation of the organism to its environment because it is these phenotypic characters that interact with biotic and abiotic (i.e. living and non-living) factors of the environment. Variations observed in this study were those of the plumage colour, feather distribution (feathering of the leg and the feet), while variation in the feather structure included silkiness, frizzle feathering and variations in feather arrangement (e.g. feather crests). Other variations observed were those of body weight, naked neck and comb types. The indigenous chickens express various plumage colour patterns, comb types, shank colour and other external characteristics. Gene frequencies in chickens traits in the four Northern regions of Namibia presented in Table4.2 are more or less comparable with results found in indigenous chicken populations in Nepal (Okada *et al.*, 1986).

4.14.0. Plumage colour and feather patterns

This study has found multi colouration of the plumage dominate in the local chickens. Some colours that were also observed included black, cream and yellow plumage as shown in Figs 4.8 - 4.15. Katalyi (1989) described indigenous chickens as non-descriptive and unimproved. Plumage colourations in chickens are said to have some advantages to the owners. For example, Barua and Yomushira (1997) explained that the main purpose for indigenous chickens possessing diverse plumage colour is for camouflage against predators. The functions of plumage colour in chickens may go beyond camouflaging. For instance, Ensinminger,(1992) stated that plumage colour particularly the white or light have become an important factor in the field of breeding particularly in broilers because it is easy to pick, clean and also good appearance of carcass and cut parts thus having market implications.

Some anatomical variations observed in the current study were crested heads, naked neck, frizzle, barred and normal feathers as well as different comb types. Other features although they appeared sporadically were those of feathers on the legs and toes. Some chickens were having six toes instead of the normal five possibly due to a genetic anomaly. Traits similar to what was observed in this study were also observed in Tswana chickens of Botswana (Badubi, *et al.,* 2006) and in Senegal Horst (1989). Some of the traits observed in this study were like those that are described by Horst (1989) as having economic importance in the tropics. Nesheim *et al.,* (1979) and Ensiminger (1992) described them as heritable and cause by single gene pairs. Farmers in the study areas said they used these traits such plumage colour and feather patterns, for distinguishing their chickens from each other.

Fig.4.9. Greyish colour hen

Fig.4.10. Mixture of white and black colour

Fig 4.11.Yellow and black colour Fig.4.12. Black yellow and white colour

Fig4. 13. Black and brown colour Fig4.14.Pure black Variations in qualitative traits such as plumage colour, shown in Fig (4.8-4.15), comb type in Fig 4.16 (a-c) and shank colour in Fig 4.22 – 4.25 were further evaluated in order to find out the distribution of the individual genes Table 4.3 controlling these phenotypes from samples of indigenous chickens . The diverse morphological traits observed in the current study are consistent with those of McAinsh *et al*. (2004) who stated that the

variation in phenotypes is exactly what characterizes local chickens. They further stated that this is probably an expression of high variability at genotype level.

Fig4.15. Barred colour pattern

Fig4.16. Yellowish colour type

4.14.1. Comb types.

The current study investigated that Comb types was one of the parameters, and are believed to have an impact on the behaviour of chickens (reference). Variations in comb types observed in the study were rose, pea and single as presented in Fig 4.17(a-c)**.** However, the result of the analysis indicated significance differences in comb types between the regions shown in Table 4.2. Most chickens from Omusati, Oshana and Ohangwena have single comb with rose and pea comb types. The result is comparable with the finding of Okada (1996). Chicken populations in Kavango region were very different from the rest of regions in terms of comb type simply because they carry only single comb type. This finding was similar to that of Tenabe, *et al.* (1999) who reported that indigenous chicken population in Southern Region of Ehime Prefecture, Shikoku Japan carried single comb only.

Fi

Fig4.17a. Single comb Fig 4.17b. Pea comb Fig 4.17c. Rose

comb

Table4.2. Frequencies of comb type observed in the four regions

Comb type	Regions				Total observed	P<0.05
	OMS	OSN	HGN	KAV		
No. observed	(52)	(42)	(63)	22	179	.0.0001
Pea	1	4	12	0	17	
Rose	25	28	28	0	67	
Single	26	24	23	22	95	

4.14.2. The importance of comb types

The single comb is the commonest of the comb types in the Namibian local chicken follow by rose. Oluyemi and Roberts (1979) also reported similar observations in

Nigeria**.** Combs are regarded as important avenues for heat loss in birds (Van Kampen ,1974). Also, Ikeobi (1984) found that birds with large combs had significantly heavier body and egg sizes which would be important under conditions of natural selection and adaptation. These specialized structures contribute about 40% of the major heat losses by radiation, convection and conduction of heat produced from body surfaces at environmental temperature below 80^0F (Nesheim *et al.*, 1979).

4.14.3. Feather structure

Variations in feather structure or types observed in the present study were mainly normal, with special forms such as crested and naked neck appearing sporadically. Exceptions to the observed normal feather structure are silky and frizzle feathering types as presented in Fig 4.18 - 4.21. Frizzle chickens have feathers curved outward away from the body. This feature reduces insulation by the feather cover, which makes it easier for a bird to radiate heat from the body while feather follicles are absent from the head and the neck. Frizzle and naked neck chickens are among those chickens with important genes. For example, according to Horst (1998),both feather distributions Naked neck (Na) and feathers structure Frizzle (F) genes are associated with increased heat resistance. These two strains are known to perform well at high ambient temperatures due to their ability to dissipate heat by convection, thus leading to less heat stress than normal feathers (nana) genotypes (Yahav *et al.,* 1998; Deeb and Cahaner 1999; Adedeji *et al*., 2006); their interactions, could be considered for incorporation into the development of high performance local birds for the tropical hot environments.

Fig4.18 a. Frizzle chicken

Fig4.18 b.Naked neck chicken

The superiority of individuals of naked neck and frizzle-feather genes, either singly or in combination for increased growth rates, body weights, feed conversion, egg production and disease tolerance in tropical environments has been reported (Muthur and Horst, 1990; Fraga, 2002; Missohou et al., 2000; Mahrous *et al*., 2008). In addition, Islam and Nishidori (2009) have also described naked neck chickens as having good heat dissipation mechanisms and well adapted to harsh tropical environment and poor nutrition and highly resistant to disease and also superior to the normal feather chickens be it indigenous or exotic. Due to the these characteristics described in several reports this study recommends for further studies of these two traits to investigate how best they will adapt to the Namibian environmental conditions.


Fig4.19. Crested head without a comb


Fig4.20.Crested head with a single comb


Fig4.21. Wild type (reddish, yellowish, black and greyish colour types

4.14.4. Shank colour

Shank colour is determined by combinations of pigment controlling genes. W+ and w; Id and id+; and E and e+ controls production of carotenoid, dermal melanin, and epidermal melanin, respectively. As a result, a variety of shank colours appear such as white, yellow, green and, black. In the current study variation observed in terms of shank colours were as shown in the Fig4.22.- 4.25**.** These variations are in agreement with the reports in other countries (McAinsh et al., 2004; Badubi et al., 2006).

Fig4.22. Black shank

Fig4. 23. Yellow shank

Fig4. 24. Green shank

Fig4.25. Red shank with feather

Most of these traits mentioned above are similar to those e reported by Horst, (1998), who described them as having some direct and indirect influence on the production characteristics under tropical management situation. According to Nesheim et al., (1979), the size and colour of the comb and wattles are associated with gonad development and secretion of sex hormones. The current study therefore recommends that the major genes which exist in Namibian chicken population should be exploited to increase the production performance to the benefit of the rural farmers.

4.13.9. Gene frequency for physical characteristic of indigenous chickens

Physical characteristic of indigenous chickens are affected by both environmental and genetic factors. Genes code for the outward expression of physical traits of the organism, however, any variation that exists within the genetic constitution of an organism or the outward appearance of an organism is a product of its genotypic variation. The frequencies of the different genes influencing plumage color, shank and comb types are shown in Table 4.3.

The gene frequencies for external characteristics were estimated for Omusati, Oshana, Ohangwena and Kavango regions. Concerning the gene controlling the white plumage colours in chickens the *I* allele was not observed in all the chickens throughout the regions and this implies that there was little or no introduction of exotic breeds especially white leghorn in the regions. At the *E* locus because of the difficulty of phenotype classification, only the alleles of *E*, e^+ and *e* alleles were used.

There were a noticeable absence of the e^+ allele in chickens from Kavango region and also a rare occurrence of the **s** allele. A good representation of *ee* alleles which is the wild type colour was noticed in all the regions. Other colours such as silver *S* and barren *B* were noticed among the chicken population across the regions. Concerning gene frequency controlling shank colour frequency for *Id* allele was high in chickens from Omusati, Ohangwena and Oshana but low in chickens from Kavango region. The results of the phenotypes analysis suggest that no introduction of exotic breeds because most of the characteristics displayed by chickens in all the regions fit into the pattern for indigenous chickens especially in developing countries. Concerning the comb types, however, Okavango chicken population possessed only single comb, whereas chicken population in Ohangwena, Omusati and Oshana carry all combs (single, pea and rose). None of the regions showed pure white colour. The results agree with those of Yammamoto *et al*; (1996) who reported that most native chickens from an area called Ri in Indonesia single comb was more common. Central Nepalese native chickens did not show any pea comb (Nishida *et al*, 1986). Domination of single combo also was reported in the Nigerian local chickens by Oluyemi and Roberts (1979).

However, the differences observed in the current study were probably due to the combined inhibiting effects of social preferences, natural selection and adaptation of certain genes to a particular environment. Even though during the interview some farmers reluctantly agreed that they use birds for ritual purpose, the absence of some external characteristics may be counted for societal preference farmers attached to the birds. In Nigeria, Yakubu *et al.* (2009) reported that most of the birds with peas and rose comb encountered in their study were found with traditional worshippers.

Table4.3. Phenotypic distribution and gene frequency y of external traits of the indigenous chicken population in four Northern Regions of Namibia

External trait		Oshana	Ohangwena	Omusati	Kavango
	Allele	Freq.± S.E.	Freq.± S.E.	Freq.± S.E.	Freq.± S.E.
Plumage color		(41)	(62)	(51)	(22)
	I	0.0	0.0	0.0	0.0
	i	1.0	1.0	1.0	1.0
		(40)	(62)	(48)	(22)
	E	0.120±0.038	0.197±0.038	0.236±0.047	0.147±0.056
	e^+	0.106±0.037	0.168±0.038	0.169±0.044	0.0
	e	0.775±0.050	0.635±0.049	0.595±0.058	0.852±0.056
		(41)	(61)	(48)	(20)
	S	0.236±0.061	0.225±0.048	0.303±0.065	0.036±0.036
	s	0.764±0.061	0.775±0.048	0.697±0.065	0.964±0.036
		(41)	(62)	(48)	(22)
	B	0.118±0.045	0.197±0.045	0.148±0.046	0.069±0.047
	b	0.882±0.045	0.803±0.045	0.852±0.046	0.931±0.047

Table4.3. Contd . Phenotypic distribution and gene frequency of polymorphisms of external traits of the indigenous chicken population in four Northern Regions of Namibia.

External trait		Oshana	Ohangwena	Omusati	Kavango
	Allele	Freq.± S.E.	Freq.± S.E.	Freq.± S.E.	Freq.± S.E.
Shank color		(42)	(62)	(51)	(22)
	Id	0.214±0.058	0.304±0.053	0.220±0.052	0.141±0.065
	id	0.786±0.058	0.696±0.053	0.780±0.052	0.859±0.065
Comb type		(42)	(62)	(51)	(22)
	P	0.049±0.024	0.102±0.028	0.010±0.010	0.0
	p	0.951±0.024	0.898±0.028	0.990±0.010	1.0
		(42)	(62)	(51)	(22)
	R	0.184±0.045	0.238±0.041	0.286±0.049	0.0
	r	0.816±0.045	0.762±0.041	0.714±0.049	1.0

Figs in () parentheses indicate the number of observations.

CHAPTER FIVE

5.0. Study on the genetic variation of indigenous chicken population in Northern Namibian regions by blood typing method**.**

5.1. Introduction

Indigenous chickens are important sector in Namibia contributing to a high proportion of supply of animal protein to humans through meat and eggs. Indigenous chickens are especially suitable to rural households due to low capital investments, high cost efficiency and low production risk. Despite their importance, information on their genetic makeup in terms of their performances, adaptability, resistance, genetic variability and genetic relationships is lacking in Namibia. Elsewhere, indigenous chickens have been described as having unique genes which are important in adaptation to their agricultural production system and agro-ecological environments (Guèye, 1998).

The genetic characterization of the domestic animals is also part of the FAO Global Strategy for the Management of Farm Animal Genetic Resources. This strategy places a strong emphasis on the use of molecular methods to assist the conservation of endangered breeds and to determine the genetic status of breeds. Genetic characterization contributes to breed definition, especially populations which are not well- defined and provide an indication of their genetic diversity. It also has a potential to identify unique alleles in the breeds or lines studied. Conservation of farm animals including chickens will be important for future designing of sustainable breeding programs (Lamont 1998a).

Throughout the world, however, many methods of varying complexity have been developed that can be used either for study, assessing or evaluating the structural biodiversity and biological performance in chickens in order to understand the relationship between the variation in biodiversity with biological performance. Before the contemporary molecular tools were developed, researchers relied on methods such as, morphological traits protein polymorphisms and immunogenetic systems. The major histocompatibility complex (MHC) contain a number of genes which have very important roles in immune responses. MHC has been named differently in different animals: human leukocyte antigen (HLA) is for human MHC, H-2 complex for mouse MHC, BoLA for cattle MHC, B and Y complex for chicken MHC and SLA for pig MHC (Miller *et al*., 2004; Smith *et al.,* 2005). This MHC region encodes cell surface glycol proteins, which bind to foreign antigens of T lymphocytes that are central to the induction and regulation of adaptive immunity (Germain, 1994). The MHC class I and class II genes are highly polymorphic and are known to be related to immune response related auto-immune disease, infectious disease, and responses to immunization. For example reports by Pazderka *et al*. (1975), Lamont (1998b) and Le Page *et al*. (2000) have shown that B-complex is associated with resistance against Marek's disease, fowl pox, cholera, cocciodiosis and leukosis. In Namibia chickens B- system were only found in the Kavango chickens, especially the B 15, B16 ,B1, B15, B19 and B21 and these are known to be related to resistance against diseases like, fowl cholera, coccidiosis, leucosis and Marek's disease (Lamont, 1998b). B21 blood systems have different numbers of alleles and each allele controls a different antigen. For example B system has 30 alleles but the L system has only two alleles that (L1 and L2). The absence of B- system in Namibia chickens may mean that these chickens may have different antigens with new alleles.

Although considerable information is available on blood groups of the chicken, relatively little information has been published on blood groups of local breeds of domestic fowl of different villages of the world. This study aimed at characterizing the indigenous chicken breeds of Northern Namibia, which are associated with specific tribes and regions. Through genetic characterization, the information as to how unique or how different these chickens are from each other may be revealed and can be step in designing appropriate management and conservation program.

5.2.0. Materials and Methods

5.2.1. Blood sampling and typing

The blood sampling method used in this study was the same as that used by Yamamoto et al., (1998). Blood samples were drawn from one hundred seventy five local chickens (n=175) sampled from Omusati, Oshana, Ohangwena and Kavango. One ml of blood was drawn from the wing vein of the chickens using a syringe containing heparin as an anticoagulant. Age of the chickens could not be determined because farmers do not keep records. After each bleeding the needle was immediately removed from the syringe and the blood was transferred to the centrifuge tube by pushing down the plunger gently to avoid haemolysis. The lid was replaced on the centrifuge tube and rotated gently to mix and immediately placed in a cool box containing ice blocks. Each sample tube was labelled indicating the region from which the chicken was obtained and whether it was male or female. Blood samples were later brought and stored in the refrigerator for the agglutination test.

5.2.2. Laboratory procedure

5.2.2.1. Washing of blood samples

Whole blood was washed twice in physiological saline water and centrifuged for 5 minutes, at 2,500 rpm. A supernatant after each wash was poured out leaving the red blood cell pellet at the bottom of the tubes. Erythrocyte cell suspensions of 2% were prepared in physiological saline. One drop (50 µl) of cell suspension was added to two drops of appropriately diluted reference antiserum or reagent in 10 X 75 mm micro titters and two mixtures were mixed by shaking.

5.2.2.2. Blood agglutination

In this study, a total number of 109 antisera were reacted with each blood sample from the individual chickens by adding one drop (50 µl) of cell suspension to one drop of antiserum or reagent into a micro-tube using a syringe. Tubes were shaken, incubated for 30 minutes at a temperature of 37^0C and visually observed to see whether or not agglutination (clumping) occurred in Table 5.0.

Table5.0.The degree of agglutination (clumping) of blood samples with different antisera

Description	coded symbol	designation
Very strong reaction	+++	pp
strong reaction	++	P
weak reaction	+	Np
Unclear clear reaction		N

The 109 anti sera used for agglutination in this experiment were developed at Nippon Institute for Biological Science, Kobuchizawa Research Station in Japan in 2001 by Dr. Mizutani, a senior researcher. These one hundred and nine anti sera were produced by immunization with erythrocytes between inbred chickens differing at one or more blood group loci.

5.2.3. Scoring based on agglutination

The agglutination reactions were scored for their presence and this include strong and very strong reaction as described above or absence (Table 5.0). If the sum of a column is 0, it means all chickens in the region responded negatively against the antiserum; and 1 means one chicken responded positively to antiserum. If all the regions indicate either all negative or all positive to a particular antiserum, this means that there is no variation among the indigenous chickens in that region.

5.2.4.0. Genetic variation within the populations

5.2.4.1. Gene frequencies

The frequency of alleles for each antigen locus in the population varied from 0 to 1 Table 5.1. The polymorphic information content for 109 antigens (loci) for the four regions was: Omusati 0.220, Oshana 0.569, Ohangwena 0.321 and Kavango 0.670 which were less than 0.99 and hence highly polymorphic.

Gene frequencies were calculated by the direct method. An antigen is considered as a locus a where dominant gene is designated as + (positive): and recessive is designated as – (negative). The frequency of '-' is estimated to be the square root of the proportion of (-) alleles. And a locus at which the frequency of the most frequent allele is less than 0.99 is designated as polymorphic.

5.2.5.2. Genetic variability

Genetic variability within the population was quantified by measuring the heterozygosity (H) and average heterozygosity($\hat{H}$) is the probability that a random individual is heterozygous for any two alleles at a gene allele frequency Pi. Therefore average heterozygosity of individual chicken was estimated by using the following formula (Weir 1996):

Heterozygosity on the other hand = [Heterozygosity=1- [(frequency of +)^2+(frequency of-)^2] = $H=1-\Sigma pi^2$

(When the frequencies of alleles at a locus are respectively p1, …, pi, …, pn

n = the number of the alleles in the population concerned. .

5.2.5.3. Genetic distances

Principal of component analysis of SPSS version 17.0, 2007) was used for the analysis of the similarities and divergence among and between chicken from the four Northern regions. Principal of component analysis was applied to extract antisera that show variations among the chickens blood sample used for agglutination. The second step in PCA is to calculate eigen values, which defines the amount of total variations displayed on the PC axes which show clustering groups among the chickens from the four regions.

RESULTS AND DISCUSSION

5.3.0. Genetic frequencies

The number of alleles for each antigen locus in the population varied from 0.008 - 0.99 as shown in Table 5.1. The lowest allele frequency i.e. 0.008 was observed for antigen locus 6611and 1554. The range of polymorphic information content for 109 antigen (loci) were calculated as follow: Omusati 24/109=0.220, Oshana region 35/109= 0.569, Ohangwena region, 62/109 = 0.321 ad Kavango region 73/109=0.670 which were less than 0.99 and highly polymorphic

Table5.1. Frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region									
		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	−	+	−	+	−
1	8456	0.016	0.984	0.691	0.309	0.039	0.961	1	0
2	7443	0	1	0.066	0.934	0	1	0.673	0.327
3	7618	0.081	0.919	1	0	0.123	0.877	0.673	0.327
4	4321	0	1	0	1	0.019	0.981	0.465	0.535
5	6502	0	1	0.155	0.845	0	1	0.811	0.189
6	9267	0	1	0.083	0.917	0.01	0.99	0.673	0.327
7	4834	0	1	0.564	0.436	0.156	0.844	1	0
8	9259	0	1	0.066	0.934	0.019	0.981	0.577	0.423
9	565	0	1	0.066	0.934	0	1	0.5	0.5
10	6655	0	1	0.066	0.934	0	1	0.5	0.5
11	2088	0	1	0	1	0	1	0.319	0.681
12	4836	0.293	0.707	0.622	0.378	0.049	0.951	0.733	0.267
13	8-14	0	1	0.622	0.378	0.445	0.555	0.733	0.267
14	3158	0	1	0	1	0	1	0.293	0.707

Table 5.1.contd. Frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region									
		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	−	+	−	+	−
15	4844	0	1	0.109	0.891	0.01	0.99	0.537	0.463
16	5539	0	1	0.127	0.873	0	1	0.5	0.5
17	1761	0	1	0.223	0.777	0.01	0.99	0.537	0.463
18	9891	0	1	0.234	0.766	0	1	0.5	0.5
19	1608	0	1	0.155	0.845	0	1	0.5	0.5
20	1764	0	1	0	1	0	1	0.244	0.756
21	5101	0	1	0	1	0	1	0.244	0.756
22	3024	0	1	0.333	0.667	0.01	0.99	0.402	0.598
23	1315	0	1	0.024	0.976	0	1	0.293	0.707
24	1846	0.032	0.968	0	1	0	1	0.268	0.732
25	1472	0	1	0	1	0	1	0.221	0.779
26	6611	0	1	0.008	0.992	0	1	0.244	0.756
27	4316	0	1	0.265	0.735	0.029	0.971	0.465	0.535
28	4765	0	1	0.333	0.667	0.039	0.961	0.036	0.964
29	5188	0	1	0.333	0.667	0.01	0.99	0.198	0.802

continued

Table5.1.contd. Frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	−	+	−	+	−
30	9265	0	1	0	1	0	1	0.198	0.802
31	7602	0	1	0.109	0.891	0	1	0.373	0.627
32	9640	0.048	0.952	0.423	0.577	0.321	0.679	1	0
33	5791	0	1	0.118	0.882	0	1	0.345	0.655
34	716	0	1	0	1	0	1	0.176	0.824
35	5825	0	1	0.193	0.807	0	1	0	1
36	854	0.065	0.935	0.496	0.504	0.463	0.537	0.402	0.598
37	1760	0	1	0	1	0.039	0.961	0.198	0.802
38	360	0	1	0.193	0.807	0	1	0.155	0.845
39	3136	0	1	0.016	0.984	0	1	0.155	0.845
40	9990	0	1	0	1	0	1	0.114	0.886
41	5793	0	1	0.164	0.836	0.168	0.832	0.433	0.567
2	9772	0	1	0.083	0.917	0	1	0.221	0.779

Table5.1. contd. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	−	+	−	+	−
43	2293	0	1	0	1	0.091	0.909	0.198	0.802
44	3134	0.016	0.984	0	1	0	1	0.114	0.886
45	6710	0.152	0.848	0.244	0.756	0.101	0.899	0.5	0.5
46	6647	0	1	0.136	0.864	0.039	0.961	0.244	0.756
47	9387	0.065	0.935	0.203	0.797	0.029	0.971	0.268	0.732
48	5781	0	1	0.118	0.882	0	1	0.018	0.982
49	3140	0.388	0.612	0.718	0.282	0.35	0.65	0.622	0.378
50	273	0.016	0.984	0.146	0.854	0	1	0.074	0.926
51	6493	0	1	0	1	0	1	0.074	0.926
52	6497	0.315	0.685	0.496	0.504	0.203	0.797	0.465	0.535
53	1060	0	1	0.049	0.951	0.134	0.866	0.198	0.802
54	1991	0	1	0.091	0.909	0.091	0.909	0.244	0.756
55	1250	0	1	0	1	0.059	0.941	0.114	0.886
56	517	0.065	0.935	0.244	0.756	0.18	0.82	0.373	0.627

Continued

Table5.1. contd. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	−	+	−	+	−
57	8064	0	1	0.091	0.909	0	1	0.074	0.926
58	8154	0	1	0.024	0.976	0	1	0.094	0.906
59	1178	0.099	0.901	0.193	0.807	0.24	0.76	0.402	0.598
60	2096	0	1	0.041	0.959	0	1	0.094	0.906
61	6499	0	1	0.109	0.891	0.019	0.981	0.055	0.945
62	9645	0	1	0.057	0.943	0	1	0.094	0.906
63	9769	0	1	0.024	0.976	0.01	0.99	0.094	0.906
64	5304	0.032	0.968	0	1	0	1	0.055	0.945
65	5915	0	1	0	1	0	1	0.036	0.964
66	2857	0.19	0.81	0.423	0.577	0.307	0.693	0.244	0.756
67	7606	0	1	0.091	0.909	0.049	0.951	0.134	0.866
68	331	0.032	0.968	0	1	0	1	0	1
69	928	0.032	0.968	0.016	0.984	0	1	0.074	0.926
70	1427	0.081	0.919	0.234	0.766	0.24	0.76	0.244	0.756
71	9179	0.646	0.354	0.874	0.126	0.861	0.139	0.811	0.189

Continued

Table5.1. contd. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	−	+	−	+	−
72	8288	0	1	0.016	0.984	0.049	0.951	0	1
73	7599	0	1	0	1	0.01	0.99	0.036	0.964
74	3240	0	1	0.024	0.976	0	1	0	1
75	8681	0	1	0.024	0.976	0	1	0	1
76	611	0.25	0.75	0.244	0.756	0.24	0.76	0.402	0.598
77	4832	0	1	0	1	0.019	0.981	0.018	0.982
78	5011	0	1	0.016	0.984	0	1	0	1
97	3897	0	1	0	1	0	1	0	1
98	4667	0	1	0	1	0	1	0	1
99	4969	0	1	0	1	0	1	0	1
100	5141	0	1	0	1	0	1	0	1
101	5680	0	1	0	1	0	1	0	1
102	6795	0	1	0	1	0	1	0	1
103	7604	0	1	0	1	0	1	0	1
104	7699	0	1	0	1	0	1	0	1
105	8686	0	1	0	1	0	1	0	1

Continued

Table5.1. contd. Occurrences of frequencies of 109 chicken antigens in Namibia local chickens from the studied areas

Region		Oshana		Ohangwena		Omusati		Kavango	
No.	Antigen	+	−	+	No.	Antigen	+	−	+
106	9086	0	1	0	1	0	1	0	1
107	9232	0	1	0	1	0	1	0	1
108	9342	0	1	0	1	0	1	0	1
109	9343	0	1	0	1	0	1	0	1
Average Heterozygosity		0.0452		0.138		0.0718		0.2210	

5.3.1. Genetic Variability

Genetic variability of each population was quantified from the gene frequencies using 109 antigens. The heterozygosity values of each antigen locus were calculated for the entire 109 antigen in all the chickens' varieties from the four Northern Regions using values in Table 5.1. An example computing of heterozygosity at locus 8456 within Oshana chickens

H= 1-∑pi

Where H= Heterozygosity

P^i frequency of i^{th} allele

[Heterozygosity=1- [(frequency of +)^2+(frequency of-)^2] = [.0162)^2+(0.9842)^2]

=1-0.9685

=0.31488 heterozygosity

5.2.3. Average Heterozygosity

The results of average heterozygosity values for the antigen loci among the chicken are shown in Table 5.1. The average heterozygosity varied from 0.0452 to 0.2210 where 0.045 was for Oshana, 0.1383 for Ohangwena, 0.0718 for Omusati and the highest was 0.2210 for Kavango chickens. The average heterozygosity across all the regions was 0.119 indicating high level of genetic uniformity possibly due to inbreeding. The results of average heterozygosity obtained in the current study were similar with those reported by Tenabe *et al*. (1999) but lower than what were reported by (Van Koester *et al* 2008.). Muchadey *et al.* (2007) reported high percentage of average heterozygosity value of local chickens (Zimbabwe 64 -66%) for Malawi chickens 60.7%, for Sudan chickens 56.1%).

Heterozygosity for each antigen locus was computed using the formula;

$H=1-\sum Pi^2$

Average heterozygosity (Ĥ) across all 109 antigen loci was computed as follows;

$\hat{H} = 1-1/m\sum_l\sum$

M= number of antigen loci

where Pi = frequencies of i^{th} alleles.

H= Hetorzygosity

Ĥ= Average heterozygosit

M= number of antigen loci

Pli is the frequency of the ith allele at the lth locus

5.4.2. Genetic relationship of indigenous chickens in the four regions of Northern Namibia

The main objective of the present study was to evaluate genetic relationship among all the 175 chickens from the four regions of Northern Namibia (Oshana, Ohangwena, Omusati and Kavango). Principal component analysis (PCA) was used to extract 24 components that explained the variation in the data set Appendix 4. Out of the 24 components two were then used across the 85 antisera in order to find out which of them explains variation in the chicken population studied. Component 1 PCA1) scored 19% and component 2 (PCA2) explained 19% and 6%of the variation explained the two components were later called factor 1 and 2 on the graph and the value calculated Appendix 2 were used for the construction of a graph Fig 5.0.

The graph constructed based on the factor score by PCA revealed that chicken populations were assorted according to their geographical origin which were Omusati, Ohangwena Oshana and Kavango. In addition the results also indicate overlap between the regions. The dendogram showing the phylogenetic tree of the relationship among the 175 chickens chicken populations studied using Primer 5 statistical packages of is presented in Fig 5.0 provides a reasonable complete picture of genetic variability and population structure in the indigenous chickens in Northern Namibia. The 175 chickens were grouped in four clusters. The omusati chickens and Oshana chickens had a close genetic relationship and this indicates genetic similarities between the birds from the two localities. From the geographical perspective, Omusati and Oshana regions are in close proximity to each other in Northern Namibia therefore geographical element may explain the close relationship of the chickens for the regions. It was convenient for these two populations to mix with each other through marketing, gifts because there is a possibility for people in these two areas to be related to another.

Though the Ohangwena and Kavango regions are very near geographically, chickens from the two regions did not show close genetic relationship. Even within Kavango region chickens showed greater genetic diversities in agreement with the highest average heterozygosity (0.222) across loci. Some possible overlaps observed in this study, may be due to migration of people form one region to another. Generally farmers when moving from one area to another do move with all their belongings including chickens. Few studies of genetic differentiation in indigenous chicken especially in developing countries have been reported (Yamamoto *et al*.1996 and Wimmers *et al*.2002). A study of genetic variability by Yamamoto *et al.* (1998) revealed that there is genetic variation between Vietnamese chicken population and that of Asian indigenous chicken population where the geographical influence played a role.

Table5.2. Comparison of eigen values of first and second Principal components derived from the covariance matrix of 24anti sera.

Component	Extraction Sums of Squared Loadings		
	Total(eigen value)	% of Variance	Cumulative %
1	16.347	19.231	19.231
2	5.479	6.445	25.677
3	4.004	4.710	30.387
4	3.752	4.414	34.801
5	3.232	3.802	38.602
6	2.889	3.399	42.001
7	2.667	3.137	45.138
8	2.497	2.937	48.075
9	2.444	2.875	50.950
10	2.082	2.449	53.400
11	2.037	2.397	55.797
12	1.958	2.304	58.100
13	1.766	2.077	60.178
14	1.716	2.018	62.196
15	1.479	1.740	63.936
16	1.453	1.710	65.646

Table5.2. contd Comparison of eigen values of first and second Principal components derived from the covariance matrix of 175 indigenous chickens studied**.**

Component	Extraction Sums of Squared Loadings		
	Total(eigen value)	% of Variance	Cumulative %
17	1.429	1.681	67.327
18	1.361	1.602	68.929
19	1.312	1.543	70.472
20	1.259	1.481	71.953
21	1.220	1.435	73.388
22	1.160	1.365	74.753
23	1.072	1.261	76.014
24	1.019	1.199	77.213

The availability of genetic diversity is important for the present and future improvement and sustainability of indigenous chicken production systems (Benetez, 2002). Similarly, according to Yamamoto *et al.* (1998) the evaluation of indigenous chicken population as genetic resources includes the determinations of genetic distance between the available populations. As illustrated below genetic characterization is providing new information to help guide and prioritize conservation. For example conservation programs may put specific focus of *in situ* utilisation the wide diversity found in Kavango region.

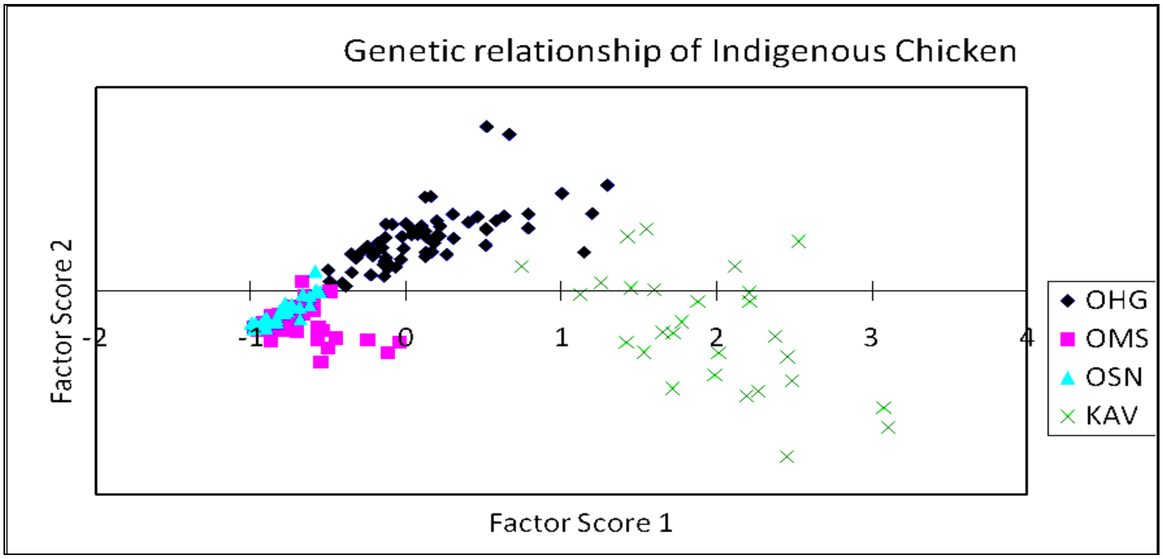

Fig5.0. Genetic relationship among and between indigenous chicken populations in studied areas.

Chickens in general have 13 blood systems which were discovered by several scholars in their respective studies (Briles *et al.*,1977; Briles (1984); and Dietert *et al.*. 1992). Of the 13 blood systems L system was common and is widely distributed among the Namibia chickens Table 5.3 with B - systems appearing only in few chickens in especially those from Kavango region. Alloantigen system *L* is a polymorphic protein expressed on the surface of chicken erythrocytes and possibly certain leukocyte subpopulations. Previous studies demonstrated that the *L* system affects Rous sarcoma out come and phagocytic functions.

Previous research has shown that allele combinations of the *L* system influence a range of immune responses including the fate of Rous sarcoma virus (RSV)- induced tumors (Le Page et al.200*0*), phagocytosis (Qureshi *et al*., 2000) and response to *Eimeria tenella* (Taylor and Briles, 2000). In chickens, the MHC is called the *B* complex and it was originally described as a system controlling blood group antigens (Briles *et al*., 1950). MHC or B -system is a region on chromosome which contains not only the genes for antigenic determinants on the cells, but also a number of other genes related to the immunological system.

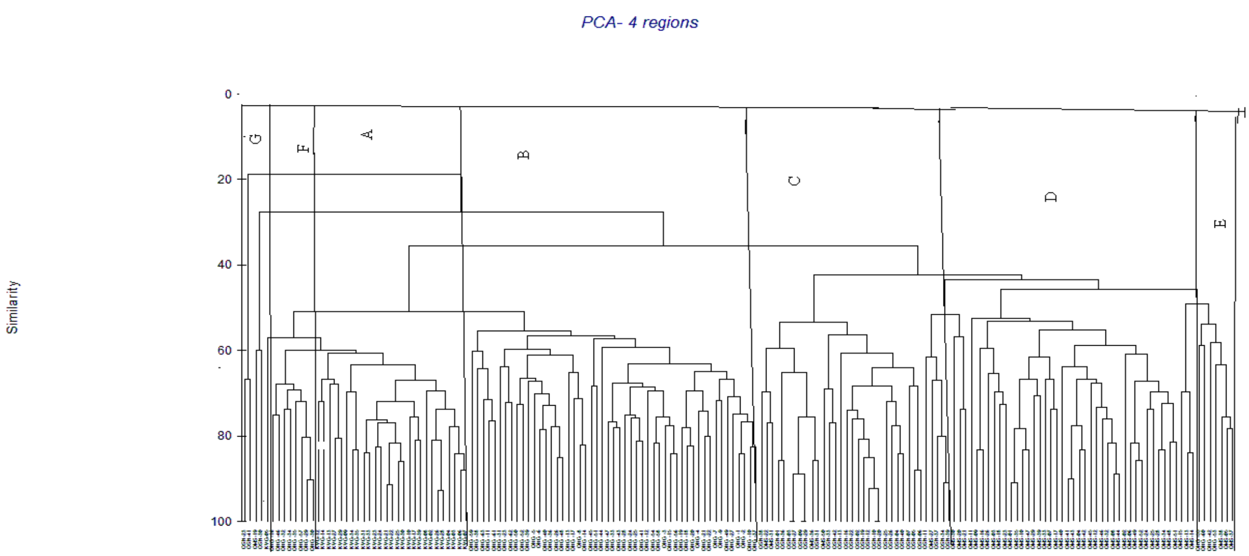

Fig 5.1. Phyllogenetic tree for the chickens in the four Northern regions

Definition A= Kavango chickens, B=ohangwena chickens, C=Oshana chickens

D=Omusati chickens , E=Combination of Omusati and Ohangwena chickens, F= Ohangwena chickens ,G=Combiantions of Ohangewna, Omusati and Kavango chickens

Table5.3. The frequency of occurrence of B and L system in the chicken from the four regions

Antigene	Regions							
	OMUSATI		OHANGWENA		OSHANA		KAVANGO	
	+	-	+	-	+	-	+	-
5680(BG 15)	0	52	0	32	0	63	0	28
5101(BF 15)	0	52	0	32	0	63	12	16
6611(BF 16)	0	52	0	32	0	63	12	16
928(BF16)	0	52	0	32	0	63	4	24
5141(BG 16)	0	52	0	32	0	63	0	28
5781(BF 19))	0	52	0	32	0	63	0	28
3897(BG 1)	0	52	0	32	0	63	0	28
9232(BF 1)	0	52	0	32	0	63	0	28
7699(BF 21)	0	52	0	32	0	63	0	28
449(L1)	46 (88.5%	6 (11.5%)	25 (78%)	7 (21.9%)	57 (90.5 %)	6 (9.5)	26 (92.8 %)	2 (7.1%)
1427(L2)	23 (44.2%).	29 (14.5%)	13 (40.6%)	19 (59.4%)	26 (41%)	37 (58.7%)	12 (42.9)	16 (57.1%)

CHAPTER SIX

6.0. Production performance of indigenous chickens under confined environment and fed four (4) dietary protein levels

6.1. Introduction

In Namibia like any other countries in Africa, indigenous chickens depend on scavenging resources which include kitchen left over, worms and whatever they can find in the surroundings. Elsewhere, they are invariably reported as scavengers, reared under free range with little or no feed supplementation (Mushraf, 1990). According to various investigators, indigenous chickens are characterized by low productivity due to lack of adequate nutrition, prevalence of disease and lack of adequate management (Sonaiya, 2004; Akinokun, 1990 and Nwosu, 1979). They are also regarded by many as an interesting tool to respond rapidly to rural poverty gaps. Feed remains the most important cost of animal production and nutrition in particular is one of the most critical constraints to poultry production under rural systems. A report from the villages of the central highlands of Ethiopia indicated that the protein and energy supplied from the scavenging feed resources (SFR), as determined from chemical analyses of crop contents of scavenging local hens, were on average 8.8% and 2864 kcal/kg, respectively (Deissie and Ogle, 2001).

The protein contents are even lower during the short rainy and dry seasons, while energy supply is more critical in the drier months (Tadelle and Ogle, 2000). These values were below the protein requirement of free ranging local hens of the tropics, estimated at about 11g/ bird /day, and ME supply could meet the requirement of a non-laying hen only (Scott et al., 1982), indicating limitations of the SFR in terms of nutrient supply to increased productivity. The nutrients intake of local chickens obtained through scavenging seem to be sufficient only for maintenance and low production. Dessie and Ogle (1996) suggested that in order to increase the indigenous chicken production, additional inputs are required. Housing conditions are important to protect the birds against diseases and predators, and also against adverse temperature, solar radiation, rain and chilling weather.

6.2. Hypotheses

Two hypotheses for this study were:

H0= Feed intake and growth rate increase when chickens are offered high protein compared to low protein level.

HA= Feed intake and growth rate do not increase when chickens are offered high protein compared to low protein level.

H0=Mortality is reduced when chickens are kept in confinement.

HA= Mortality is not reduced when chickens are kept in confinement.

6.3. Objectives

To compare the feed intake and growth performance of chickens fed on different levels of protein.

6.4. Methods and materials

6.4.1. Experiment procedure

6.4.2. Collection of experimental birds

The experiment was carried out from the first October 2007 to May 31st, 2008. A total of two hundred and four (204) young indigenous chickens aged between 2-7 days old of mixed sex were purchased from villages in Omusati and Oshana Regions. The collection of the chicks was completed within three days and the chicks were kept in the same pen until the last day of collection. The birds were then transported to Ogongo Agricultural College.

The chicks were weighed and their weights were recorded. On arrival at Ogongo Agricultural College, the chicks were provided with vita-stress (a medication against stress) in water. This vitamin was aimed at calming down the chicks because of the new environment in which they were to be raised. Feed consumption was recorded on weekly bases.

The average weekly feed intake (AWFI) by birds in all the treatment during the nine (9) months of feeding was investigated.

6.4.3. Management

The birds were housed in deep litter houses of 18 m^2 made of cement concrete and zinc sheet roofing. All the houses were naturally ventilated, throughout the experiment. Wood shavings were used as litter. Tubular metal hoppers 40 cm in diameter carrying 10 kg of feed were used as feeders. All the birds had permanent access to fresh water provided to them in round plastic basins, 15 cm deep and 25 cm in diameter. Feed troughs were cleaned and filled with feed once per day.

The first four weeks of the experiment was regarded as an acclimatization period. This was in order to achieve uniformity and stabilize the weights of the chicks. From the fifth week of rearing, the chicks were randomly allocated into twelve groups.

6.4.4. Experimental design

The experimental design was a factorial arrangement of treatments in a randomized complete block design, replicated four times. In the control group, the birds were fed commercial feed formulated for local chickens. Table 6.1 present the composition of the Starter, grower and layer diets. At the low level protein, the protein was 18% in the first rearing stage (start – 8 weeks), 16% in the second stage (8-22 weeks) and 12% in the third stage (22-36 weeks). At the high protein level, the protein was 23% in the first stage, 20% in the second stage and 16% in the third stage.

Analyses of feed were done by an Animal nutritionist at Feed Master Pty Limited in Windhoek and feeds in a raw form were bought from FEDCO Animal in Windhoek. The mixing of the raw materials was done in the Department of Animal Science, University of Namibia. Feeds ingredients used in the experiment are presented in Table6.0.

Table 6.0. Ingredients used in the experiment

	Experimental treatments				
Ingredients	Low protein level		High protein level		Control
	Starter	Grower	Starter	Grower	
Yellow maize	64.15	51.79	71.06	58.75	
Prime gluten	1.33	-	3.57	-	
Bran	-	10.0	-	10.0	
Hominy Chop	-	10.0	-	10.0	
Sunflower	15.0	15.0	-	5.96	
Import fish	12.41	8.29	11.97	6.61	
P21 Mono-calcium phosphorus	1.10	0.92	1.2	1.15	
Bentonite	4.75	2.69	10.74	6.10	
Limestone	1.18	1.06	1.24	1.13	
Sodium chloride	0.15	0.23	0.17	0.27	
Total	100	100	100	100	

6.4.5. Measurements and sampling

Measurements such as weight and food intake were taken on weekly basis. Mortality and any other abnormalities were recorded as they occurred

Survival in percentage, weight gain, and feed consumption (feed intake) and feed conversion ratios were calculated for each pen using the following formulae:

Survival (%) = Final number of birds in the treatment/ initial number of birds in the treatment x100

Weight gain (%) = Final mean average body weight –initial mean average body weight / initial mean average body weight x100. Average body weight was recorded at the beginning and then weekly up to the end of the experiment by using a spring balance.

Feed consumption (g) = (Amount of feed given - amount of feed left in the hopper and feed wastage) / number of birds in the pen. Mortalities were recorded as they occurred

6.4.6. Chemical analysis for the chicken carcasses

At the end of the experiment, two birds were selected from each treatment. Birds were individually weighed, slaughtered, de-feathered and eviscerated. Chemical analysis were performed on the breast with and without skin, and thigh with and without skin to determine, moisture, crude protein, calcium, phosphorous, ash and gross energy according to standard procedure of AOAC (1990).

6.4.7. Statistical Analysis

The outcome variables were subjected to one-way analysis of variance (ANOVA) using the SAS statistical package (SAS 1999).Genstat package for teaching purposes (option analyses of variance ANOVA) was also used where applicable.

Table6.1. Nutrient composition of the experimental diets

Nutrients	Unit	Starter(1-8 weeks)		Grower 8 -21 weeks)		Layers (22-32 weeks0	
		low	high	Low	High	low	High
Metabolizable Energy	MJ/KG	12.4	12.4	11.9	11.9	11.5	11.5
Protein	g/kg	160	20	140	180	150	180
Lysine	g/kg	8.26	10.33	6.72	8.64	6.67	7.76
Methionine	g/kg	4.00	3.17	3.17	4.08	3.45	4.14
Methionine+cystine	g/kg	6.67	8.5	5.60	7.20	6.03	7.23
Calcium	g/kg	10	10	8.5	8.5	3.8	3.8
Phosphorus	g/kg	4.4	4.4	3.9	3.9	3.5	3.5
Sodium	g/kg	1.8	1.8	1.8	1.8	2	2

RESULTS AND DISCUSSION

6.5.0. Comparisons of observed mortality of chickens across the three dietary protein level**s.**

Mortality affects the sustainability and productivity of the local chicken enterprises (Kugonza, *et a*l.2008). Mortality experienced among the indigenous chickens in the present study from 0 -32 weeks are presented in Table 6.2. The overall mortality experienced was 42.2% of the total number of chickens used in the whole experiment. The highest mortality occurred between weeks1- 8 of age. Between 9 -22 weeks, chicken mortality was reduced to 14.4% and to 5.6% between 22- 32 weeks. Visible disease symptom observed before chicks died during this period was diarrhoea. Furthermore, a few chicks from management system were sampled for further laboratory analysis at Ondangwa State Veterinary laboratory for post- mortem analysis. The post-mortem done on chickens carcasses that died during experiment did not find lesions associated with particular diseases. Mortality observed in the current study was mostly occurring at night time because chicks were found dead in the early morning hours. Factors such as cats and snakes predation also contributed to the chick mortality. Ogongo College is said to have a lot of snakes according to the residents there. Other causes of chicks' mortality might have been traumatisation due to new environments which include confined environment, feeding situation, mixing of chicks from different households and different villages, a sudden isolation of chicks from their mother. As a recommendation for future studies of this nature, the study suggests that the best way to rear chicks from early age is to use already weaned chicks or use chicks that are hatched on station using artificial incubation process. In some studies, (Okoye and Aba-Adulugba, 1998) mortality among the indigenous chickens was described as a result of an outbreak of bronchitis and infectious respiratory diseases. Velogenic Newcastle disease(ND) has been recognized as one major disease which kills large populations of these birds annually in Africa and Asia (Echeonwu *et al*,1993).Other possible reasons of bird deaths in this experiment were due to: trauma to new environments because indigenous chickens are naturally scavenges in their natural environment where they move freely; lack of motherly care during the experiment (free range chicks were used to their mother sitting on them providing them with warmth protection which they could no longer get).

Through observations, especially at night, chicks preferred to gather in a group especially in corners of the house and due to overcrowding some of the chicks died of suffocation. Furthermore, since these chicks were reared by different communities and in isolated villages, there was a problem of compatibility within the group. Similarly (Demeke, 2003) reported that the reason for high mortality of local chickens under intensive management was possibly due to the fact that they are not used to confinement. The reason for high mortality of local chickens under intensive management according to Tadelle Dessie and Ogle (1996) could be probably due to diseases which are important under confinement in Ethiopia, such as coccidiosis, chronic respiratory disease, Marek's disease, and *Salmonella pullorum* and nutritional deficiencies which could cause more serious problems in local than in exotic stock

Lack of interest in their environment, wing droppings, huddling at the corners, signs of leg weakness, and cannibalism were frequently seen among local chickens kept under intensive management. Some chicks were too nervous and this resulted in a pecking and cannibalism leading to mortalities due to injuries. The problems of cannibalism and pecking observed in this study, was also reported by of Savoy (1995) who blamed it on the deficiencies in essential amino acids. Pecking indigenous chickens according (Riber *et al.*, 2007) is thought to be a redirected foraging behaviour rather than a form of aggression, and may be due to the hens' mistaken perception of feathers as an appropriate foraging substrate.

Table6.2. Chicken mortalities during 1-32 weeks of age

Age of birds in weeks	Number of birds which died				
	Control	Low Protein	High Protein	Initial number of birds	Percent mortality
1 – 8	0	30	28	204	28.4
9 -21	12	6	3	146	14.4
22 – 32	6	1	0	125	5.6
Total	18	37	31	271	42.2

The tendency to feather peck in domestic fowl is also thought to be influenced by experiences early in life. Feather pecking has been shown to be negatively correlated with ground pecking, and it is thought that broody hens play a role in encouraging their chicks to explore their environment and perform ground-pecking behaviour (van Krimpen *et al.* (2005)

The percent loss or mortalities under intensive management reported in the current study was 42.2% which is higher than those reported in previous studies (Nwosu *et al.*, 1984; Pedersen, 2002; Demeke, 2003; Tadelle *et al*., 2003; Lwelamira and Katule, 2004). Mortality experienced in this study was during the 8th week of age comparable to that in chicks of three weeks old (Mopte *et al.*2009).

6.5. 2. Feed consumption

The trends of feed consumption by chickens in the experiment are presented in Fig 6.0**.** The birds in control group consumed significantly ($P< 0.05$) less feed than those fed with the high and low protein diet. This also evident in the intercept for the control compared to the other groups (Table 6.4). Birds fed low protein tend to eat more but with less weight gain as compared to those that were fed on high protein although no significant differences were observed. Boorman, (1979) reported that chickens in general will increase their feed intake in response to marginal level of first limiting feed nutrients, independent on the nutrient requirement of the diet energy level

The fitted regression model that gives the relationship between age and AWFI for the duration of the experiment in Table 6.3 and is calculated using follows

$Y_{ij} = b_o + b_i X_i$

Where Y_{ij} = predicted feed consumed (kg) by the k^{th} bird in the j^{th} week on i^{th} diet

X_i = age of the birds in weeks(j= 2,3,4,........32)

b_o = Intercept

b_i = estimated slope of the i^{th} diet (1= control,2 =low.3 =high)

It should be noted that sex was not included in the model because of confounding arising from lack of recording of individual feed consumption,

Table6.3. Least Square Mean (± s.e) in kg for feed consumption based on different dietary protein levels fed to indigenous chickens

Dietary level	Feed consumed /bird/week in (kgs)
Control	0.163±0.03 [a]
High	0.468± 0.013[a]
Low	0.536± 0.013[c]

The least square means in a column with the same superscript are not significantly different at (P<0.05)

Table 6.4. Regression coefficient of AWFI birds for the duration of 32 weeks of the experiment

Treatment	Regression equation	R^2
Low	0.425 +0.006X	$R^2 = 0.754$
High	0.431 +0.002X	$R^2 = 0.385$
Control	0.088 +0.002X	$R^2 = 0.801$

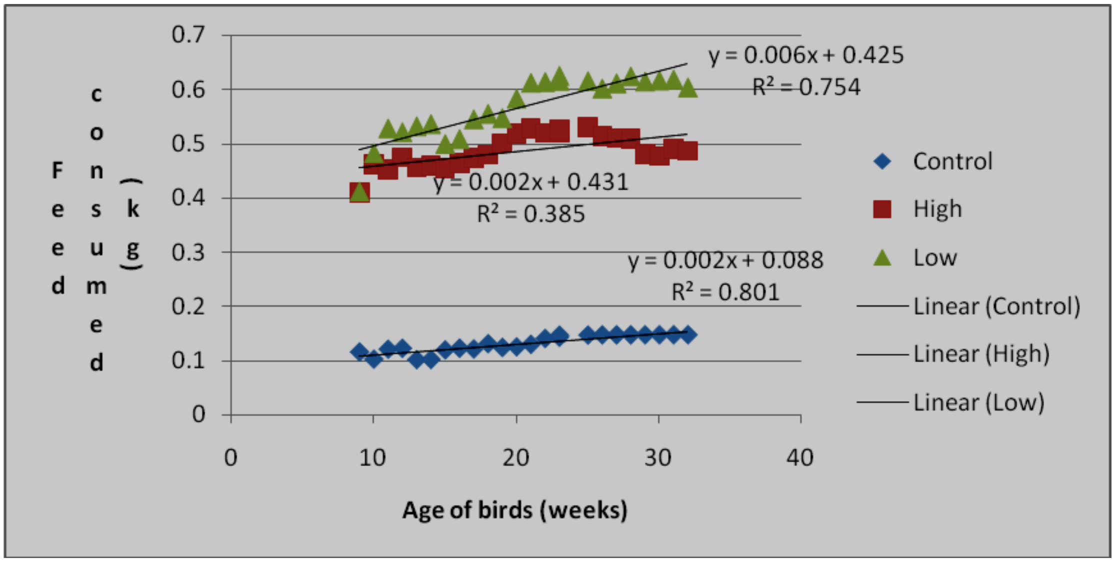

Fig 6.0. Feeds consumption trend in rural chickens

Emma and Fisher, (1986) also confirmed that appetite is dependent of on nutrient requirement of the animal and the content of those nutrient in the feed thus, indigenous chickens fed low protein level in current study consumed more feed in attempt to meet their requirements for those nutrients, which were limiting with decreasing dietary crude protein levels.

Moreover, Mbajiorgu (2010) observed that indigenous Venda chickens increased their feed intake with increase in feed energy level with decrease in feed protein which (Tadelle *et al*.,2000) blamed on genetic limitation. The author suggested that genetic influence of indigenous chicken on growth responses affect their nutritional requirements.

In the control group, where chickens were fed with grains mainly pearl millet, feed consumption was very low as compared to the two crude protein treatments of low and high. Ferket and Great (2006) reported that there are several factors that are responsible for low feed consumption in birds and these include; anti nutritional factors, low dietary vitamins and minerals, dietary protein and amino acids. Since these chickens were fed with unprocessed and unanalysed feed, it is concluded that factors that were mentioned by the previous authors may have played a responsible role for low consumption of feed be by the chickens.

Singh (2004) reported whole grains to be advantageous when fed to chickens, because it is believed they enhance gizzard function, which in turn may improve enzyme access to substrate particles. The same author suggested that when utilizing when whole pearl millet as feed for chickens it should be used at moderate levels of inclusion and by doing so there would no apparent effect on feed intake or egg production. As a food source (pearl millet), its crude protein and Lys content is higher than maize (Adeola and Rogler 1994; Singh, 2004) but its metabolizable energy is equal (Davis et al., 2003) or marginally lower than maize. Mehran *et al*. (2010) suggested that although pearl millet is a good source of energy and protein and could be used as a replacement feed (up to 75%) for maize in laying hen diets with no adverse effect on bird performance and egg quality. It is not advisable total replace maize with pearl millet because of reduced laying hen performance and feed efficiency.

Rate of passage may also be one of the possible causes of low feed consumption in the control group since the grains require more time to be digested fully before another feed is consumed again. Chicken is a monogastric animal and have shorter digestive tracks which require readily digestible materials.

Another observation was the existence of feather pecking order problem. During feeding, some birds prevented others from eating and made some weaker birds stay away from the feed. Feather pecking and cannibalism were observed in the early life chickens even though the study could not clearly point the actual factors that led to these behaviours.

According to Van Krimpen *et al.* (2005) feather pecking may be caused by factors that are related to either external factors like the genetic nature or the physiological status of the birds, or to external factors like housing conditions of the birds or nutritional factors or the combination of these. Another contributing factor to low feed consumption could be related to the quality of the feed used, particularly to the lower energy concentration as previously noticed (Smith 1999) for poultry diets in the tropics.

Feather pecking is thought to be a redirected foraging behaviour rather than a form of aggression, and may be due to the hens' mistaken perception of feathers as an appropriate foraging substrate (Riber *et al.*, 2007). In another study of van Krimpen et al.(2005) reported the tendency to feather peck in domestic fowl is as a result of influences experienced early in life through their mothers. The findings support the assumptions that broody hens play a role in encouraging their chicks to explore their environment and perform ground-pecking behaviour. In this respect, the results of the present study together with the information in the previous studies, suggest that feather pecking is positively correlated with ground pecking with the chicks as early one week old. Indigenous chickens sometimes have to survive solely on scavenging especially where farmers do not give supplement; therefore scratching becomes part of their life. During the survey, chicks together with their mother were seen scratching the ground in search of food. Cannibalism was also one the causes of chick mortality. Vent pecking was observed during the experiment and this in line with what was reported by Riddell (1991) and Appleby *et al.,* (1992). These authors described Vent-pecking (also called cloacal cannibalism) as one of the most common and severe forms of cannibalism in chickens.

Selection of bigger particles in the feed was also observed during feeding. Bathing of chickens in the feed especially when the birds were small was also observed. Variations in feed consumption can be explained by the nature of the birds themselves and it was r not very easy to precisely estimate the feed consumption by local birds due their feeding habit. Indigenous chickens by implication are scavengers and do a lot of scratching in search of food. Most often when feeds are poured in the hoppers, some birds jumped into hoppers and scratch them out on the floor where they continue eating and scratching at the same time. Feed poured out on floor are sometimes mixed up with feaces and ended up not been consumed or accounted for.

6.5. 14. Growth performance of indigenous chickens in the confined conditions

Growth is defined as an increase in entire body, body parts or individual organ unit size per unit time (Yang *et al*., 2006). Body growth is influenced by genotype of the birds, by nutrition, tissue specific regulatory factors, as well as other aspects of the feed (Car1son, 1969).Low protein reduces growth as a consequence of depressed appetite and thus reduces intake of nutrients (Campel and Taverner, 1988).The depression in feed intake is regarded as responsible for the retarded growth chickens (Kingori et al., 2003). In this study, chickens fed with low protein had low body weight as compared to those fed with high protein level. Equally chickens fed with grains showed retarded growth. However, in the report of (Bikker *et al*. (1994) suggested that protein deficiency reduces growth while feeding above protein requirement does not increase the growth.

Results of the present study are in agreement with (Hocking 1990, Yaisle and Lilburn (1998) who in their study concluded that the higher protein content in the feed, the higher is their body weight of an animal. Malheiros *et al.* (2003) also observed that chickens fed on low crude protein diet showed a reduction in body weight.. Protein deficiency in feed reduces growth as a result of depressed appetite and intake of nutrients. According to Harper and Rodger (1965) when there is dietary protein deficit in the feed, the free amino acid patterns of both muscles and plasma become imbalanced and consequently trigger the appetite regulating system to reduce fed intake.

This may be a scenario when free range growers receive inadequate supply of protein or utilize diet with imbalanced ratio or proportion of amino acid.

Live weight and growth curve of indigenous chickens fed different levels (low, high and control) from 9-32 weeks obtained in the study are given in Fig.6.1. The live weight of the chicken at 25 weeks were slightly higher than those reported or indigenous chickens in Sri Lanka(1516g) (Gunaratne *et al.,* 1993) and in Kenya (1800- 1964)g (Kingori *et al.,*2007).

The differences in the weights reported for the indigenous chickens by different authors may be due to differences in their nutritional (whether offered protein supplementation or not). Indigenous chickens normally have lower growth rate and mature body weight as compared to commercial growers but with protein supplementation, they might attain improved growth rates. In the current study, live body of a mature chicken measured up to 2 kg especially those that were fed on high protein level and 1.8kg in chicken fed on low protein diet. Chickens in the control group grew very slowly.

In adult birds, after the completion of ossification period and growth, the effect of dietary CP level on body weight was not remarkable. Statistically birds continuously fed high and low dietary protein levels had significantly ($P< 0.001$) faster growth rates than those birds in control group Table 6.5 This also in line with the result of Jackson *et al*., (1982) who stated that increased dietary protein content result in improved growth performance of chickens. There was a significant difference ($P<0.05$) in growth rate where chicken fed on a high protein diet showed an increase in body weight between the 11th and 15th weeks while the reverse was the case in chickens fed on low dietary protein level. However, the growth rate of the two groups became similar after week 15.

Table 6.5. Regression coefficients of body weight on age of bird for chickens feed diets of varying protein levels

Treatment	Regression equation	R^2
Low	1.087+0.032X	0.94
High	1.199 + 0.028X	0.879
Control	0.725+ 0.018X	0.712

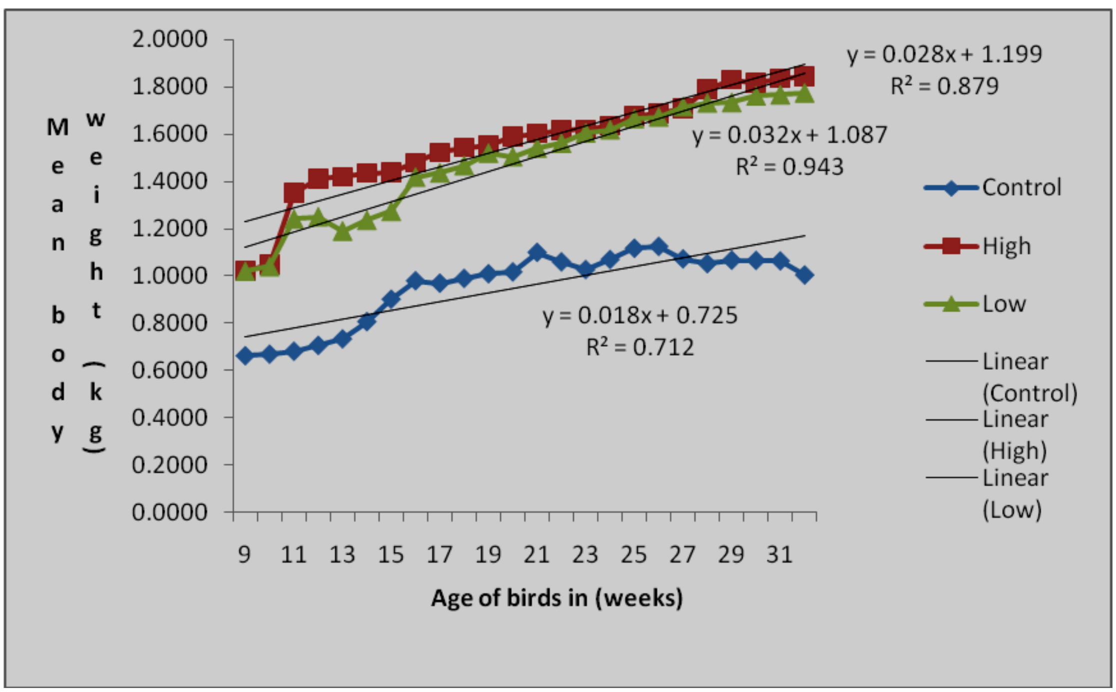

Fig 6.1. Mean body weight versus the age of birds (9 – 32 weeks) for the three dietary treatments.

In Table 6.5 above, it is observed that different treatments gave different reposes in growth rate. Table 6.6 below presents the least square means of body weights for chickens on different diets. The body weights in the control group were significantly ($P<.05$) lower.

The uneven growth trends displayed by birds in the experiment could be blamed or caused first by high chick mortality that occurred in all the treatments during the experiment. Secondly, the random allocation of birds to the pens at the beginning of the experiment might also have resulted in disproportionate number of male birds in the pens which would influence the mean weight observed in this study. When allocation of chicks to different treatments was done, some birds could not be easily identified as to whether they were males or females and this resulted in disproportionate number of males in some pens.

Table6.6. Least of square means and standard error of difference in body weight of chickens fed on different level of protein

Protein level	LSM±SED
Control	0.968 ± 0.086^{a}
Low	1.503 ± 0.086^{b}
High	1.506 ± 0.086^{b}

Means with the same superscript are not significantly different at ($p<0.05$)

Thirdly, the infighting of males in pens may also have influenced the mean weight of the birds. Differences in the severity of protein restriction may also perhaps be responsible for the variations observed. Finally, age, sex genotype and their interactive may also have contributed to the uneven body weight distribution among the experimental birds.

6.5.15. Carcass characteristics

Several studies have been conducted concerning the relationship between dietary and nutrients body composition (Negesse and Tera 2009). Body composition of any living organism is affected by many factors like strain, sex, age, quantity of the dietary CP, slaughter and sampling methods and environmental conditions. In this experiment, the effect of protein levels on nutrient composition (moisture, crude protein, calcium, phosphorous, ash and gross energy) of the breast meat in broilers was evaluated using fish meal as main source of protein.

Currently, there are no studies concerning the relationship between the dietary and body compositions of chickens in Namibia. The evaluation of carcass composition Table 6.7 could be important in understanding how different parts of chicken body retain the nutrients they are fed on. In this study, the amount of ash and crude protein content in chicken carcasses was significantly (P< 002) influenced by protein level in the feed. Proteins are the major component of dry matter of meat and the protein content in muscles is variable and depends on the function of a particular tissue (Ingr, 1996). Results show that the higher the protein in the feed, the higher the protein retention in the carcass and this implies a resultant improvement in the quantity quality of protein in the carcasses.

As shown in Table 6.7 protein content are 22% for birds in low and control and 25% in birds fed on high protein diet. Protein per cent found in this study slightly higher than those of Suchý1 et al. (2000) who reported that content of proteins in muscles ranges between 18 and 22%. Model used for CP analysis =0.402 for ash R^2 =0.44 and for GE R^2 =0.512

The same authors claimed that proteins are the most important components of meat from a nutritional point of view and technological aspects. Germain *et al*. (2004) reported that traditional African chickens are richer in protein content than Rhode Island which is an exotic breed

Table 6.7. Least Squares Means (± s.e) of nutrients composition of carcasses of chickens fed different diets

Nutrient	LSM±SE
Moisture	
Control	1.104± 0.022a
Low	1.029± 0.022[a]
High	0.980± 0.022[b]
Calcium(ca)	
Control	0.010 ± 0.005[a]
Low	0.023±0.005[b]
High	0.029±0.005[c]

Table 6.7 cont. Least Squares Means (± s.e) of nutrients composition of carcasses of chickens fed different diets

Nutrient		LSM±SE
Ash		
Control		1.104±0.021
Low		1.029±0.021
High		0.980±0.021
Gross Energy (GE)	Body parts	
	Breast	22.732±0.359
	Thigh	24.030±0.359
	Skin parts With skin	
	Breast	22.417±0.359
	Thigh	24.389±0.359

Muscle growth is one of the most important factors in poultry meat production. The breast, thigh and drumstick are the components yielding most of the meat and the portions that are mostly consumed (Broadbent *et al.*, 1981).The analyses have shown that breast and thigh muscles differ in the content of individual elements. Our results found, the protein content in chicken breast muscles ranges from 22.5 to 22.6%. Therefore chicken meat can be classified as a high-protein meat. Lower content of proteins (18.3–19.1%) was found in thigh muscles. These differences in protein contents between breast and thigh muscles are in agreement with findings of Chambers, (1990), who reported that muscles differ in the content of proteins, which could result from different functions of particular muscle tissues.

Thigh muscles have a higher content of Calcium (Ca) in carcass was neared to significant = 0.56. Significant differences exist in level of energy in the thigh as compare to the breast. Gross energy in the carcass was significantly P= 0.015 differed between breast and thigh. There was also a significant ($P<0.001$) difference in Gross energy between carcasses that had skin and those whose skin has been removed Table 6.7.

CHAPTER SEVEN

7.0. Conclusion

Rural farmers are faced with a lot of challenges in rearing chickens. Some of these are proper feeding (in terms of quality and quantity), housing and mortality due to diseases and predators. Lack of adequate health should be addressed by providing rural farmers with animal health services and technical training through the veterinary directorate, construction of proper chicken houses using locally available materials that are affordable to the rural farmers. This research has also demonstrated that indigenous chickens represent a pool of heterogeneous individuals that largely differ in morphology and genetic traits some of which are important in diseases resistance. It was observed that sick chickens are consumed, hence it was concluded that rural farmers should be sensitized on the risk of consuming meat from sick animals. The obtained results evidence a possible utilisation of the used of blood typing method as an alternative to genomic analyses using molecular markers in the field of gene characterization studies. However, this method is outdated and may not be précised as the contemporary methods e.g molecular markers. The chickens are mainly marketed alive and this presents many challenges with regard to transportation. Despite their importance, the study has revealed that indigenous chickens in Namibia were accorded very little attention by their owners who regarded them as secondary to other farming activities for example crop production and livestock.The chickens are mainly marketed alive and this presents many challenges with regard to transportation. Despite their importance, the study has revealed that indigenous chickens in Namibia were accorded very little attention by their owners who regarded them as secondary to other farming activities for example crop production and livestock rearing, especially ruminant animals. Secondly, livestock researchers and veterinary services put greater emphasis on ruminant animals at the expense of chickens and other small stock. Information on the genetic make-up of the Namibian chicken is also not available.

The external characteristics of indigenous chickens in the four Northern Namibia regions revealed the absence of autosomal dominant gene I that shows white plumage colour. Hence the study concluded that white leghorn might not have been introduced into northern Namibia. Furthermore, it was observed that not all the chickens in the study areas carried all B blood group types especially types 15,16 and 21 and only few chickens in Ohangwena and Kavango have type B19.

Therefore, it was concluded that indigenous Namibia chickens in the studied areas have acquired different B types that fit under rural poor management system. of antigens for assessing genetic variation and divergence of local chicken strains and population Information made available indicates that quantity, quality and availability of scavengeable resource base depend on season and grains availability in the household. The current study demonstrated that indigenous chickens performed well under intensive production and this indicates that there is a chance for better performance if proper management is employed including proper designed of feeders that will help to minimize feed wastage.

Recommendations

Since this study is the first of its kind, results can serve as an initial step to plan the characterization and conservation of native chickens in Namibia and for this to take place the study recommend some further study to be carried out in other parts of the country order to have a national picture of genetic diversity of indigenous chicken for the whole Namibia.

Cost of feed associated with feed wastage due to the behavioural characteristics discussed in chapter 5 does not warrant farmers adopting the rearing of indigenous chickens under confinent environment because it is not economically feasible, hence farmers should be advised to continue providing their chickens with cheap and locally available supplement on regular bases.

To improve the productivity of indigenous chickens, in rural areas there is a need address all factors contributing to low productive in a holistic manners.

7.2 Limitations of the study

There were some limitations that may have impacted negatively on the results in the study. These include:

7.2.1. Inability to sex the chicks hence biases in estimate especially in feed intake and body weight gains.

7.2.2 High chick mortality rate.

7.2.3. The researchers had difficulty in getting precise numbers of chickens per household and other production information due to lack of recoding.

7.2.4. Conservation

In most households, the retention of significant numbers of indigenous birds in the rural regions has been ensured by their demonstrated capacity to survive and produce under relatively harsh scavenging conditions with very low level inputs, and the preference given to their meat and eggs by the local populace, both in the rural regions and in the cities and towns. *In-situ* conservation programs should be prioritised in the Kavango region because of their distinctiveness from those of other regions.

7.3. Further research suggested

To aid in *in-situ* conservation programs it is imperative that effort be made to improve productivity of local chickens. Initial focus should be on investigation of disease prevalence in the rural areas and how mortality could effectively be reduced. Furthermore, more precise characterization of indigenous chickens using DNA based markers (eg.RFLPs, microsatallites, SNPs) would enable identification of unique strains to be prioritized in conservation programs.

REFERNCES

AACMC (Australian Agricultural Consulting & Management Company). 1984 Livestock sub sector review, Volume 1, Annex 3.

Abasht, B., J.C. M., Dekkers, and S.J. Lamont, 2006. Review of Quantitative Trait Loci Identified in the Chicken. Poult Sci 2006.85:2079-2096. Available at http://ps.fass.org/cgi/content/full/85/12/2079#T3 access 12-06 2009

Abdelqader, A., C.B.A. Wollny, and M. Gauly, 2007. Characterization of local chickens' production systems and their potential under different levels of management practice in Jordan Tropical Animal Health Production 39:155–164

Abubakar, M.B, A.G., Ambali, and T. Tamjdo, 2007. Rural Chicken Production: Effects of Gender on Ownership, and Management Responsibilities in Some Parts of Nigeria and Cameroon. Poult. Sci. 6: 413-416

Adedeji, T.A., O,A. Adebambo, S.O Peters, L.O. Ojedapo, and A.O Ige, 2006. Growth performance of crossbred and purebred chickens resulting from different sire strains in a humid tropical environment, Journal of Animal and Veterinary Advance, 5: pp 674 – 678

Adegbola, A.A., 1988. The structures and problems of poultry industry in Africa. In: Proceedings, 18th World Poultry Congress, Nagoya, Japan, 4–9 September 1988

Adene, D. F., 1990. The management and health problems of rural poultry stock in Nigeria. CTA-Seminar proceedings on smallholder rural poultry production. 9-13 October 1990, Thessloniki, Greece, 2:175-182.

Adeola, O., J.C. Rogler, and T.W. Sullivan. 1994. Metabolism and nutrition: pearl millet in diets of White Pekin ducks. Poultry Sci. 73:425-435.

Agbedé, G.B., A. Tegui and Y. Manjil, 1995. Enquête sur l'élevage traditionnel volailles au Cameroun Tropicultura, 13:22-24.

Ahlers, C, R. Alders, B. Bagnol, A.B., Cambaza , M. Harun , Mgomezulu, H. Msami , B. Pym, P.Wegener, E. Wethli, and M.Young, 2009. Improving village chicken production: A manual for field workers and trainers. ACIAR Monograph No. 139. Australian Centre for International Agricultural Research, Canberra. Available at Http://www.aciar.gov.au/publication /MN139 date accessed 12- 11- 2010.

Aini I., 1990. Indigenous chicken production in South-east-Asia. World's Poultry Science Journal, 46: 51-57

Akinokun, O., 1990. An evaluation of exotic and indigenous chickens as genetic materials for development of rural poultry production in Africa. In: E. B. Somaiya (Ed.) *Rural Poultry In Africa* (pp. 56- 61). Ile-Ife: African Network on Rural Poultry Development

Aklilu,H.A. C.J. M. Almekinders, H.M.,J Udo,. and A.J.Van der Zijpp, 2007. Village poultry consumption and market in relation to gender, religious festivals and market access.Trop Anim Health Prod 39:165–177. Published Online on 5 April 2007. Springer Science and Business Media B.V. Available at http://www.aseanfood.info./article/11019586.pdf.accessed 07-09-2008

Aklobessi,K.K.,1990. Smallholder rural poultry production. In: CTA Seminar proceedings, volume2, Smallholder Rural Poultry Production, Thessaloniki, Greece, PP 237 – 242.

Alders, R.G, and P.B. Sprdbrowed, 2000. SADAC planning workshop on Newcastle Disease Control in Village Chickens. Proceedings of an International Workshop, Moputo, Mozabique, 5 – 9 March (2000). ACIR Proceedings Number 103, pp 76 – 79

Alders, R., B., Bagnol, M., Haruna, M and Young, 2007. Village poultry, food security and HIV/AIDS mitigation. LEISA Magazine 23 3 Septembre 2007. 20-21.

http://www.leisa.info/index.php?url=getblob.php&o_id=191135&a_id=211&a_seq=0 accessed 03 -12 -2008

Alders R.G. and R.A.E. Pym, 2009. Village poultry: still important to millions, eight thousand years after domestication. .World's Poult Sci., 65:181-190

Alemu, Y., 1995. Poultry Production in Ethiopia. World's Poult. Sci. 51:197-200.

Alemu, Y. and D. Tadelle. 1997. The Status Of Poultry Research And Development In Ethiopia. Research bulletin No. 4, Debre Zeit, Ethiopia**.**

Andrews, P., 1990. Rural Poultry Development in the Gambia. Proceedings CTA International Seminar on Smallholder Rural Poultry Production, Thessaloniki, Greece, Oct. 9-13.Vol. 2, pp. 81-86

Antwi. A1993.Effects of storage conditions on hatchability of chicken eggs in a warm climate British Poult Sci., 34: 911 – 914

AOAC.,199O. Association Of Analytical Chemists. Official Methods of Analysis (15th ed) AOAC, Washington, DC.

Appleby, M. C., B. O. Hughes, and H. A. Elson, 1992. Page 238 *In*: Poultry Production Systems: Behaviour, Management,and Welfare. CAB International, London, UK.

Australia Agricultural consulting and management company (AACMC) (1984) Livestock Sub- sector Review volume 1 Annex 3

Awuni, J.A. 1989. Strategies for the improvement of rural chickens Production in Ghana.In: *Characteristics and Parameters in Family Poultry Production in Africa*, (IAEA) Vienna . http://www-naweb.iaea.org/nafa/aph/public/4-strategies-awuni.pdf accessed 12- 07- 2006

Badubi, SS, M .Rakereng and M Marumo 2006. Morphological characteristics and feed resources available for indigenous chickens in Botswana.Livestock Research for Rural Development 18 (1) 2006.Available at. http://www.cipav.org.co/lrrd/ lrrd18/1/badu18003.htm.

Bagust, T.J., 1994. Improving health for a poultry industry in Asia: a developmental perspective. Avian pathology,23: 395–404

Baeza, E., N. Williams, D. Guemene and M.J. Duclos, 2001. Sexual dimorphism for growth in Muskovy duck and changes in insulin-like growth factor I (IGF- I), growth hormone (GH) and triiodothyronine (T3) plasma levels. Reprod. Dev. 41: 173-179.

Bagust, T.J., 1999. Village free-range poultry in health and disease. Commonwealth Veterinary Association: Regional workshop on livestock production in the South Pacific Islands 27-30 October 1999.

Barua, A. and Y. Yoshimura, 1997. Rural poultry keeping Bangladesh. World Poultry Sci. J. 53: 387 – 394.

Bell, J.G. and Abdou, I., 1995. Dynamics of village poultry production in the Keita region of Niger. Nigerian J. Anim. Prod. 22: 141-144.

Benabdeljelil, K. and T. Arfaoui, 2001. Characterisation of Beldi chicken and turkeys in rural poultry flocks of Morocco.Current state and future outlook. Animal Genetic Resource Information, 31, 87–95

Benitez, F., 2002. Reasons for the use and conservation of some local Genetic Resources in poultry IN: Proc.7yh World Cong. Genetic Applied Livestock Production. August 19-23, 2002. Montpelier, France.

Bikker, P. M.W.A. Vestrgen, S.Tamminga, 1994. Partitioning of dietary nitrogen between body component and and waste in your pigs. North J. Agric.Sci 42; 35-45.

Boonyanuwat K., S.Thummabutra, N.Sookmanee , V.Vatchavalkhu, V.Siripholvat, T.Mitsuhashi , 2006. Influences of MHC class II haplotypes on avian influenza traits in the Thai indigenous chickens. Journal . Poult. Sci. 43: 120-125.Available athttp://www.apeiresearch.net/document_file/document_20070808015128-1.pdf accessed 12-06-2007

Boorman, K.N., 1979. Regulation of Protein and Amino Acid Intake. In: Food Intake Regulation in Poultry, Boorman, K.N. and B.M. Freeman (Eds.). British Poultry Science Ltd., Edinburgh, UK., pp: 87-125

Boye, C., 1990. L'aviculture au Sénégal: caractéristiques, contraintes et perspectives de développement. In: CTA Seminar Proceedings, Vol. 2, Smallholder Rural Poultry Production, 9-13 October 1990,Thessaloniki, Greece, pp. 199-204.

Branckaert, R .D. S. and E.F.F. Guèye, 1999. FAO's programme for support to family poultry production. In: Poultry as a Tool in poverty Eradication and Promotion of Gender Equality Proceedings of a Workshop., Tune, Denmark 22-26 March, 1999 . http://www.husdyr.kvl.dk/htm/php/tune99/24-Branckaert.htm accessed 08-09-2004

Branckaert, R.D.S,. 2007. Avian influenza: the new challenge for family poultry.World's Poult. Sci. 63:129-131.

Briles, W.E.1960. Blood groups in chickens, their nature and utilization. World Poultry Scie. J. 16:223 242 reprint

Briles, W.E., 1952. Additional blood group systems in chicken Ann.Y.Y. Acad.Sci.97: 166 – 172

Briles, W. E., W. H. McGibbon, and M. R. Irwin, 1950. On multiple alleles affecting cellular antigens in the chicken. Genetics35:633–652.

Briles, W. E., R. H. A. Stone, and R. K. Cole, 1977. Marek's disease: Effects of B histocompatibility alloalleles in resistant and susceptible chicken lines. Science 195:193–195.

Broadbent, A B. J. Wilson, C. Fisher, 1981. The composition of the broiler chicken at 56 days of age: Output, components and chemical composition. *British Poultry Science*, 1466-1799, 22: 385 – 390.

Buyse, J., E. L., E.R.K. Decuypere, Berghman,. KÃ¼hn and F. Vandesande, 1992. Effect of dietary protein content on episodic growth hormone secretion and on heat production of male broiler chickens. Br. Poult. Sci., 33: 1101-1109.

Chambers, J.R., 1990. Genetics of growth and meat production in chickens. R.D. Crawford, (Eds.).Elsevier, Amsterdam, The Netherlands. Poult. breeding and genetics, 559-643.

Campbell, R.G. and M.R. Taverne, 1988. Genotype and sex effects on the relationship between energy intake and protein deposition in growing pigs. J. Anim. Sci. 66, 676-686.

Campbell, K.L.I., Garforth, C., Heffernan, C., Morton, J., Paterson, R., Rymer, C, and Upton, M. (2006). Smallstock in Development, *CD-ROM*. DFID Livestock Production Programme, Natural Resources International Ltd, Aylesford, Kent, UK. ISBN: 0-9546452-8-6available at http://www.smalstock.info/issues/diversity.htm accessed 12-04 -2008

Carlson, I.R., 1969. Growth regulators. In: Animal growth and nutrition. Eds. Hafez, E.S.E. & Dryer, I.A. Publishers: Lea & Febiger, Philadelphia, USA. pp. 138-155.

Carter, G. F., 1971. Pre-Columbian chickens in America. In: Riley, C. L., Kelley, J. C., Pennington, C.W., and Rands, R. L. (eds.), Man Across the Sea: Problems of Pre-Columbian Contacts, Austin: University of Texas Press, pp. 78–218.

Cheng, H.H., Levin, I., Vallejo, R.L., Khatib, H., Dodgson, J.B., Crittenden, L.B and J. Hillel, 1991. Development of a genetic map of the chicken with markers of high utility. Poult. Sci. 74:1855-1874.

Chivunduka , D.M., 1976. Plants regarded by Africans as being of medical value to Animals Rhodesian Veterinary Journal, 7: 6-12.

Crawford, R.D., 1984. Domestic fowl: In CC Manson (Ed.).Evolution of domesticated animals. Longman, London. pp 298-302.

Cuc N.T.K., F.C Muchadeyi, U. Baulain, H. Eding, S. Weigend, and C.B.A Wollny, 2006. An assessment of genetic diversity of Vietnamese H'mong chickens International Journal of Poultry Science 5: 912-920

Cumming, R.B., 1992. Newcastle Disease research at the University of New England. *Newcastle Disease in village chickens.* Ed. P. Spradbrow. Proc. 39 ACIAR. Canberra. Pp 84-91

Damerow, G., 1994. The chickens health hand book. North Adams, Massachusetts pp1-344

Davis, A.J., N.M. Dale, and F.J. Ferreira. 2003. Pearl millet as an alternative feed ingredient in broiler diets. J. Appl. Poult. Res. 12:137–144.

Deeb, N. and A. Cahaner, 1999. The effects of naked neck genotypes, ambient temperature and feeding status and their interactions on body temperature and performance of broilers. Poultry Science, 78: pp1341 – 1346.

Deeb, N. and A. Cahaner, 2001. Genotype by Environment Interaction with Broiler Genotypes Differing in Growth Rate.1. The Effects of High Ambient Temperature and Naked- Neck Genotype on Lines Differing in Genetic Background. Poultry Sc.79:695-702

Demeke, S., 2003**.** Growth performance and survival of Local and White Leghorn chickens under scavenging and intensive systems of management in Ethiopia . Livestock Research for Rural Development 15 (11). Retrieved September 23, 2010, from http://www.lrrd.org/lrrd15/11/deme1511.htm

Deeming, D. C., and M.W.J. Ferguso, 1991. Physiological effects of incubation temperature on embryonic development in reptiles and birds. in Egg Incubation. D. C. Deeming and M. J. W. Ferguson, ed. Cambridge University Press, Cambridge, UK. 147–172

Dessie, T., 1996. Studies on village poultry production systems in the central highlands of Ethiopia Mc.Sc .Thesis , Swedish University of Agricultural Science, Uppsala, Sweden.

Dessie, T. and B. Ogle, 1996. Studies on Village Poultry Production in the Central Highlands of Ethiopia. Workshop proceedings, Tune Landboskole, Denmark.

http://www.husdyr.kvl.dk/htm/php/tune96/7tessier.htm accessed 02-209-2005

Dessie T. and B.Ogle 2001. Village poultry production system in the Central Highlands of Ethiopia. *Trop Anim Health Prod*, 33, 521–537, 2001.

Dietert, M.F., F. Robert, Taylor Jr. and R.D. Rodney, 1992. Avian Blood Groups. Poult Sci. Rev.4: 87-105

Dolberg F., 2001. A Livestock Development Approach that Contributes to Poverty Alleviation and Widespread Improvement of Nutrition Among the Poor. Livestock Research for Rural Development: http://www.cipav.org.co/lrrd/lrrd13/5/dolb135.htm accessed 09-11-2005.

Duguma, R., 2006. Phenotypic characterization of some indigenous chicken ecotypes of Ethiopia. Livestock Research for Rural Development 18: 2006. http://www.lrrd.org/lrrd18/9/dugu18131.htma accessed 14-06 2007

Ebangi, A.L. and S.N. Ib, 1994. Heritabilities of and genetic correlation between some growth traits in Nigeria local chickens. Nigeria J. Anim. Prod. 21: 19- 24.

Echeonwu, G.O.N., C.U. Iroegbu,A.C. Emeruwa, 1993. Recovery free-roaming birds in Nigeria. *Avian Pathology, 22,* 383-387.

Ekue, F. N., K.D.Pone, M. J,. Mafeni, A. N. and J. Njoya. 2002. Survey of the traditional poultry production system in the Bamenda area, Cameroon. In : Characteristics and Parameters of Family Poultry Production in Africa. FAO/IAEA. IAEA Vienna. retrieved 2005http://www.iaea.or.at/programmes/nafa/d3/public/2-survey-ekue.pdf accessed 12-03-2005

El Houadfi, M,. 1990. Report sur la production avicole et problems lies aux elevages traditional au Maroc.In: CTA Seminar proceedings, volume2, Smallholder Rural Poultry Production, Thessaloniki, Greece, pp 161-171.

Emmans, G.C. and C. Fisher, 1986. Problems in Nutritional Theory. In: Nutrient Requirements of Poultry and Nutritional Research, Fisher, C. and K.N. Boorman (Eds.). Butterworths, London, pp: 9-39.

Ensminger, E. M. 1992. Poultry science: animal agriculture Series. 3rd edition, Interstate Publishers, Inc. Denville, Illinois, pp 65-93.

Faranisi, A.T.,1995. Poultry breeding in Zimbabwe. In: Proceedings of the International Symposium on Livestock Production Through Animal Breeding and Genetics. Edited by Dzama, K Ngwerume F.N. and Bhebhe E. University of Zimbabwe May 10 -11 1995.

Farrell, D. J. 2000. .The energy and protein needs of Scavenging laying hen. Livestock Research for Rural Development.(http://www.cipav.org.co/Irrd12/4/farr124.htm accessed 03-11- 2006

Fayeye, T.R., A.B. Adeshiyan, AA Olugbami, 2005. Egg traits, hatchability and early growth performance of the Fulani-ecotype chicken. Livestock Resource for Rural Development 17: Art. #94, http://www.lrrd.org/lrrd17/8/faye17094.htm, 2005 .

Ferket, P.R., A.G. Germat, 2006. Factors that affecting feed intake of meat birds. Review. International Journal of Poult Sc.10: 905 – 911.

Food Agricultural Organisation (FAO), 2004. Manual Small Scale Poultry production technical guide by Sonaiya E.B and Swan S.E. J. FAO Animal Production and Health Series No. 1. Available at http://www.fao.org/docrep/008/y5169e/y5169e00.HTM date accessed 04-09-2009.

Fraga, L.M., 2002. Reasons for the use and conservation of some local Genetic resources in poultry. In: Proceedings of the 7th World Congress on Genetic applied to to Livestock Production. Montpelier, Frnce , 19th - 22rd August 2002.

Fulton, J. E., H.D Hunt, L.D. Bacon,. 2001. Chickens Major Histocompatiblity Complex Class 1 Definition Using Antisera Induced by Cloned Class 1 Sequences. Poultry Science 80: 1554 – 1561.

Ganabadi,S. S., M.A. Mutuviren, S.M.A. Babjee, H. Yaakub,and S.Fakurazi, 2009. Carcass Composition of Jungle Fowl in Comparison with Broilers and Indigenous. Chicken. Asian Journal of Animal Sciences3 (1) pp 13-17available athttp://scialert.net/fulltext/?doi=ajas.2009.13.17accessed 12-07 , 2009.

Germain, R. N,. 1994. MHC-dependent antigen processing and peptide presentation: providing ligands for T lymphocyte activation. Cell 76:287-299.

Gilmour, G.D.1960. Blood groups in chickens. Poultr Sci. 1: 75-100.

Gondwe, T.N.P., 2004. Characterization of local chicken in low input-low output production systems: is there scope for appropriate production and breeding strategies in Malawi? (PhD thesis, Georg-August-Universität Göttingen, Germany)

Gondwe, T.N.P., C.B.A.Wollny, and W, Kaumbata, 2005. Marketing system and channels for scavenging local chickens in Lilongwe, Malawi.Livestock Research for Rural Development 17: 2005. Available at http://www.lrrd.org/lrrd10/3/sene103.htm. Accessed 03-05-2007

Gondwe, T. N.P and C. B. A. Wollny, 2007. Local chicken production system in Malawi: Household flock structure, dynamics, management and health. Tropical Animal Health and Production 39: 103-113

Gordon, R.F and F.T.Jordan, 1982. Poultry diseases. Bailliere Tindalle, 2nd ed. Great Britain, 1982, 1-197.

Goromela, E.H., R.P. Kwakel, M.A.A. Verstegen, A.M. Katule, 2006. Strategies to optimize the use of scavengeable feed resources base by smallholders in traditional poultry production systems in Africa: A review. Africa Journal of Agricultural Research 1: 91-100

Goromela, E.H., R.P. Kwakel, M.A.A. Verstegen, A.M Katule,.2008. Effect of season and farming system on the quantity and nutritional quality of scavenge-able feed resources an performance of villages poultry in central Tanzania. Journal of cell an Animal Biology 2(3) 063 – 071 available online at htt://www.acaemicjournals.org/JCAB . accessed 12-08-2009

Groenen, M.A.M., R.P.M.A., Crooijmans, R.J.M., Dijkhof, R. Acar, J.J. van der Poel, 1999. Extending the chicken-human comparative map by placing 15 genes on the chicken linkage map. Anim Genet. 30**:**418–422.

Guèye, E. F. et W.Bessei, 1995. La poule locale sénégalaise dans le contexte villageois et les possibilités d'amélioration de ses performances. Paper presented at ANRPD Workshop and General Meeting, 13-16 June 1995, Addis Ababa, Ethiopia.

Guèye, F.F. and W. Bessei, 1997. The importance of poultry farming in Senegal. Animal Research and Production 45: 82 -88

Guèye, E.F.,1998a. Village egg and fowl meat production in Africa. World Poultry Science Journal 54:73-86.

Guèye, E.F., A. Ndiaye, and R. D.S. Branckaert, 1998b. Predictions of body weight on the basis of body measurements in mature indigenous chickens in Senegal. Livestock

Research for Rural Development 10 http://www.lrrd.org/lrrd10/3/sene103.htm. accessed 12-07- 2005

Guèye, E.F. 1999. Ethanoveterinary medicine against poultry diseases in Africa village. World's Poult. Sci., 55:187 – 198.

Guèye, E. F. 2003. Poverty alleviation, food security and the well-being of the human production through family poultry in low-income food-deficit countries. Food, Agriculture and Environment 1:12-21

Gunaratne, S.P., A.D.N.Chandrasiri, W.A. P Mangalika Hemalatha, and J.A.Roberts, 1993. Feed resource base for scavenging village chickenss in Sri Lanka Tropical Animal Health and Production 25: 249 - 257

Hafez, H.M., 2005. Governmental regulations and concept behind eradication and control of some important poultry disease. World's Poult. Sci. 61: 569-591

Halima, H., F. W .C Neser. T. Dessie, A. De Kock, and E.Van Marle-Koster, 2006. Studies on the growth performance of native chicken ecotypes and RIR chicken under improved management system in Northwest Ethiopia. Livestock Research for Rural Development 18 (6) http://www.lrrd.org/lrrd18/6/hass18076.htm accessed 02-04- 2008

Halima H.F.W.C, E.Neser , E.Van Marle-Koster ,A. de Kock, 2007. Village based indigenous chicken production systems in north-west Ethiopia. Trop. Anim. Healt. Prod J. 39: 189-197.

Harper, A.E and Q.R. Rogers, 1965. Amino acid imbalance In: Proceedings of the Nutrition Society, 24: 173- 190.

Haruna, M., A.Cambaza, L.Alemao, G. Maxihuza, M..Joaquim, G.Manganza, A. Namaneque, O. Lobo, and, R. Alders, 2001. Community base Experience in Controlling New Castle Diseases in Rural Areas of Mozabmbique to Achieve Food Security, Poverty Alleviation and HIV/AIDS Mitigation, Mozambique. AUSAID Southern Africa Newcastle Disease Control Project (SANDCP).

Haruna, M. and F.A. Massango, 2001. Village Poultry Production in Mozambique: Farming Systems and Ethnoveterinary Knowledge in Angonia and Tsangano Districts, Tete Province [online]. In: SADC Planning Workshop on Newcastle Disease *Control in Village Chickens.* Workshop on Newcastle disease in village chickens, Maputo, Mozambique, March 6-9, 2000. ACIAR Books Online. Available from: http://www.aciar.gov.au/publication/PR103. Pr103chapter17.pdf. ISBN 0 642 45687

Henning, J., R. Pym, T. Hla,N. Kyaw,and J.Merres, 2007. Village chicken production in Mymmar- purpose magnitude and major constraints. World’s Poult Sci., 63:308-322.

Hocking, P.M., 1990. Comparison of the effects of the degree of food restriction during rearing on ovarian function at the onset of lay in unselected ducks and in line selected for improved foodefficiency**.** British Poult. Sci.,31: 351-359.

Hoffmann, I., 2005.Research and investment in poultry genetic resources – challenges and options for sustainable use. World's Poult. Sci., 61: 57-70

Horst, P., 1989. Native fowl as reservoir for genomes and major genes with direct and indirect effects on the adaptability and their potential for tropically oriented breeding plans. Arch. Anim. Breed., 53: 93–101

Horst, P.,1988. Indigenous fowl as reservoir for genomes and major genes with direct and indirect effects on production adaptability. Proc. 18th World Poult. Congr. Nagoya, Japan.

Horst, P., P.K. Mathur and A.Valle Zarate, 1996. Breeding policies for specific tropical environments using appropriate combination of major genes. Proc. World's Poultry Congress, New Delhi, India. 2-5 September 1996. 1: 640 -663.

Huque, Q.M.E., 1999. Nutritional status of family poultry in Bangladesh. Livestock Research for Rural Development 11: 3 1999. http://www.lrrd.org/lrrd11/3/huq113.htm accessed 04-05-2005.

Ikeobi, C.O.N., M.O. Ebozoje, O.A. Adebambo, J.A. Adenowo and O.A. Osinowo, 1996. Geneticdifferences in the performance of the local chicken in South Western Nigeria. Niger. J. Genet., 11: 55-*60*.

Ikeobi, C.O.N., 1984. The relationship between the physical features of the fowl and its laying performance. M.Sc. Project report, University of Ibadan, Ibadan, Nigeria.

Ikeobi, C.O.N., 1994. Seasonal changes in the live weight of cattle in Ogun State, Nigeria.Int. J. Ani. Sci. 9: 52-54

Ingr, I., 1996. Meat Technology. Brno,pp 290

International Livestock Centre for Africa (ILCA),1993.Handbook of African Livestock Statistics, (Experienced ILCA, Addis Ababa Ethiopia) 15-17

Iqbal, S., and Z.A. Pampori, 2008. Production potential and qualitative traits of indigenous chicken of Kashmir. Livestock Research for Rural Development 20: available at http://www.lrrd.org/lrrd20/11/iqba20182.htm accessed 20-01-2009.

Islam, M.A. and M. Nishibori, 2009. Indigenous naked neck chicken: a valuable genetic resource for Bangladesh. World's Poult.Sci.,65:125-138

Jackson, S. J., D. Summers, and,S. Leeson, 1982. Effects of protein and energy on broiler carcass composition and efficiency of nutrient utilization. Poult. Sci. 61: 2224-2231.

Jansen,H.K and F. Dolberg, 2002. The Bangladesh Model and other experience in FAMILLY Poultry Development A conceptual Framework for using poultry as a tool poverty alleviation. INTRODUCTORY PAPER INFDP E- Conference. International Network for Family Poultry Development Program.Availble at htt://www.fao.org/AG/Ainfo/subjects/en/infopd/encof_banga.html.) accessed10/06/ 2007

Jaturasitha, S., T. Srikanchai, M. Kreuzer and M. Wicke, 2008.Differences in Carcass and Meat Characteristics between chicken indigenous to Northern Thailand (Black-Boned and Thai Native) and Imported Extensive Breeds (Bresse and Rhode Island Red. Poult Sci 87:160-169. http://poultsci.highwire.org/cgi/content/full/87/1/160#WATTANACHANT-ETAL-2005 Accessed 06-12- 2007.

Jorge, E.C, A. Figueira, M.C. Ledur, A.S.A.M.T. Moura and L.L Coutinho, 2007. Contributions and perspectives of chicken genomics in Brazil: from biological model to export commodity. World's Poult. Sci. 63: 597 - 610

Kaiser, D.,1990. Improvement of traditional poultry keeping in Niger. Rural poultry. CTA Wageningen, Rural Poultry production in Hot climates, 12 June 1987, Hamelin, Germany

Kansci, G., B. E. Lele, M. Minette, M. Fotso, E.Fokou, 2004. Nutrient Content and Organoleptic Quality of Traditional African Strain and Rhode Island Chickens and the Effect of Feed Rations.The Journal of Food Technology in Africa Vol. 9 No. 1, 2004, pp. 26-28

Khalafalla, A.I.,S. Awad, and W. HASS, 2002. Village poultry production in the Sudan. In: Characteristic and Parameters of family Poultry Production in Africa. IAEA. 87-93

Kingori, A.M., J.K. Tuitoek, H.K. Muiruri and A.M. Wachira, 2003. Protein requirements of growing indigenous chicken during the 14-21 weeks growing period. S.Afric. J. Anim. Sci., 33: 78-82.

Kitalyi, A.J., 1998a. Family poultry management systems in Africa. *First INFPD/FAO electronic conference on family poultry*, FAO, Rome, Italy.

Kitalyi, A.J., 1998b. Village chicken production systems in Africa: Household Food Security and Gender Issues. Animal Production and Health paper 142, FAO, Rome, Italy.PP 23- 48.

Kitalyi, A .J. 1999. Family poultry management systems in Africa. First INFPD/FAO Electronic Conference on Family Poultry, The Scope and Effect of Family Poultry Research and Development (Guèye, E.F., Ed.), http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGA/AGAP/lps/fampo/leadpap3.htm ACCESSED 12- 03- 2005

Kugonza, D. R., C. C. Kyarisiima and A. Iisa, 2008. Indigenous chicken flocks of Eastern Uganda: I. Productivity, management and strategies for better performance. Livestock Research for Rural Development 20 (9) 2008. Available at http://www.lrrd.org/lrrd20/9/kugo20137.htm accessed 10-09-2009

Kumaresan, A. K.M. Bujarbaruah, K.A. Pathak, B. Chhetri , S.K. Ahmed , S. Haunshi, 2008. Analysis of a village chickens production system and performance of improved dual purpose chickens under a subtropical hill agro-ecosystem in India. Tropical Animal Health Prod. 40: 95-402.

Kusina, J., N.T Kusina, and J. Mhlanga, 2001. A survey on Village Chickens Losses: Causes and solutions as perceived by Farmers. In: SADC planning workshop on Newcastle Disease control in village chickens. Proceeding of an International Workshop in Maputo Mozambique, 6 – 9 2000.pp 148 – 155. Available at http//www.fao.org/waicent/faoinfo/agricult/aga/agap/lps/fampo//.htm accessed 12-07 -2005

Kyvsgaard N C., L.A. Luna and P. Nansen, 1999. Analysis of a traditional gain and scavenge based poultry system in Nicaragua. In: Proceedings of a Workshop on Poultry as a Tool in Poverty Eradication and Promotion of Gender Equality (Dolberg F and Petersen P H, Editors.), Tune, Denmark. http://www.ihh.kvl.dk/htm/php/tune99/9-Kyvsgaard.htm accessed 18-09- 2003

Lamont, S.J.,1998a. The chickens major histocompatibility complex and disease. Abstract. Rev Sci. The chickens' major histocompactibility complex and disease. Rev. Sci.Off.int.Epz 17 :128-142

Lamont, S.J., 1998b. Impact of genetic on diseases resistance. Poultry Science 77 : 1111 -1118.

Lamont, S.J., M. Soller, S. Weiged, M.N. Romanov, and J.C.M. Dekkers, 2006. Strategies to Assess Structural Variation in the Chickens Genome and its Associations with Biodiversity and Biological Performance. Poultry Science 85:2061 - 2078

Latter-Dubois, J. 2000. Poulets Fermiers: Leurs Qualités Nutritionnelle et Organoleptiques et la Perception du Consommateur. MSc Faculté des Sciences de l'Agriculture et de l'Alimentation. Univ. Laval, Quebec, Canada.

Lebajoa, F.B. 2001. Country reports: Lesotho. In: SADC Planning workshop on Newcastle disease control in village chickens. Eds. Alders, R.G. & Spradbrow, P.B., Australian Centre for International Agricultural Research. Proc., No.103, Maputo, Mozambique, 6-9 March (2001). pp. 1-10.

Le Page, K. T., W. E. Briles and R. L. Taylor, Jr., 2000. Nonmajor histocompatibility complex alloantigen effects on the fate of Rous sarcomas. Poult. Sci., 79: 343-348

Losada, H., R. Pealing, J. Cortés, and J. Vieyra, 1997. The keeping of poultry and pigs in the backyards of the urbanized areas of Iztapalapa, (East of Mexico City) as a proposal for sustainable Production. Livestock. Research for Rural Development9, 3: 1997. http://www.lrrd.org/lrrd9/3/mex932.htm accessed 12-10-2003.

Lough, R., I. Morgan, J. Walls, R. Escrivao, and J. Ferrao, 2001. Report to IFAD on the contribution of livestock to poverty alleviation in Mozambique. GRM International Pty Ltd. MADER, Maputo, Mozambique.

Lul, S.A.,1990. Smallholder rural poultry production in the Somalia Democratic Republic. In: CTA Seminar proceedings, volume 2, Smallholder Rural Poultry Production, Thessaloniki, Greece,pp 207-214

Lundy, H. 1969. A review of the effects of temperature, humidity, turning and gaseous environment in the incubator on the hatchability of the hen's egg. Pages 143–176 in The Fertility and Hatchability of the Hen's Egg. T. C. Carter and B. M. Freeman, ed. Oliver and Boyd, Edinburgh, UK.

Mabbett T., 2005. Integrated management of mycotoxins. Poultry International Journal accessed 12 07- 2005. 8. 10-14

MacDonald,K.C. and Edward,D.N, 1993.Qasr Ibrim.Antiquity.6767(256):584 – 589

Maigandi,S.A., K.M..Usman, 1996. A survey of turkey production in Sokoto State, Nigeria. A.NRPD News letter 6:5-7

McAinsh, C.V., J. Kusina, J. Madsen, and O. Nyoni, 2004. Traditional chickens' production in Zimbabwe. World's Poult. Sci 60: 232-242

Mack, S., D. Hoffmann, and J. Otte. 2005. The contribution of poultry to rural Development. World's Poultry Science Journal, 61: 7-14 doi: 10. 1079/WPS200436

Magothe, M., W.B. Muhuyi, andA.K. Kahi, 2010. Influence of major genes for crested-head, frizzle-feather and naked-neck on body weights and growth patterns of indigenous chickens reared intensively in Kenya.Tropical Animal Health Production 42:173–183

Mahrous , M., A. Galal, M.M. Fathi, and A. Zein El- Dein, 2008. Impact of naked neck (Na) and Frizzle (F) genes on growth performance and immunocompetence in chickens. International Journal of Poultry Science. 7:45-54

Malheiros, R.D., M.B. Moraes, A. Collin, P.J. Janssens, E. Decuypere and J. Buyse, 2003. Dietary macronutrients, endocrine functioning and intermediary metabolism in broiler chickens. Nutr. Res., 23: 567-578.

Maphosa, T., Kusina, J., Kusina, N.T., Makuza, S. and S Sibanda, 2004. A monitoring study comparing production of village chickens between communal (Nharira) and smallscale commercial (Lancashire) farming areas in Zimbabwe. Livestock Research for Rural Development, 16 (7). (http://www.cipav.org.co/lrrd/lrrd16/7/maph16048.htm) accessed 10 -02- 2011

Mapiye, C. and S., Sibanda, 2005. Constraints and opportunities of village chicken production systems in the smallholder sector of Rushinga district of Zimbabwe. Livestock Research for Rural Development, 1: 1-7

Mason, I. L.,1984 (ed.). Evolution of Domesticated Animals (Longman, New York, 1984

Masuno, T., 2008: Chicken consumption at the mountain village in Northern Thailand. Livestock Research for Rural Development. Volume 20, Article #37. http://www.lrrd.org/lrrd20/3/masu20037.htm accessed 27- 08-2010,

Mbajiorgu, C.A., J.W. Ng`ambi and D.D. Norris, 2010 Voluntary feed intake and nutrient composition in chickens. Asian J. Anim. Vet. Adv., 6: 20-28.

Mberema, C.H.H, 1999. Systems of rearing chickens in rural areas of Kavango. BSc. (Agric) Research Project Report, Department of Animal Science, University of Namibia. 59 pp. Unpublished.

Mehran, M., P. Javad, S. GhorbanalI, 2010. Replacing maize with pearl millet in laying hens' diets.Trop Anim Health Prod 42:439–444

Miller, M. M., L. D. Bacon, K. Hala, H. D. Hunt, S. J. Ewald, J. Kaufman, R. Zoorob and W. E. Briles. 2004 Nomenclature for the chicken major histocompatibility (B and Y) complex. Immunogenetics. 56:261-279.

Minga, U.M., A.M.,Katule, T. Maeda, and J.Musasa, 1989. Potential and problems of the traditional chicken industry in Tanzania. In: Proc. of 7th Tanzania Veterinary Association Scientific Conference, held in Arusha on 3–5 December 1989, 7, 207–215.

Minh, D .V. 2005. Effect of Supplementation, Breed, Season and Location on Feed Intake and Performance of Scavenging Chickens in Vietnam.Doctoral thesis Swedish University of Agricultural Sciences Uppsala 2005.

Missohou, A., P.N. Dieye, and E.Talaki. 2002. Rural poultry production and productivity in Southern Senegal. Livestock Research for Rural Development, 14, 2:2002. http://www.cipav.org.co/lrrd/lrrd14/2/miss142.htm accessed 10-19- 2005

Mlozi, M .R. S., A .V. M. Kakengi, U.M. Minga, A.M. Mtambo ,and J.E.Olsen, 2003. Marketing of free - range local chickens in Morogoro and Kilosa urban markets, Tanzania. Livestock Research for Rural Development, 15, 2:2003. http://www.cipav.org.co/lrrd/lrrd15/2/mloz152.htm accessed 12-05- 2006

Moiseyeva, I. G., Romanov, M. N., Nikiforov, A. A., Sevastyanova, A. A. and S.K.Semyenova, 2003. Evolutionary relationships of Red Jungle Fowl and chicken breeds. *Genet. Sel. Evol.*35:403–423.

Mopate, L.Y. and M. Lony, 1999. Survey on family chickens farms in the rural areas of N'Djamina, Chad. Livestock Research for Rural Development. 11:2 1999. Available at http://www.cipav.org.co/Irrd11/2cha112.htm accessed 12-03- 2006

Moreki,J.C, 1997. Small scale poultry production systems in Serowe – Palpye Sub district (Botswana). M.Sc. Thesis, University of Melbourne Melbourne, Australia.

Msoffe, P.L, M. Minga, U.M. Olsen,J.E.Yongl, M.G.S. Juul -Madsen,H.R.Gwakisa,P.S. and Mtambo,M.M.A, 2001.Phenotypes including immunocompetence in scavenging local chickens ecotypes in Tanzania. Tropical Animal Health and Production,33: 341 – 354.

Muchadeyi, F.C., S. Sibanda, N.T. Kusina, J.F. Kusina. and S.M. Makuza, 2004. The village chicken production system in Rushinga District of Zimbabwe. Livestock Research for Rural development, 16 (online).http://www.cipav.org.co/lrrd/lrrd16/6/much16040.htm accessed 28/9/2007

Muchadeyi, F.C., S. Sibanda, N.T. Kusina, J.F. Kusina,. and S.M. Makuza, 2005. Village chicken flock dynamics and the contribution of chickens to house hold livelihoods in a smaller holder farming area in Zimbabwe. Tropical Health and Production. 37:33 - 344

Muchadey, F.C., H. Eding, C.B.A. Wollny, S.M. Groeneveld, R. Shamseldin, H Simianer, and S.Weignd, 2007. Absence of population sub structuring in Zimbabwe chickens Ecotypes inferred using microsatellite analysis. Anim. Genet.38,332-339.

Mukherjee, T. K., 1992. Usefulness of indigenous breeds and imported stocks for poultry production in hot climate. Pages31–37 In: Proceedings of 19th World's Poultry Congress, Vol. 2. Amsterdam, The Netherlands

Musa, U.,P.A.Abdu, I.I. Dafwang, U.A.Katsayal, J.A. Edache, and P.Karsin, 2008.Ethnoveterinary remedies used for the management of Newcastle disease in some selected local government areas of Plateau State NigeriaNig. Journal. Pharm. Sci., March, 2008, Vol. 7 No. 1, P. 126– 130 available at http://ww1.abu.edu.ng/journals/njps/pdf/6.pdf. accessed 15-11- 2010.

Musharaf A.N.1990. Rural poultry production in Sudan. In CTA Seminar proceedings on Small holder Rural Poultry production. Thessaloniki, Greece, 2, 227-232.

Mushi, E.Z., M.G. Binta, G. R. Chabo, R.T.Ndebele, and T.Ramathodi , 2000. Diseases and management of indigenous chickens in Oodi, Kagatlenga, district Botswana. World's poult. Sci., 56:153-157

Muthur, P.K. andP. Horst, 1990. Single and combine effects of tropically relevant major genes on performance of layers. Proceeding 4th congress on genetics applied to livestock production.Edinburgh XVI: pp65-68

Mwalusanya N.A. , A.M . Katule, S.K .Mutoyoba, M.M.A. Mtambo, J.E.Olsen,.and U.M. Minga,2001. Productivity of local chickens under village management conditions. Tropical Animal Health and Production, 34: 405-416

Mwalusanya, N.A, Katule A. M, Mutayoba, S. K, Mtambo ,M .M. A, Olsen, J. E, and Minga, U M., 2002. Productivity of local chickens under village management conditions. Tropical Animal Health and Production 34:405- 416

National Research Council (NRC), 1984. Nutrient Requirements of Poultry 8th edn National Academy of Sciences, Washington.

Ndegwa, J.M., R. Mead, O. Norrish, C.W. Kiman, .and A.M. Wachira, 2001.. The growth performance of indigenous Kenyan chickens fed diets containing different level of protein during rearing. Tropical Animal Production 33: 441 – 448

Negesse, T., 1993. Prevalence of diseases, parasites and predators of local chicken in Leku, Southern Ethiopia. Bulletin Animal Health and Production in Africa 41: 317 - 321.

Negesse, T. and A.Tera, 2009. Effect of feeding different levels of cooked and sun dried fish offal on carcass traits of growing Rhode Red Chicks. Trop Anim Health and Prod. 42:45–54.

Nei M., 1978. Estimation of average heterozygosity and genetic distance from small number of individuals. Genetic 89: 583- 590.

Nesheim, M C, R. E. Austic and L. E. Card, 1979. Poultry production**.** 12[Th] edition, Lea and Febiger, Philadelphia, USA

Nickiforov, A. A., I.G. Moiseyeva,. and J.A. Zkharov, 1998. Position of Russian chickens breeds in the diversity of Eurasian breeds Genetika, 34:61 – 694.

Nishida,T., Y. Hayashi,K. Nozawa, S.Okamato, H. Goto and H.W. Cyril, 1986. Somatometrical and genetical analysis of external characters of Lanka native fowl fowl. Rep.Soc. Res.Native Livestock, 11: 165 – 177.

Ngou Ngoupanyou, J.D., 1990. Country report on small holder rural poultry production in Cameroon. In: *CTA* Seminar proceedings on Small holder Rural Poultryproduction, 9-13 October 1990, Thessaloniki, Greece, 2, 39–41.

Nguyen**,** T..V. and C. Bunchasak, 2005. Effects of dietary protein and energy on growth performance and carcass characteristics of Betong chicken at early growth stage. Songklanakarin. J. Sci. Technol., 27: 1171-1178.

Njue, S.W., J.L. Kasiiti, M.J.Macharia, S.G. Gacheru and H.C.W.Mbugwa, 2002. Health Management improvement of family poultry production in Africa – survey results from Kenya. In: Characteristic and parameters of family poultry production in Kenya. IAEA. Vienna.

Nordskog, A.W., I.Y Pevzner ,S.J. Lamont, 1987. Sub-regions and functions of the chicken major histocompatibility complex. Poultry Science 66, 790–794

Nwosu, C.C., 1979. Characterisation of local chicken of Nigeria and its potential for egg and meat production. In: J. M. Olomu, S. A. Offiong, V. Buvanendram and O. A. Osinowo (Eds) *Poultry* Production in Nigeria, 187-210 Zaria: National Animal Production Research Institute.

Nwosu, C.C., 1990. The state of small older rural poultry production of poultry in Nigeria In: Smaaleholder Rural Poultry Production, CTA – EMINAR Proceedings Thessaloiki, Greece, October 9 -13 1990. 11: 183 -190

Nwude, N., M.A. Ibrahim, 1980. Plants used in traditional veterinary medical practice in Nigeria. Journal of Veterinary Pharmacology and Therapeutic 3: 261 – 273.

Ojo, S. O., 2003. Productivity and technical efficiency of poultry egg production in Nigeria. Nigeria International Journal of Poultry Science 2: 459-464

Okada, I., Y. Maeda , K. Hashigushichi, M..A. Hasnath, M.O Frugque, M..A. Majid, 1996. Gene constitution of indigenous in Bangladesh. Japanese Poultry Science.25 : 15-26

Okitoi, L. O., H. O. Ondwasy, M. P. Ombali and F. Murekefu, 2007a. Gender issues in poultry production in rural households of Western Kenya. Livestock Research for Rural Development 19 (2) 2007. Online. http://www.lrrd.org/lrrd19/2/okit19017.htm accessed 11-12 2009

Okitoi, L .O., O. Ondwasy, D.N. Siamba, and D. Nkurumah, 2007b. Traditional herbal preparations for indigenous poultry health management in Western Kenya.

Livestock Research for Rural Development, Volume 19, Number 5, May 2007. Available at http://www.cipav.org.co/lrrd/lrrd19/5/okit19072.htm accessed11-12-2009

Okoye, J.O. A and E . P. Aba-Adulugba, 1998. Comparative study of the resistance or susceptibility of local Nigerian and exotic chickens. Avian Pathology, 27: 168-173

Ologhobo, A.D., 1992. The dilemma of animal feeds and indigenous poultry production in Nigeria. Proceedings 19th World's Poultry Congress, 2, Amsterdam, The Netherlands, pp 81-86

Oluyemi ,J.A, and F.A. Roberts, 1979. In: J.A. Oluyemi and F.A. Roberts (eds) Poultry Production in Warm and Wet climate MacMillan, London.

Oluyemi, J.A. D.F. Adene, and G.O. Laboye, 1979. Comparison of Nigeria indigenous fowl with White Rock under conditions of disease and nutritional stress. Tropical Animal. Health. Production, 11: 199-202.

Pazderka,F., B.M .Longenecker, G.R.J. Law, H.A.Stone, R.F. Ruth, 1975. Histocompatibility of chicken populations selected for resistance to Marek's disease. Immunogenetics 2, 93–105.

Pedersen,C.V., 1998. Farmer driven Research on village chicken Production Senyati, Zimbabwe. http://www-naweb.iaea.org/nafa/aph/public/18-farmer-pedersen.pdf accessed 12-8 2005

Pedersen, C.V., 2002. Production of semi-scavenging chicken in Zimbabwe. PhD thesis, Royal Veterinary and Agricultural University, Copenhagen,Unpublished

Permin, A. and J.W. Hansen, 1998. Epidemiology, diagnosis and control of poultry parasite, FAO, Rome., pp: 160

Permin, A., J.B. Esmann, C.H. Hoj, T. Hove, and S. Mukaratirwa, 2002. Ecto-, endo- and haemoparasites in free-range chickens in the Goromonzi District in Zimbabwe. Preventive Veterinary Medicine, 54: 213–224.

Pousga, S., H. Boly, J.E. Lindberg ,.and B. Ogle, 2005. Scavenging Pullets in Burkina Faso: Effect of Season, Location and Breed on Feed and Nutrient Intake. Tropical Animal Health and Production, 37:623–634

Quereshi, M.A, R.A.Ali, L.N.Thomas, R.N. Baloch, and W.E. Briles, 2000. Alloantigen systems Land P influence phagocystic function independent of major historcompatibilty complex (B) in chickens. Poult Sci, 79: 127 -5 available at htt://www. Ncbi.nlm.nih.gov 11-05- 2007

Ramlah, A.H.and H.. Kassim, 1992. Production performance of village chickens. In: Proceedings of the National IRPA Seminar (Eds. Ho, Y.W, M.K. Vidyadaran, N. Abdullah, M.R. Jainudeen and A.R. Bahaman) 2: 496-497

Ramlah A.H., 1996. Performance of village fowl in Malaysia. World Poultry Sci.. 52: 76-79

Rashid, M., B. C. Roy and V. Asaduzzaman, 2004. Chemical composition of crop contents of local scavenging chickens.Pakistan Journal of Nutrition, 3: 26–28.

Rashid MM, M.N.Islam B.C. Roy, K.Jakobsen C. Lauridsen, 2005. Nutrient concentrations of crop and gizzard contents of indigenous scavenging chickens under rural conditions of Bangladesh. LivestockResearch for Rural Development 17(2) .http://www.cipav.org.co/lrrd/lrrd17/2/rash17016.htm. accessed 07-08- 2008

Revelonson, C., 1990, Situation et les constraints de l'aviculture villagoise a Madgascar. In: Smallholder Rural Poultry Production, CTA Seminar proceedings, Thessaloniki, Greece, October 9 – 13, 1990,1: 135-138

Riber, A.B., A. Wichman, O.Bjarne, C.Braastad, B. Forkman, 2007. Effects of broody hens on perch use, ground pecking, feather pecking and cannibalism in domestic fowl (*Gallus* g*allus domesticus*). Applied Animal Behaviour Science 106, 39-5

Riddell, C., 1991. Developmental, metabolic, and miscellaneous disorders. pge 827 In: Diseases of Poultry. 9th ed. Iowa StateUniversity Press, Ames, IA.

Roberts, J.A. and S.P. Gunaratne,1992. The scavenging feed resource base for village chickens in a developing country. Proceedings, 19th World´s Poultry Congress, 1: 822-825, cited by Gunaratne, S. P. in this First INFPD/FAO Electronic Conference on Family Poultry.

Romanoff, A. L, 1960. Atmospheric changes. In: Pathogenesis of the Avian Embryo: An Analysis of Causes of Malformations and Prenatal Death. Wiley Inter science, New York. Pages 57–104.

Safalaoh, A.C.L., 1992. A review of Poultry Production in Malawi: Constraints and Possible Solutions. Malawi National Commission for UNESCO Publication

Safalaoh, A.C.L, 1997. Characteristics of indigenous chickens of Malawi. *Animal Genetic Resource Information,* 22: 61–69

Safalaoh, A.C.L., 2001. Village chickens upgrading program in Malawi. World's Poult. Scie. 57:170-188

Savory , C.J., 1995. Feather pecking and cannibalism, Word's Poultry Sci. J. 51 215 – 219.

SAS, 1999. SAS Users Guide, Version 8.1. SAS Institute Inc. Cary, NC, USA

Scott, M.L., M.C. Nesheim, and R.J. Young, 1982. Nutrition of the chicken, M.L. Scott and Associates, Ithaca, New York

Siegel, P. B. J.B. Dodgson and L. Andersson, 2006. Progress from Chickens Genetics to the Chickens Genome. Invited reviews. Poult Sci 85:2050-2060. Online at http ps.fass.org/sgi/contnt/full/85/12/2050

Singh, R.V., S.P. Singh, 2004. Possibilities of exploitation of indigenous poultry germplasm. Paper presented in National Symposium on Livestock Biodiversity vis-a-vis resources exploitation. Introspection, 11-12 February held at NBGRR, Karnal India 21-30pp available at http://www.Irrd.org/Irrd 19/10/chut 1995 1.htm accessed 13-06-2009.

Smith, A .J., 1990a. Poultry-Tropical Agriculturist series. CTA, Macmillan Publishers, London. pp 179-184.

Smith, A. J., 1990b.The integration of rural production into the family food supply system. In: *Proceedings, CTA Seminar on Smallholder Rural Poultry Production*, Thessaloniki, Greece, 9–13 October 2: 115–128.

Smith, E.R., and G.M. Pesti, 1998. Influence of broiler strain cross and dietary protein on the performance of broilers. Poult. Sci. 77: 276-281

Smith, D. M., J. J. Lunney, C. S. Ho, G. W. Martens, A. Ando, J. H. Lee, L. Schook, C. Renard and P. Chardon, 2005. Nomenclature for factors of the swine leukocyte antigen class II system. Tissue Antigens. 66:623-639

Smith A.J., 2001. Poultry Tropical Agriculturalist Series. Revised edition CTA. Mcmillan Ptrsss Ltd., London.

Smyth, J. R., 1996. Genetics of plumage, skin and pigmentation in chickens. In: Poultry Breeding and Genetics, pp 109–167 Crawford, . R. D. ed. Elsevier, New York, NY.

Sofowora, D., 1993. Medicinal plants and traditional Medicine in Africa. John Wiley and Sons, NewYork, Pp.102

Sonaiya, E.B., 1990. The context and prospects for development of small holder rural poultry production in Africa. Proceedings CTA international seminar on Small holder Rural Poultry Production, Thessaloniki, Greece Oct.9 -13 vol 1, pp 35-52.

Sonaiya E.B., 1995. Feed resources in smallholder poultry in Nigeria. World Animal Review. 82:25-33

Sonaiya, E.B., R. Branckart, and E.H Guèye. 1999. Research and development option for family poultry. First INFPD/FAO Electronic Conference on Family on Poultry,(http://faoext02.fao.org/waicent/faoinfo/agricult/agap/Ips/fampo/intropap.htm accessed 12-05-2006

Sonaiya, E.B., 2004. Direct assessment of nutrients resources in free range on scavenging systems. World's Poultry Science 60:523-533.

Sonaiya EB, and S.E.J. Swan, 2004. Small-scale poultry production, technical guide manual. FAO Animal Production and Health 1. Food and Agriculture Organization of the United Nations (FAO), Rome.

Soulsby, E.J.L., 1982. Helminths, Arthropods and Protozoa of Domesticated Animals. ELBS Bailliere Tindall, London. p.117

Spradbrow, P. B., 1996. Protection against important diseases including Newcastle disease. Proceedings 20th World's Poultry Congress, Vol. 1, New Delhi, India, pp. 31-34.

Spradbrow, P.B., 2001. The Epidemiology of Newcastle Disease in Village Chickens [online]. In: SADC Planning Workshop on Newcastle Disease Control in Village *Chickens.* Workshop on Newcastle disease in village chickens, Maputo, Mozambique, March 6-9, 2000. ACIAR Books Online. Available from: http://www.aciar.gov.au/publication/PR103. Pr103chapter13.pdf. ISBN 0 642 45687 accessed 18-08-2005

Stephen, C.Y.I.P, X. Zhang, and F.C. Leung, 2001. Genomic hormone gene polymorphism in native Chinese chicken Exp. Biol Mwd, 226: 458-462

Stevens, L., 1991. Genetics and evolution of the domestic fowl. Cambridge University press, Cambridge.

Tadelle, D. and B. Ogle, 1996. A survey of village poultry production in the central highlands of Ethiopia. M.Sc Thesis (paper I), Swedish Univeristy of Agricultural Sciences, pp 22.

Tadelle, D., Y. Alemu and K.J.Peters, 2000. Indigenous chicken in Ethiopia: Genetic potential and attemptsat improvement. Poult. Sci., 56:45-54.

Tadelle, D. AndB. Ogle., 2001.Village poultry production systems in the central highlands of Ethiopia. Tropical Animal Health and Production, 33, 251–237

Tadelle, D., Million, T., Y. Alemu and K.J. Peters, 2003. Village chicken production systems in Ethiopia: 2. Use pattern and performance valuation and chicken products and socio-economic functions of chicken. Livestock. Research. Rural Development. 15(1), http://www.cipav.org.co/lrrd/lrrd15/1/tadeb151.htm accessed 05-05 2005

Tamboura, H.H., L. Swadongo, H. Kabora, and S.M. Yameoga, 2000. Ethnoveterinary medicine and indigenous Pharmacopoeia of Passore Province in Burkina Faso.Ann NY Acad.916:259-64 (available at http:www.ncbi.nlm.nlh.gov:80/entrez/query.fcgi?cmd &db=PubMed &list_uids=1193630&dopt+abstract) accessed 06-05-2005

Teketel, F., 1986. Studies on the meat production potential of some local strains of chicken in Ethiopia. PhD. Thesis, J.L. Giessen University. University .p29

Temin, S., A.M. Chagneau, S. Guillaumin, J.Michel, R.Peresson, and S.Tesseraud, 2000. Does excess dietary protein improve growth performance and carcass characteristics in heat- exposed chickens? Poult. Sci. 79: 312-317.

Tenabe, Y., H. Yokoyayama, J. MurakamiH. Kano, O. Tanawaki , H. Okabayashi, Y.Maeda , C.Koshimoto, K. Nozawa, K Tumennasan, B. Dashnyam , and T.Zhanchiv, 1999. Rep. Soc.Res. Native.Livestock 17:139 -153.

Tanabe Y., H.Kano,K. Kinoshita, O. Taniwaki and H. Olabayashi, 2000. Gene constitution of a newly found population of Japanese native chickens in Southern region of Ethine Prefecture, Shikoku,Jspan. Jpn .Poult. Sci.37;101-107available at Http://www.virginismous accessed 12 – 03 -2007

Taylor, R. L., Jr. and W. E. Briles, 2000. Non-MHC Alloantigen effects on resistance and susceptibility to*Eimeria tenella*. Poult. Sci., 79 (Suppl. 1):39.(Abstract)

Van Kampen, M., 1974. Physical Factors afecting Energy Expenditure. In**:** Energy Requirements of Poultry eds. T.R. Morris and B.M Freeman.Edinburgh British Poultry Science Ltd

Van Krimpen, M.M., Kwakkel, R.P., Reuvekamp, B.F.J.,C.M.C van der Peet-Schwering,L.A den Hartog, M.W.A. Verstegen, 2005. Impact of feeding management on feather pecking inlaying hens. World’s Poul. Sci. 61: 663-686.

Van Marle-Köster, E and E.C. Webb, 2000. Carcass characteristics of South African native chicken lines. The South African Journal of Animal Science 38: 2008: pp. 282-289. Available online at http://www.sasas.co.za/Sajas.html accessed 09-05-2009

Van Marle-Köster, E. & Casey, N.H., 2001. Phenotypic characterization of native chicken lines in South Africa. Anim. Genet. Res. Info. 29: 71-78. FAO, Rome, Italy.

Van Marle-Köster, E., C.A. Hefer, L.H. Nel, and M.A.M. Groenen. 2008. Genetic diversity and population structure of locally adapted South African chickens lines: Implications for conservation. South African Journal of Animal Science, 38: 271-281 http://www.sasas.co.za/publications/van%20marlekoster38issue4.pdf

Van Niekerk, A., 1998 Indigenous chickens: the wise choice, Spotlight on Agriculture, N0. 8 Ministry of Agriculture Water Rural Development, Windhoek

Vilijoen, W.C.J., 1986. Hoendrrase, Pluimvee A2/ Boerdery in Suid Afrika.Dapartment of Agriculture, Pretoria. South Africa

Wattanachant, S., S. Benjakul, and D.A. Ledward, 2005. Microstructure and thermal characteristics of Thai indigenous and broiler chickens muscles. Poult. Sci. 84:328–336. Available at http://ps.fass.org/cgi/content/abstract/84/2/328.accessed 09-03-2007

Weigend, S., and S.J. Lamont, 1998. Poultry Science, 78: 112- 116

Weigand, S. and M.N. Ramanov, 2001. Current strategies for assessment and evaluation of genetic diversity in chickens' resources. World's Poult. Sci. 57: 275 -288

Weir B.S. 1996. Genetic data analysis II. Sinauer Press, Sunderland, Massachusetts.

Wilson, H. R., 1991. Physiological requirements of the developing embryo: temperature and turning 145–156 . In: Avian Incubation. S. G. Tullet, ed. Butterworth-Heinemann, London.

Wilson, R.T., 2007. Numbers, ownership, production and diseases of poultry in the Leo People's Democratic Republic. World's Poultry Science Journal 63: 4 655-663

Wimmers, K., S. Ponsuksili, T. Hardge, A. Valle-Zerate, P.K.,Mathur, P. Horst, 2000. Genetic distinctness of African Asian and South American local chickens. Animal Genetics, 31:159-165.

Yahav, S., D. Luger, A, Cahner, M.M. Dotan, M. Rusal, and S. Hurwtz , 1998. Themlegulation in naked neck chickens subjected to different ambient temperatures British Poultry Science 39:517-521.

Yaissle J., M.S. Lilburn, 1998. Effects of dietary protein and strain on the growth of broilerbreeder pullets from zero to five weeks of age. Poult. Sci.77, 1613-1619.

Yakubu, A., D. Kuje and M. Okpeku, 2009. Principal Components as Measures of Size and Shape in Nigerian Indigenous Chickens. Thai Journal of Agricultural Science 2009, 42(3): 167-176 available at www.thaiagj.orgretrieved August 2010

Yalçin, S. and I. Çiftçi, 1996. Feed fats and their characteristics. Feed Magazine, 4: 22-32.

Yammamoto Y. I. Okada,. Y.Maeda , K.Tsunoda, T. Namikawa , T. Amino T., Shotake, T.Nishida, H.B. Rajbhandary, 1992. Genetical Analysis of Blood Groups and External Characters of Native Chicken in Nepal

Yammamoto, Y., T. Namikawa, I. Okada,. M, Nishibori,, S.S., Mansjoer, H., Martojo, 1996. Genetical Studies On Native Chicken in Indonesia. AJAS, 9: 405 -410.

Yammamoto, Y., T. Amino, T.,Namikawa, K., Tsunoda, H., Kabayashi, H., Hata, K., Nozawa, T. Nishida,T. Yamagata, N. Isobe, K.Kurogi, K. Tanaka, H.V. Son, C.B. Loc, V.Tong-,Xuan H.Q.Hung, V.D.Giang., D. V. Binh, 1998. Genetic Constitution of the Chicken in Vietnam. Rep. Soc. Res. Native Livestock 16:75 - 84

Yang, Y., D.M. Mekki, S.J. Lv, L.Y. Wang, J.H.Yu, and J.Y. Wang, 2006. Analysis of fitting growth models in Jinghi mixed- sex yellow chicken, International Journal of Poult.Sci. 5: 517 – 521.

Yasuda, N. 1968. Gene frequency estimation by a counting method. Japanese Journal of Human Genetics, 12(4): 226-245 [Japanese, English abstract]

Zaria, T., Sinha, P.K., Natiti, L.S. and D.R. Nawathe, 1993. Ectoparasites of domestic fowl in an arid zone. African network of rural poultry development, Newsletter, 3: 7.

Zeuner, F.E., 1963. A history of domesticated animals. Hutchison, London. pp189

APPENDIX

1.0. Phenotypic characterization for indigenous chickens' questionnaire

o	Sex	Body weight	Comb type	Feather type	Feather colour	Shank colour	Other feature
1	F/M		P/R/W/S	N//F/S	B/R/Br/W//Or/ etc	Y/W/B/L/G	
2	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
3	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
4	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
5	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
6	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
7	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
8	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	

Definition of terms:

1. Com types: P; pea, R; rose, W; walnut; S
2. Colour. Bl; black, R, red, Br, brown, W; white, Or;
3. Shank colour; Y; yellow, W; white, Bl; black, L; lead

1.1. Questionnaire Production System

Farmer's name …………………………………………………………………..

Name of the village …………………………………………………………………..

How many number of chickens …………

male……………………………………………

Female …………………………………………

chicks

How long have you been keeping chickens?……………………………………………

Reasons for keeping chickens

Income generation ………………………………

Visitors…………………………………………….

Custom……………………………………………..

Home consumption……………………………..

Any other reasons………………………………

Feeding

1. Do you feed your chickens? ……………………………………..

2. How often do you give them feed? ……………………………………

3. What types of feeds do you give your chickens?

list……………………………………

4. How much do you give them? ....

5. Among the family whose responsibility to feed chickens?.

6. How often times of the day do you feed your chickens?

i) Once in the in the morning, twice in the morning

ii) Once in the afternoon or twice in the afternoon.

Whenever there is feed available

Where do you get the feeds that you give to your chickens?

Breeds

How many types of breeds do you keep?

Which one of them do you prefer and why?

Do you practice breeding? yes or no

If yes, how?

If no why?

Housing

1.Do your house

a) Yes or No

2. Give reason to your answer

3. When and which time of the year do you house your chicken?

Disease and mortality

Have you ever experienced disease outbreak of your chickens?

Describe the disease and time of occurrences.

When your chickens are sick what type/s of medicine/s do you give them?

Where do you get your medicine and how?

At age are your flock dies most?

Productivity

How many eggs do your chickens lay and how many per clutch?

What time of the year do they lay most?

Marketing and consumption

How often do you laughter your chicken and for what purpose?

Do you sell chicken and to whom?

In which form do you sell you chickens?

Which do sell most?

Do you sell eggs and for what?

1.2. Appendix C Questionnaire for physical characteristics

No	Sex	Body weight	Comb type	Feather type	Feather colour	Shank colour	Other feature
1	F/M		P/R/W/S	N//F/S	B/R/Br/W//Or /etc	Y/W/B/L/G	
2	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
3	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
4	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
5	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
6	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
7	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	
8	F/M		P/R/W/S	N//F/S	B/R/Br/W/etc	Y/W/B/L/G	

Definition of terms:

Com types: P; pea, R; rose, W; walnut; S; single

Colour. Bl; black, R, red, Br, brown, W; white, Or; Orange

Shank colour; Y; yellow, W; white, Bl; black, L; lead

Appendix 1.3. The factor score matrix used for the construction of graph Fig 24

OHG		OMS		OSN		KAV	
fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1
0.45925	1.46042	-0.86775	-0.59874	-0.97163	-0.62884	1.65208	-0.80293
0.57725	1.3843	-0.79734	-0.77439	-0.77057	-0.33911	1.5966	0.0351
-0.02721	1.07039	-0.56837	-0.95727	-0.92341	-0.58961	1.44845	0.06731
0.09528	1.28175	-0.48857	-0.00796	-0.62362	-0.09694	1.42414	1.07531
-0.00205	1.32466	-0.70807	-0.33059	-0.55732	-0.0174	2.21272	-0.19343
0.30053	1.51055	-0.64301	-0.37026	-0.58487	0.01641	2.11312	0.49159
-0.14164	0.28572	-0.86945	-0.97231	-0.78146	-0.24184	1.12063	-0.06133
-0.03507	0.61992	-0.71997	-0.32318	-0.88839	-0.60655	2.20924	-0.02685
0.17777	0.94091	-0.65133	-0.31984	-0.78036	-0.39402	1.77212	-0.59775
0.07238	1.11452	-0.81364	-0.4676	-0.73982	-0.26025	1.41707	-0.99595
-0.06812	0.46394	-0.66746	0.17868	-0.81537	-0.37707	0.74621	0.49032
-0.14756	0.51456	-0.53905	-0.7802	-0.58715	0.38032	1.25352	0.16972
-0.21508	0.69061	-0.50293	-1.1259	-0.68645	-0.54799	2.26779	-1.96107
0.13325	1.05064	-0.11757	-1.21481	-0.69004	-0.31318	2.48378	-1.76525
0.15526	0.84791	-0.24957	-0.96081	-0.78036	-0.39402	2.01149	-1.21186
1.0023	1.92225	-0.79784	-0.65606	-0.76635	-0.38391	1.71268	-1.90955
-0.13514	0.58828	-0.87057	-0.84621	-0.93566	-0.64947	2.44989	-3.25076

Appendix1.3. contd. The factor score matrix used for the construction of graph Fig 5.0

OHG		OMS		OSN		KAV	
fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1
0.63064	1.47444	-0.62249	-0.35905	-0.62337	-0.27499	3.10001	-2.6806
1.14502	0.76069	-0.84775	-0.52649	-0.79416	-0.40141	2.37401	-0.88289
0.12051	1.18205	-0.65232	-0.08818	-0.92341	-0.58961	1.5285	-1.2013
0.19333	1.08524	-0.82801	-0.58136	-0.88839	-0.60655	1.87783	-0.20018
0.03287	1.22052	-0.9051	-0.73982	-0.91227	-0.56572	1.71679	-0.81405
-0.20585	0.74703	-0.70235	-0.54519	-0.98553	-0.7442	2.18864	-2.06002
-0.22763	0.31292	-0.78863	-0.68657	-0.79068	-0.43687	2.45247	-1.28627
-0.32246	0.64389	-0.83294	-0.70136	-0.90372	-0.72599	3.07172	-2.28354
0.03345	1.10788	-0.95039	-0.76932	-0.99787	-0.62712	2.52422	0.98655
0.51063	0.89779	-0.66387	-0.44954	-0.83461	-0.62083	1.54886	1.22304
-0.13007	1.31576	-0.75015	-0.69604	-0.91333	-0.59826	1.98655	-1.65171
fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1
1.29422	2.08597	-0.76746	-0.59293	-0.83782	-0.54277		
1.19831	1.5275	-0.88248	-0.70087	-0.669	-0.06027		
-0.11447	0.46091	-0.78933	-0.67054	-0.98458	-0.74788		

Appendix1.3 contd. The factor score matrix used for the construction of graph Fig 5.0

OHG OMS OSN KAV

0.51529	1.20446	-0.78363	-0.50814	-0.90252	-0.52367
-0.13393	1.05362	-0.97612	-0.72215		
0.78652	1.51817	-0.69204	-0.45735		
0.51281	1.234	-0.91455	-0.63388		
0.15781	1.86305	-0.96568	-0.70879		
0.30562	1.03494	-0.59522	-0.1232		
0.12436	0.76138	-0.59512	-0.38076		
0.51823	3.24195	-0.72788	-0.30859		
0.66324	3.09407	-0.04577	-1.01464		
-0.29751	0.74962	-0.78044	-0.50012		
-0.38939	0.09215	-0.73266	-0.59037		

Appendix 1.3**.**The factor scores used for the construction of graph Fig 5.0

OHG		OMS		OSN		KAV	
fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1	fac1_1	fac2_1
0.16323	0.76889	-0.76566	-0.42472				
0.21302	1.07947	-0.70188	-0.3852				
-0.17905	0.95336	-0.45294	-0.9273				
0.25995	0.71774	-0.71071	-0.40937				
-0.09194	1.31006	-0.8685	-0.48607				
0.12095	1.85138	-0.54762	-1.39328				
-0.13158	0.65519	-0.71788	-0.41536				
-0.25157	0.88119	-0.70361	-0.79265				
0.21836	1.27441	-0.567	-0.71372				
-0.3543	0.72524	-0.85501	-0.58277				

-0.41271	0.15061	
0.40026	1.35299	
0.12351	0.67201	
-0.01748	0.83141	
0.786	1.23706	
0.1958	1.37991	
-0.50236	0.40929	
-0.49345	0.17923	
-0.35076	0.35916	
-0.12581	0.55248	
-0.24385	0.83874	

Appendix1.4. List of antisera explaining the variation among the four regions chickens in the studied regions based on PCA analysis

Antisera with variation				
8-14	1760	4832	6647	9645
273 331 360 449	1761 1764 1846 1991	4834 4836 4844 5011	6655 6710 7443 7599	9769 9772 9891 9990
1760	1760	1760	1760	1760
517	2088	5101	7602	
565	2096	5188	7606	
611	2293	5298	7618	
705	2423	5304	8064	
716	2481	5539	8154	
854	2857	5781	8258	
928	3024	5791	8228	
1060	3134	5793	8456	
1178	3136	5825	8681	
1250	3140	5915	9179	

Continued

Appendix1.4.contd. List of antisera explaining the variation among the four regions chickens in the studied regions based on PCA analysis

Antisera with variation				
1315	3158	6493	9259	
1427	3240	6497	9265	
1472	4316	6499	9267	
1554	4321	6502	9387	
1608	4765	6611	9640	

Note:

1) Based on 175 birds over the following four regions:

Oshana (n=32) Ohangwena (n=63)

Omusati (n=52) Kavango (n=28)

2) 24 antigens are not present in Namibian indigenous chickens