EPIDEMIOLOGICAL ASSESSMENT OF PRODUCTIVITY CONSTRAINTS AND APPROPRIATE INTERVENTION MEASURES ON INDIGENOUS CHICKEN PRODUCTION IN SOUTHERN NYANZA, KENYA

A THESIS SUBMITTED IN FULFILMENT OF REQUIREMENTS FOR DOCTOR OF PHILOSOPHY DEGREE OF UNIVERSITY OF NAIROBI (EPIDEMIOLOGY AND ECONOMICS)

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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DEDICATION

To my beloved wife Joyce Adhiambo Olwande; son Isaac Omondi and daughters Jael Achieng, Praise Anyango and Joy Akinyi for their prayers and support

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LIST OF ABBREVIATIONS AND ACRONYMS

AGID:	Agar Gel Immunodiffusion
AICAD:	African Institute of Capacity Building and Development
AHA:	Animal health assistant
APMV-1:	Avian paramyxovirus type 1
ASAL:	Arid and semi-arid land
ASPS:	Agricultural Sector Programme Support
BVM:	Bachelor of Veterinary Medicine
CCO:	Chick Confinements Only
CGD:	Community Group Discussion
CGKSO:	Consistent Maize Grains and Kitchen Left Over Supplementations Only
COIN:	Integrated Interventions (Vaccination, Chick Confinement and Supplementation)
Control:	No Interventions
DANIDA:	Danish International Development Assistance
DVS:	Director of Veterinary Services
ELISA:	Enzyme Linked Immunosorbent Assay
FAO:	Food and Agriculture Organization of the United Nations
FFS:	Farmer Field School
FGD:	Focus Group Discussion
FPVO:	Fowl Pox Disease Vaccinations Only
GDP:	Gross Domestic Product

GoK: Government of Kenya

GVO: Gumboro Disease Vaccinations Only

Ha: Alternate hypothesis

HA: Hemagglutination assay

H&E: Hematoxylin and Eosin

HI: Haemagglutination inhibition

Ho: Null hypothesis

IBDV: Infectious bursal disease virus

IDS: Institute for Development Studies

IHA: Indirect Haemagglutination

IIED: International Institute for Environment and Development

ISA: Institut de Selection Animale

KARI: Kenya Agricultural Research Institute

KNBS: Kenya National Bureau of Standards

MA: Ministry of Agriculture

MEM: Minimum Essential Medium

MLD: Ministry of Livestock Development

MSc: Master of Science

ND: Newcastle Disease

NDV: Newcastle Disease Virus

NPDP: National Poultry Development Project

NVO: Newcastle Disease Vaccinations Only

OIE:	World Organization for Animal Health
PATTEC:	Pan African Tsetse and Trypanosomiasis Eradication Campaign
PE:	Participatory epidemiology
PHA:	Passive Hemagglutination
PRA:	Participatory Rural Appraisal
PLA:	Participatory Learning and Action
RBCs:	Red Blood Cells
RRA:	Rapid Rural Appraisal
RT-PCR:	Reverse-Transcription Polymerase Chain Reaction
SPF:	Specific Pathogen Free
SSI:	Semi-Structured Interviews
UoN:	University of Nairobi
VN:	Virus Neutralization

ABSTRACT

The purpose of this study is to determine the factor(s) that limit indigenous chicken productivity; assess and prioritize them and come up with appropriate interventions that are sustainable in this livestock production system. The study was conducted in three phases in Migwa and Kagak villages in Kasipul division of Rachuonyo South Sub-County in Homabay County. The first phase was a rapid rural appraisal study that was followed by a cross-sectional survey in the second phase whereby identification and prioritization of indigenous chicken constraints was carried out. The third phase was a one year longitudinal study that assessed and quantified the constraints, and the benefits of controlled interventions.

The data was obtained by actual measurements, on spot observation, interview of household members directly responsible for management of chickens, community and focus group discussions, post mortem examinations and laboratory analysis.

Post mortem examination and laboratory analysis were conducted on sick and fresh dead chickens to establish causes of deaths throughout the study period whenever such cases arose.

Participatory Rural Appraisal and Participatory Learning and Action studies that complemented the other study approaches ran throughout the study.

The major production system was free-range whereby the birds got much of their own food through scavenging with irregular and inconsistent supplementation (mostly cereal grains and kitchen left overs) and housing mainly provided at night in human dwellings. Women controlled most of the activities related to the daily management of the birds.

Diseases were found to be the most important constraint to indigenous chicken production (about 80% of the total chicken deaths). Newcastle disease, Gumboro and fowl pox were the most important indigenous chicken diseases in order of importance. Bacteria and parasites were also found to be important diseases in the chickens. Predation of the chicks by birds of prey (eagles and hawks) and animals including mongoose, wild dogs and cats ranked second most important. The third most important constraint was scarcity of feed. Other constraints identified and ranked were theft, poor animal health service delivery, inadequate poultry management skills among farmers, poor housing, poverty amongst farmers and poor breed selection; in order of importance.

An important finding in this study is the identification of Gumboro as one of the most important diseases that lower productivity of the indigenous chickens. Previous studies have always considered the disease to be important only in the exotic chickens.

In the control group (with no interventions), the overall mean flock size for the study area was 15.8 birds per household. Chick survival rate to the age of twelve weeks was 24%. Chicken deaths accounted for 87% of total losses; with diseases being responsible for 80% of all deaths. Newcastle, Gumboro and fowl pox diseases were responsible for 36.1%, 21% and 16.9%, respectively, of the total disease deaths. Predation caused 20% of the total deaths. Mean Crude true rate mortality was 0.2316 per bird months at risk.

The intervention group that applied a combination of all interventions (COIN) recorded the lowest crude true rate mortality of 0.0191 per bird months at risk; more than 12 times lower than the rate in the control group, highest mean chick survival rate (82.6%) and largest mean household flock size (43.0 birds) and off takes. The COIN group concurrently controlled important indigenous chicken diseases; Newcastle, Gumboro and fowl pox (through vaccinations), prevented predations (especially in chicks by confinements) and improved the nutrition of the birds by consistently providing maize grains and kitchen left over supplementations. The productivity parameters reported by COIN group were statistically different ($p < 0.05$, in all cases) from the other groups; that practised only one of the following interventions; Newcastle vaccinations (NVO), Gumboro vaccinations (GVO), fowl pox vaccinations (FPVO), chick confinements (CCO) (from day one to three months of age) and consistent supplementations with maize grains and kitchen left overs (CGKSO) and the control.

This study identified combined intervention (COIN) as the most appropriate and sustainable technology, for the improvement of productivity of the indigenous chickens.

It is recommended that extension packages that would enhance the knowledge and skills of the indigenous chicken farmers on integrated interventions, as applied in the COIN group be initiated and sustained for the improvement of the productivity of the birds.

CHAPTER 1

1.0 Introduction

1.1 Background and information

Improving productivity of the indigenous chickens; that comprise over 70% of the 32 million domesticated birds and are kept mainly by the resource-poor rural families (MLD, 2010) is one way of increasing the agricultural production in Kenya. The agricultural sector contributes 25-26% of gross domestic product (GDP) of which 4% is from the poultry sub-sector (KNBS, 2010). Indigenous chickens contribute 71% of the total egg and poultry meat produced in Kenya (Nyaga, 2007) and therefore impact significantly on the rural trade, welfare and food security of small holder farmers.

There are two distinct poultry production systems in Kenya, namely intensive and extensive. Intensive system is usually found in the urban and peri-urban areas and uses the improved (hybrid) breeds. Indigenous chickens are mainly raised in rural areas under extensive (scavenging) system, the production is small-scaled and most households use family labour and, where possible, locally available feed resources (MLD, 2010).

Chickens under extensive system range freely during the day and find much of their own food; however some little and inconsistent grains/ kitchen left over supplements are given. Housing is done at night, mainly in human dwellings to protect the birds from wild animals and thieves (Wachira *et al.*, 2010; Okeno *et al.*, 2011). The extensive system exposes the indigenous chickens to harsh conditions such as diseases, predation, inadequate feeding, poor housing and extreme weather changes, resulting in low productivity (Ondwasy *et al.*, 2006).

Previous studies on indigenous chicken productivity constraints in Kenya including those of Okitoi *et al.*, (2006; 2008; 2009), Ondwasy *et al.*, (2006), and others have shown that extra effort in the management of the indigenous chickens in the area of housing, feeding, animal health care and genetic selection will be able to improve among others; flock and clutch sizes, egg production and hatchability.

Most of these studies have made recommendations for the improvement of productivity, with implementations done by farmers. Despite this, surveys still report low productivity (Wachira *et al.*, 2010). Studies including Nyaga, (2007) and Okeno *et al.*, (2011) confirm that indigenous chicken production in Kenya is still constrained, with low productivity, and needs to be improved.

This low productivity despite improvement efforts is an indication that, apart from the already documented constraints, other factors that are not yet identified could also be playing some role (Wachira *et al.*, 2010). Productivity improvement could only be realised when real constraints are identified and effectively addressed (Okuthe, 1999).

Livestock constraints differ from region to region and amongst production systems (Okuthe, 1999). Availability of indigenous chicken production baseline data for southern Nyanza would guide mitigations for the improvement of the indigenous chicken productivity in the region.

Indigenous chicken production requires low initial capital investment to start and it is always an affordable source of livelihood in terms of food and cash income for resource-poor people, especially women and children.

This study was conducted in Rachuonyo South Sub-County in Homa County to complement Pan African Tsetse and Trypanosomiasis Eradication Campaign, Kenya (PATTEC-Kenya) project. PATTEC-Kenya intends to initiate integrated/ multi-sectorial economic land use activities after tsetse fly suppression for the benefit of the local community. This was to enable the recommendations arising from this study to be incorporated in the PATTEC-Kenya project activities. PATTEC-Kenya was also geared towards improving indigenous chicken production in order to improve the livelihood of the local poor through alleviation of poverty and food insecurity by ensuring sustained availability of protein.

The study assessed the constraints that lowered indigenous chicken productivity and recommended sustainable intervention measures for improved productivity and increased production. The strength of this study was that farmers were involved all the way from constraints identification and ranking, through interventions to evaluation. The recommended interventions were therefore relevant and sustainable, because they were built on farmers' viewpoints.

This study is the first to report Gumboro as the second most important disease of the indigenous chickens after Newcastle disease. A number of previous studies have always ignored the disease in this category of chickens and only considered it as important in the exotic breeds (commercial layers and broilers).

1.2 Hypotheses

1.2.1 Null hypothesis (Ho)

Identification of production constraints and putting in place appropriate intervention measures will not improve productivity of the indigenous chickens.

1.2.2 Alternate hypothesis (Ha)

Identification of production constraints and putting in place appropriate intervention measures will improve productivity of the indigenous chickens.

1.3 Objectives

1.3.1 Overall objective

To assess the productivity constraints and appropriate intervention measures on indigenous chicken production in southern Nyanza, Kenya

1.3.2 Specific objectives

1. Identify and prioritize constraints causing indigenous chickens' production losses
2. Quantify the indigenous chicken productivity constraints
3. Quantify the impacts of intervention measures on the indigenous chicken constraints

2. 4 Justification and significance of the study

Indigenous chickens comprise the highest number of poultry in Kenya, and with very little input from the owners, they contribute significantly to the socio-economic welfare of the rural communities.

The indigenous chickens are easier to rear compared to other livestock that require a large capital outlay. Any efforts towards increasing the productivity of these birds will help in poverty alleviation and food security improvement for the majority of the people living in the rural areas. Efforts to improve the productivity of the indigenous chickens have been tried in the past, with several recommendations coming up from previous studies and being implemented by farmers. No tangible results have come from these attempts, productivity of the birds have remained low over the years. The meaning of this could be that some key factors and constraints that lower the productivity of these birds have not been accurately identified by the previous studies to inform effective, efficient and sustainable mitigation processes.

This study therefore, was an attempt to identify factors that persistently lowered the indigenous chicken productivity in southern Nyanza, despite implementations of previous study recommendations.

Since livestock constraints differ from region to region and amongst production systems. Obtaining indigenous chicken constraints and production data for southern Nyanza is key in guiding sustainable mitigations. Although past studies have made some progress by identifying some indigenous chicken constraints in other parts of Kenya; data for southern Nyanza would certainly provide some information that is specific for the region. That would be taken into account during mitigation formulation.

Southern Nyanza has a large number of indigenous chickens (over 3 million) with almost every household keeping the birds. The potential of these birds is hampered by heavy production losses that result into low productivity. This study aimed at addressing this.

CHAPTER 2

2.0 Literature review

2.1 General information

Indigenous chickens are generally multicoloured, long legged and smooth feathered with a few fizzled feathered, naked necked and dwarf birds (Njenga, 2005; Mogesse, 2007; Yakubu, 2010). The Food and Agriculture Organization of the United Nations (FAO) classifies indigenous chickens as Sector 4; a category of poultry that is rural (non-urban) in location and subsistent or non-commercial in purpose. The birds are more adapted to the adverse conditions found in most of the developing countries of the world compared to the commercial (improved) breeds (Njenga, 2005; Gonomela *et al.*, 2006; Mogesse, 2007). The birds are mostly kept under extensive system (Nyaga, 2007; Wachira *et al.*, 2010; Yakubu, 2010) in sub-Saharan Africa and other parts of the world (Gueye, 2002a; Mapiye and Sibanda, 2005; Mandal *et. Al.*., 2006; Sekeroglu and Aksimsek, 2009; Yakubu, 2010; Msoffe *et al.*, 2010; Youssouf *et al.*, 2011).

Indigenous chicken production requires the lowest capital investment of any livestock species; they have a short production cycle (Sonaiya and Swan, 2004; Sekeroglu and Aksimsek, 2009) and mainly feed through free-ranging, with little grain supplement (Swai *et al.*, 2007). The output of indigenous chickens is lower than that of intensively raised hybrid chickens but is obtained with a minimum input in terms of housing, disease control, management and supplementary feed (Haitook *et al.*, 2003; Sonaiya and Swan, 2004; Okitoi *et al.*, 2007).

In Kenya the indigenous chickens' egg production ranges from 36 to 97 eggs per hen annually (Siamba *et al.*, 2002; Okeno *et al.*, 2011); and the range for exotic chickens is 250-280 eggs per hen annually (MLD, 2010).

A lot of efforts to improve the indigenous chicken production in Kenya have been made. A cockerel exchange programme was carried out in Kenya from 1976 to 1994 under the auspices of the National Poultry Development Programme (NPDP), jointly funded by the Government of Kenya (GoK) and the Netherlands Government, but failed due to high mortalities and non-broody nature of the progeny (NPDP, 1985-1986; Njenga, 2005). In 2003, the Smallholder Poultry Development Project was initiated under the Agricultural Sector Programme Support (ASPS), funded by the Danish International Development Assistance (DANIDA) in collaboration with GoK in Coast province where Institute for egg layer Selection (ISA) Brown hens were being crossed with local cocks to produce hybrid chickens. The major challenge was the requirement of a constant external parent stock supply that would mean continuous presence of a well-managed hatchery facility and grandparent stock. This was beyond the scope of the smallholder farmers (Njenga, 2005).

Several other studies on indigenous chicken production, including Siamba *et al.*, (2002), Bebora *et al*., (2005), Okitoi *et al.*, (2006), Nyaga, (2007), Mutinda, (2011) and Njagi *et al.*, (2012) among others, have made recommendations, aimed at improving the productivity of these birds. Surveys, however, still show low productivity despite the implementation of most, if not all of the recommendations by the farmers (Wachira *et al.*, 2010).

It is important to note that in free range production system, under which over 90% of indigenous chickens are kept (Bebora *et. al.*, 2005; Ondwasy *et al.*, 2006), several factors; some yet to be identified, play significant roles in lowering productivity and production of the birds (Wachira *et al.*, 2010). Most of the livestock (including indigenous chicken) constraints are biological and act through interactions, that is, the presence or absence of one would modify the effect(s) of the other(s) (Okuthe, 1999). Studies, and thus recommendations that would only target one or just very few constraints, but ignore other related factors would always fail to improve the productivity of the birds.

Most previous studies expected to solve the problem of low productivity, were, however, specific in focus, and targeted specific constraint(s); within their objectives and never considered any other factors perceived to be outside the objectives. For instance, the studies by Njagi, (2008) and Mutinda, (2011) were specific to Newcastle and Gumboro diseases, respectively; and each study made recommendations within its objectives. Okitoi *et al.*, (2006), on the other hand, was a little bit broader and investigated chick predation and inadequate feeding, but only assessed one disease, Newcastle disease, and gave recommendation(s) within the study objectives.

Farmers have been implementing most of the recommendations, but no significant productivity improvement has been recorded (Wachira *et al.*, 2010; Okeno *et al.*, 2011). An indication that factors that lower the productivity are not yet fully addressed and integrated by previous recommendations.

A holistic approach that would accommodate perceptions of major stakeholders in the indigenous chicken production is a recommended option for productivity improvement (Catley *et* *al.*, 2001; Catley *et al.*, 2002; Okuthe *et al.*, 2003; Msoffe *et al.*, 2010). Real constraints and factors that hinder indigenous chicken production would be accurately determined by a holistic method. This is to inform relevant mitigation processes for improved productivity of the birds.

This study, thus, used both qualitative and quantitative methods, coupled with one year controlled intervention trials, to evaluate the factor(s) that hindered indigenous chicken production and recommended sustainable intervention measures for improved productivity within the indigenous chicken industry. Controlled intervention trials on the identified constraints were run for one full year with full participation of the farmers. The aim was to come up with mitigation measures that would take care of social, cultural, economic and climatic (seasonal) aspects of the target community. Such aspects are important for successful adoption of project recommendations by target communities (Okuthe, 1999).

2.2 Productivity of indigenous chickens

Productivity of an animal can be defined as product output per animal unit per unit time, for instance, eggs per hen per year or product output per unit of input, example, live weight gain per kilogram of feed or the value of product output per unit input in monetary terms (Mwalusanya, 1998; Siamba *et al.*, 2002; Sonaiya and Swan, 2004; MLD, 2010; Sekeroglu and Aksimsek, 2009). It has been established that, when raising chickens, low inputs, as in the case of indigenous chicken production result in low productivity, while high inputs, associated with raising of improved commercial chickens, result in higher yields (Swai *et al*, 2007; Abdelqader *et al.*, 2007; MLD, 2010; Yakubu, 2010; Desta and Wakeyo, 2011).

Studies by Mwalusanya (1998) in Tanzania, Nahamya *at al.*, (2006), in Uganda and Yakubu, (2010) in Nigeria on indigenous chickens reported household flock sizes ranging between 10-20 chickens per household, Abdelqader *et al.*, (2007) in Jordan reported household flock size of 42 birds, with hen to cock ratio of 3:2. Abdelqader *et al.*, (2007) in Jordan reported positive significant correlation between management level (disease control, feeding, among others) and chicken performance; in terms of flock size, growth rate, egg production, eggs size, among others.

Research findings in many parts of the world including Msoffe *et al.*, (2002) and Mwalusanya, (1998) in Tanzania, Gnakari *et al.*, (2007) in Cote d'voire, Mandal *et al.*, (2006) in India and Yakubu, (2010) in Nigeria showed that indigenous chickens were characterized by slow growth and majority of the birds were immature, with chick survival rate in some cases lower than 10%. Cocks were the fewest of all the categories of chickens kept, with the mean cock to hen ratio of 1:4-5. Average age at first laying, for the indigenous chickens ranged between 6-10 months (Mandal *et al.*, 2006), compared to the improved (commercial) chickens that start laying at 5 months of age (MLD, 2010). In Tanzania the mean live weight for cocks and hens was reported as 2261gramme (g) and 1441g, respectively (Msoffe *et al.*, 2002) and 1948.1g and 1348g, respectively (Mwalusanya, 1998); the live weight at one week of age was 37.7 ± 5.3g and at 3 months were 398 ± 107g for females and 588 ± 152g for males (Missohou *et al*, 2002). Low annual egg production levels have been reported in different studies. Mapiye and Sibanda, (2005) in Zimbabwe reported average number of eggs laid and incubated per clutch and egg weight to be 10 ± 2, 8 ±1 and 52.2g ± 2, respectively. Msoffe *et al.*, (2002) in Tanzania reported clutch size, number of clutches per year and egg weight (in grams) as 17.7 ± 0.25, 2.6 ± 0.06 and 46.4 ± 0.86, respectively. Fisseha *et al.*, (2010) in Ethiopia reported egg size of 43 g. High hatchability rates of 100%, 77% and 60-65% had been observed in Tanzania (Mwalusanya, 1998), Senegal (Missohou *et al.*, 2002) and India (Mandal *et al.*, 2006), respectively.

In Kenya, indigenous chickens are the majority, comprising 70% of 32 million poultry in the country, but only contribute 60% and 50% of the chicken meat and eggs consumed in the country. Productivity of the indigenous chickens is low compared to that of the exotic/ commercial chickens (broilers and layers) and this has been attributed to low inputs associated with free-range production system, the preferred system for over 90% of the indigenous chicken farmers in the country (Nyaga, 2007; Wachira *et al.*, 2010).

Most studies including those of Siamba *et al.*, (2002), Okitoi *et al.*, (2006), Olwande *et al.*, (2010) and Okeno *et al.*, (2011) reported flock sizes with wide variations among regions; ranging between 10-22 chickens per household. The majority of the chickens in the flock were immature birds, just as observed in other parts of the world. Siamba *et al.*, (2002), Okitoi *et al.*, (2002) and Olwande *et al.*, (2010) reported hatchability of 84%, over 70% and 80%, respectively. Despite the good hatchability of indigenous eggs, most of the chicks that are hatched die in their early life due to both diseases and predation (Okuthe, 1999; Ondwasy *et al.*, 2006; Wachira *et al.*, 2010).

2.3 Indigenous chicken productivity constraints

Most indigenous chickens in sub-Saharan Africa are on free-range system and are fed little grain (Missohou *et al.,* 2002; Mandal *et al.*, 2006). Indigenous chicken production is hampered by several factors: Msoffe *et al.*, (2002) in Tanzania, Desta and Wakeyo, (2011) in Ethiopia, Mapiye and Sibanda, (2005) and Muchadeyi *et al.*, (2008) in Zimbabwe, Adene and Oguntande, (2006) and Yakubu (2010) in Nigeria and Mandal *et al.,* (2006) in India identified diseases and lack of proper production technologies as the most important constraints to the indigenous chicken production.

Report by Aboe *et al.,* (2006) in Ghana was in agreement with the findings from other parts of the world that Newcastle disease is the most important health issue. Newcastle disease occurs every year and kills on average 70-80% of the unvaccinated indigenous chicken flocks (Gueye, 2002b). Gondwe and Wollny, (2005) and El Zubeir (1997) reported inadequate feeding as an important constraint to the expansion of indigenous chicken production in Malawi and Sudan, respectively. Tadelle *et al.*, (2003) in Ethiopia reported a considerable loss of eggs in terms of the time taken by the laying hen to incubate eggs and brood young chicks. Such a loss could be reduced when improved technology was applied.

Other constraints to indigenous chicken production were low genetic potential of the local chicken due to lack of breed selection (Duguma, 2006; Fayeye and Oketoyin, 2006) and unreliable poultry marketing systems (Gausi *et al.,* 2004; Nyaga, 2007).

In Kenya, indigenous chicken production is hindered by several factors (MLD, 2010). The chickens are kept under poor management conditions due to lack of skills and finance (MLD, 2010).

Several findings including Kingori *et al.,* (2007) and Mungube *et al.,* (2007) identified the major constraints to indigenous chicken production as diseases, particularly Newcastle disease, feed deficit and heavy losses of chicks through predation. Okuthe, (1999) reported the major predators for the chicks as hawks and eagles; and for growers and adults as mongooses. Mungube *et al.,* (2007) reported parasites as one of the most important constraints of the indigenous chicken production in the ASALs of Kenya.

Uncontrolled mating; major cause of inbreeding among the indigenous chicken population, has been a big challenge, resulting into low genetic potential in the birds (Okeno *et al.,* 2011). The indigenous chicken marketing system is also not well organized and everything depends on the individual efforts of the farmer (Siamba *et al.*, 2002; Nyaga, 2007; MLD, 2010).

2.4 Qualitative study methods

Qualitative studies that are participatory in approach actively engage major stakeholders in the community in the study. The participatory methods enhance the penetration of data collection activities into local communities (Catley *et al*, 2001 and 2002; Okuthe *et al.*, 2003; Chambers, 2010) making the findings to reflect the average views of the target community; an important factor for the success of the interventions. A key feature of participatory epidemiology is triangulation or crosschecking information derived from multiple sources and methods (Okuthe *et al.*, 2003). These approaches comprise Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA) and Participatory Learning and Action (PLA).

2.4.1 Rapid rural appraisals

Rapid rural appraisal (RRA) is a rapid study within a fairly short period. It uses mainly qualitative tools (Townsley, 1996; Bhandari, 2003; Chambers, 2007and 2010). Local knowledge is respected and forms a major part of the data gathered but the process is essentially "extractive" (Leyland, 1991; Bhandari, 2003) in that, researchers take away the collected information. Rapid rural appraisal is mainly seen as a means for outsiders to gather information within the local community (Okuthe *et al.*, 2003).

Rapid appraisal methods have been developed to overcome limitations of baseline questionnaire surveys (Ghirotti, 1993). The use of rapid appraisals has been increasing and rapidly becoming more popular in livestock work (Catley *et al*, 2001 and 2002; Okuthe *et al.*, 2003 and 2005).

2.4.2 Participatory rural appraisals

The study methodology can be best described as a family of approaches, methods and behaviours that enable local people to share, enhance and analyze their knowledge of life and conditions, to plan for themselves what action(s) to take and to monitor and evaluate the results (Chambers, 1994 and 2010; Okuthe *et al*, 2003). The approach is similar to other diagnostic survey techniques known variably as exploratory surveys (Collinson, 1981; Bhandari, 2003; Chambers, 2007), informal agricultural surveys (Chambers, 1995; Catley, 2006) and reconnaissance surveys (Chambers, 1994).

It combines secondary data review, semi-structured interviews (SSI), observation of farm activities, and formal and informal group meetings to identify and evaluate specific needs with researcher as a facilitator in the process (Chamber, 1994; Bhandari, 2003; Barahona and Levy, 2007). Participatory rural appraisal recognizes the community residents' working knowledge of their own problems and hence involves them in the analysis of the problems and the formulation of solutions (Catley, 2006).

Participatory rural appraisal is similar to RRA in most cases, except that, in PRA information is more shared, owned and used by local people; as opposed to RRAs, where information is perceived to be taken away by outsiders/ researchers (Chambers, 1994); that is, extractive. The PRA approach emphasizes empowering local people; this is another difference from RRA which is seen as a means for outsiders to gather information (Chamber, 2007 and 2010).

Both PRA and RRA were developed by researchers as an alternative and complement to conventional structured sample surveys. Participatory rural appraisal has been applied in all domains of life including surveys in livestock research, among others (Catley *et al*, 2001, 2002 and 2006). A weakness of qualitative surveys in the form of RRA and PRA is that the quality of the information produced depends on the interviewers' skills, experience and knowledge (Okuthe *et al.*, 2005; Catley, 2006).

2.4.3 Participatory Learning and Action

Participatory learning and action (PLA) is an approach for learning about and engaging with communities (Blackburn and Holland, 1997; Chambers, 1997). It combines an ever-growing tool kit of participatory and visual methods with natural interviewing techniques and is intended to facilitate a process of collective analysis and learning. The approach can be used in identifying needs, planning, monitoring or evaluating projects and programmes (Kumar, 2002). It offers the opportunity to go beyond mere consultation and promote the active participation of communities in the issues and interventions that shape their lives (IIED, 1998).

The approach has been used, traditionally, with rural communities in the developing world. There it has been found extremely effective in tapping into the unique perspectives of the rural poor, helping to unlock their ideas not only on the nature and causes of the issues that affect them, but also on realistic solutions (Blackburn and Holland, 1997; Chambers, 1997). It enables local people to share their perceptions and identify, prioritize and appraise issues from their knowledge of local conditions (Chambers, 1997). Participatory learning and action tools combine the sharing of insights with analysis and, as such, provide a catalyst for the community themselves to act on what is uncovered (IIED, 1998).

2.4.4 Focus groups

Focus group interviewing is a qualitative tool that provides and generates a rich understanding of participants' own attitudes, perceptions, opinions, beliefs and experiences (Chambers, 1994; Okuthe *et al*, 2003). One of the most valuable benefits of focus groups is the dynamics of the discussions that occur among the participants, who are always placed in natural real life situations (Olwande, 2009).

A good focus group is fairly homogenous in composition and works best when the interest for all participants of the group is the same (Okuthe *et al.*, 2003). The recommended number for focus groups is 8 to 13 participants (Okuthe *et al.*, 2003). Focus groups can be used both in rapid and participatory rural appraisal studies. They are also very useful in monitoring and evaluation studies especially when intervention measures are carried out.

2.4.5 Community group discussion

Community group discussion (CGD) is a Participatory epidemiological study tool that engages communities in discussions to get their perceptions on issues of interest; twenty to 30 participants are recommended (Bhandari, 2003). The researcher uses a check list to guide the discussions by asking questions while active discussions/ guided activities are done by the community (Okuthe *et al.,* 2003). Community group discussion always brings together individuals of diverse interests; it is heterogeneous in composition (Chambers, 1997).

2.5 Cross-sectional studies

Cross-sectional studies are used to investigate a population at a particular point in time. They can be used to monitor diseases in field studies by recording prevalence data (Schwabe *et al.,* 1977; Martin *et al.*, 1987; Noordhuizen, 1999; Salman, 2003: Thrusfield, 2007). They are also used to provide data on a large number of other variables present in livestock populations (Okuthe *et al.*, 2003). These studies can be quick, relatively cheap to conduct and if done well, can give a very informative 'snapshot' of the situation at the time in question (French, 1999).

Cross-sectional studies have disadvantages of the inability to determine 'cause or effect' when examining associations between 'risk factors' and disease (Noordhuizen *et al.*, 1999).

2.6 Observational longitudinal studies

A longitudinal study uses repeat visits over a period of time, with a combination of research observation and structured questionnaires (Martin *et al.*, 1987; Toma *et al.*, 1999; Thrusfield, 2007).

This method of collecting accurate and representative field data in the form of active monitoring and evaluation is expensive (Martin *et al.*, 1987). It is most suitable for research projects.

It is useful for disease incidence data, confirmation of diseases and recording of livestock production parameters for species such as small ruminants and poultry for which farmers may not have a good recall of counts.

2.7 Controlled intervention trial study

Controlled intervention trials are used primarily to assess the efficacy of a therapeutic product or regimen or that of a prophylactic procedure (like a vaccine or a change in the way animals are managed) (Martin *et. al.*, 1987). The study animals are randomly allocated in their natural setting, privately owned, and not purchased or maintained for experimentation. Disease in animals is naturally occurring, not induced. While the researcher has some control over the way treatments or prophylactic procedures are carried out, the actual administration may be done by the animals' owners (Dohoo *et al.*, 2003).

2.8 Diagnosis of Newcastle disease

Newcastle disease (ND) is caused by virulent strains of avian paramyxovirus type 1 (APMV-1) of the genus Avulavirus belonging to the family Paramyxoviridae. There are ten serotypes of avian paramyxoviruses designated APMV-I to APMV-10. Newcastle virus has been shown to be able to infect over 200 species of birds, but the severity of disease produced varies with both host and strain of virus

2.8.1 Newcastle disease virus isolation

Newcastle disease virus (NDV) is readily cultivated in 10 to 12 day-old specific pathogen free (SPF) embryonated eggs, inoculated into the allantoic sac. Although virulent ND viruses can be propagated in cell cultures, embryonated chicken eggs are more preferred since they are more sensitive and convenient (Alexander, 2003). Isolation can be made from tracheal and cloacal swabs, faeces, bone marrow and spleen. The samples are normally transported on ice or frozen (Omojala and Hanson, 1986). Bone marrow may be a useful sample for virulent viruses as the viruses have been demonstrated to be present after several days at 30^0C (Omojala and Hanson, 1986). Many strains of NDV inoculated in embryonated chicken eggs will kill the embryos in 24 - 72 hours, causing haemorrhagic lesions and encephalitis. The infected allantoic fluids will agglutinate chicken red blood cells (RBCs). Most NDV strains will multiply, produce haemagglutinins, haemadsorb and cause cytopathic changes in a wide range of secondary cultures including those of rabbit, pig, calf, monkey kidney, chicken tissues and HeLa cells (Alexander, 1997).

2.8.2 Serology

Numerous serological tests may be used to detect antibodies, but the most commonly used one is the haemagglutination- inhibition test (Alexander, 2003). The OIE states that a titre may be regarded as positive if there is inhibition at a serum dilution of 2^4 or more against 4 HA units, or 2^3 or more against 8 HA units (OIE, 2000). Positive serology and clinical signs in unvaccinated birds are strong diagnostic evidence of ND especially in situations where virus isolation is not possible. For the use of HI and other tests in measuring immune status of vaccinated birds, mean level of HI titres ranging from 2^4 – 2^6 after a single live vaccine to 2^9 – 2^{11} with multiple programme are expected (Alexander, 2003).

Other tests used to detect antibodies to NDV in poultry sera include: single radial immunodiffusion (Chu *et al.*, 1982), single radial haemolysis (Hari, 1986), virus neutralization (VN), enzyme – linked immunosorbent assay (ELISA) (Snyder *et al*., 1984), passive hemagglutination test (PHA) (Roy and Venugopalan, 2000) and plaque neutralization (Beard and Hanson, 1984). Enzyme – linked immunosorbent assay (ELISA), which can be automated, has become popular, especially as part of flock screening procedures (Snyder *et al*., 1984). Good correlation has been reported between ELISA and HI tests (Cvelic – Cabrilo *et al*., 1992).

In passive hemagglutination test (PHA), once the quantified virus is tagged to the 1% fixed chicken red blood cells, the cells can be stored at 4^0C for a longer period and a large number of samples can be tested for the antibodies, thus minimizing any variation in results and rendering the test quick and easy. Results could be obtained by the PHA test in 40 minutes. Thus, the PHA test is an easily adoptable test for serological monitoring for NDV in commercial flock (Roy and Venugopalan, 2000)

2.9 Diagnosis of infectious bursal disease

Infectious bursal disease (IBD) is caused by a virus that is a member of the genus Avibirnavirus of the family Birnaviridae. Although turkeys, ducks, guinea fowl and ostriches may be infected, clinical disease occurs solely in chickens. Infectious bursal disease virus causes lymphoid depletion of the bursa, and if this occurs in the first 2 weeks of life, significant depression of the humoral antibody response may result. Two serotypes of IBDV are recognized. These are designated serotypes 1 and 2.

2.9.1 Infectious bursal disease virus isolation

Bursa of Fabricius is normally used for the isolation of the infectious bursal disease virus (IBDV) (Lukert and Saif, 2003); the virus can be found in other organs such as the spleen, thymus, liver and bone marrow but in significantly low quantities than in the bursa (Cheville, 1967). The inoculum for virus isolation is prepared by homogenizing the tissue sample in antibiotic containing buffer that is centrifuged to remove larger tissue particles and is used for inoculating embryonated eggs and tissue culture (Lukert and Saif, 2003).

Chorioallantoic inoculation in 9 -11 day old chicken embryos is the most sensitive route for the isolation of the virus. Classic viruses usually kill the embryos in 3-5 days and produce lesions of vascular congestion and subcutaneous haemorrhages in the embryos. Serotype 1 IBDV produces dwarfing of the embryo, subcutaneous oedema, congestion and subcutaneous or intracranial haemorrhages. The liver is usually swollen, with patchy congestion producing a mottled effect. In later deaths, the liver may be swollen and greenish, with areas of necrosis. The spleen is enlarged and the kidney is swollen and congested, with a mottled effect. Variant viruses however, do not kill the embryos but cause embryo stunting, discoloration, splenomegally and hepatic necrosis (Lukert and Saif, 2003).

Primary cell cultures of chicken embryo fibroblasts, bursa and kidney have been used to propagate the virus (McFerran, 1980). Isolation, antigenic analysis and pathogenicity studies of the viruses isolated from field cases are done to detect the changes in the wild virus population but for routine diagnosis of outbreaks (Lukert and Saif, 2003).

2.9.2 Serology

Serologically, IBDV in clinical samples is conveniently detected by agar gel immunodiffusion (AGID) and antigen capture enzyme linked immunosorbent assay (ELISA). The AGID test has been used for primary screening of bursa of Fabricius samples before attempting isolation and further characterization of IBDV. It does not detect serotypic differences and measures primary group-specific soluble antigens (Lukert and Saif, 2003). Immunofluorescence and molecular techniques have been used to detect IBDV antigen. The most common molecular method is the reverse-transcription polymerase chain reaction (RT-PCR) (Wu, 1992). Virus neutralization procedure is extremely sensitive and is sufficiently specific to differentiate between serotypes of IBDV (Weisman and Hitchner, 1978).

The most commonly used test for the detection of antibodies to IBDV is ELISA. It is quantifiable, sensitive and reproducible procedure, which can be automated (Marquardt *et al.*, 1980). The AGID test has been adapted to the quantitative format to quantify antibodies to IBDV (Cullen and Wyeth, 1975). Other serological tests that have been used to detect IBDV antibodies include indirect haemagglutination (Aliev *et al.*, 1990), counter immune-electrophoresis (Hussain *et al*, 2002) and single radial haemolysis (Hussain *et al.*, 2003) tests. The indirect haemagglutination (IHA) test is considered to be inexpensive, quick and easy to perform (Rahman *et al.*, 1994).

2.10 Fowl pox disease

Fowl pox is a slow-spreading viral infection of chickens and turkeys characterized by proliferative lesions in the skin (cutaneous form) that progress to thick scabs and by lesions in the upper gastrointestinal and respiratory tracts (diphtheritic form). It is seen worldwide (Cynthia and Scott, 2011).

Diagnosis

Cutaneous infections usually produce characteristic gross and microscopic lesions (Saif *et al.*, 2003; Cynthia and Scott, 2011). When only small lesions are present, it is often difficult to distinguish them from abrasions caused by fighting (Cynthia and Scott, 2011). Microscopic examination of affected tissues stained with H&E reveals eosinophilic cytoplasmic inclusion bodies. Cytoplasmic inclusions are also detectable by fluorescent antibody and immunohistochemical methods (Cynthia and Scott, 2011). Viral particles with typical poxvirus morphology can be demonstrated by negative-staining electron microscopy as well as in ultrathin sections of the lesions. The virus can be isolated by inoculating chorioallantoic membrane of developing chicken embryos, susceptible birds, or cell cultures of avian origin. Chicken embryos

(9-12 days old) are the preferred and most convenient host for virus isolation (Cynthia and Scott, 2011).

CHAPTER 3

3.0 Methods and materials

3.1 Study preparation

Permission to conduct the study was sought from the Director of Veterinary Services (DVS) before its commencement. The research team comprising the investigator and two enumerators (minimum qualification of animal health certificate) visited the Sub-County to meet the stakeholders in the poultry industry that included the field extension officers of the Ministry of Livestock Development and Ministry of Internal security and provincial administration. The team then visited 10 randomly selected farms in the company of the district extension officers to familiarize with the farming systems and introduce the research topic.

3.2 Study site

The project was carried out in Migwa and Kagak villages in Nyalenda sub-location, North Kamagak location, in Kasipul division of Rachuonyo South Sub-County, in Homa Bay County (Figures 3.1 and 3. 2).

The Sub-County is located in the southern western part of Kenya and bordered by Nyando Sub-County to the north, Kisii Central and Nyamira Sub-Counties to the south east, Homa Bay Sub-County to the south west, Kericho Sub-County to the east and Rachuonyo North Sub-County to the north and west. The Sub-County lies between latitudes 0^0 15’ and 45’ south, longitudes 34^0 25’ and 35^0 east with an area of $407km^2$. Altitude ranges between 1135 to 1600 metres above the sea level.

The Sub-County climate is modified by the effect of the altitude and proximity to Lake Victoria. The Sub-County has two rainy seasons; the long one that starts from late February and runs through June with rainfall ranging between 500mm and 1000mm and the short rainy season that occurs between late August and November, with a range between 250mm and 700mm. The Sub-County experiences the driest spells during the months of December to February and June to August during which period both agricultural and livestock activities are at minimum. Local temperatures are relatively high ranging between 14^0C and 20^0 C.

Administratively, the Sub-County is divided into two divisions namely Kabondo and Kasipul. According to the 2009 Population and Housing Census, Rachuonyo Sub-County had a total of 382,711 persons of which 199,744 are females and 182,967 are males. Forty per cent of the population consists of a dependent age; between 0-14 while 29.2% is comprised of a youthful population aged between 15-29 years (KNBS, 2010). The Sub-County has a population density of 403 persons per km^2 (KNBS, 2010).

Agriculture sector's contribution to house hold income is 70%. Main crops grown are maize, sweet potatoes, millet, sorghum and pineapples. Zebu cattle, red Maasai sheep, East African small goats and indigenous chickens are the main types of livestock kept. Rural and urban absolute poverty rate is 77.49% (MA, 2010; KNBS, 2010).

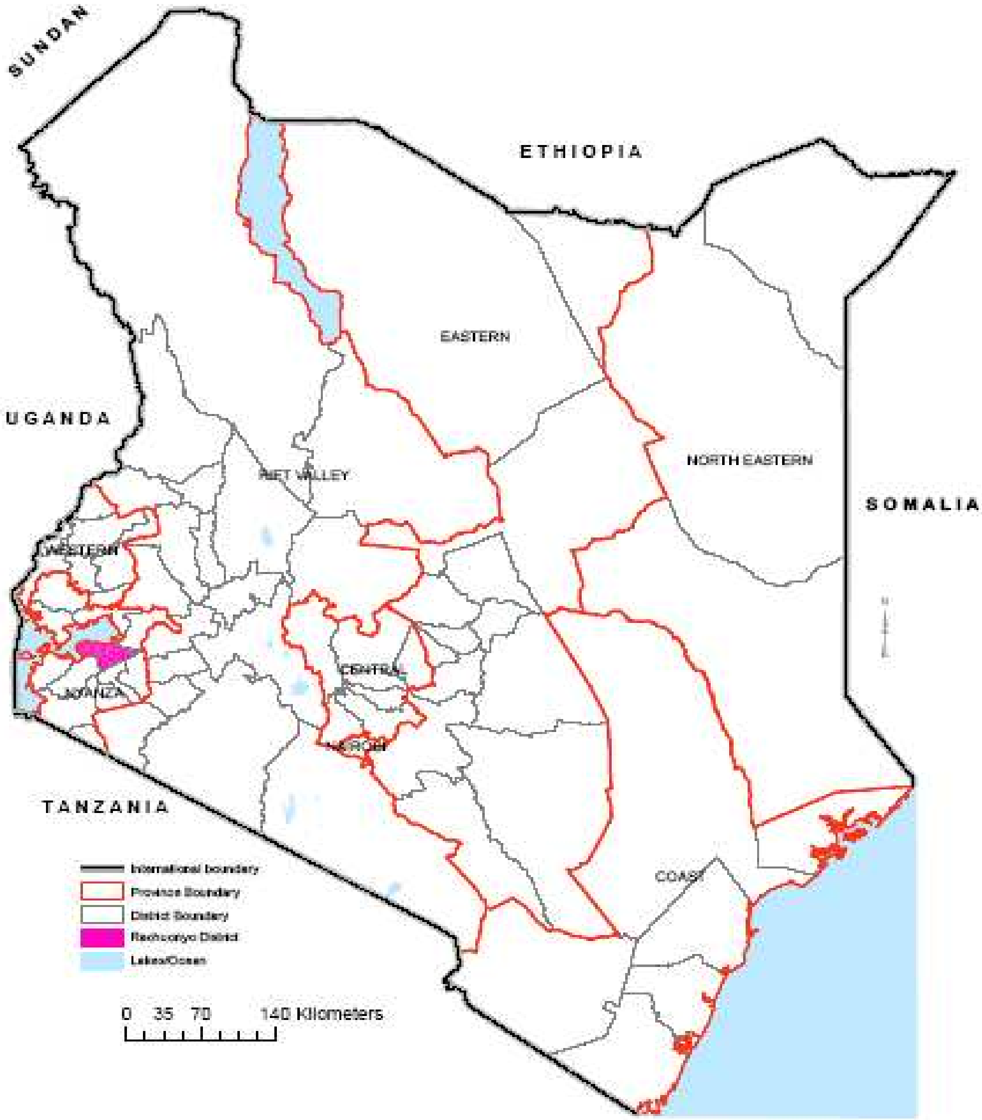

Figure 3.1Map of Kenya showing Rachuonyo South Sub-County (Source: Ministry of Planning, National Development and Vision 2030)

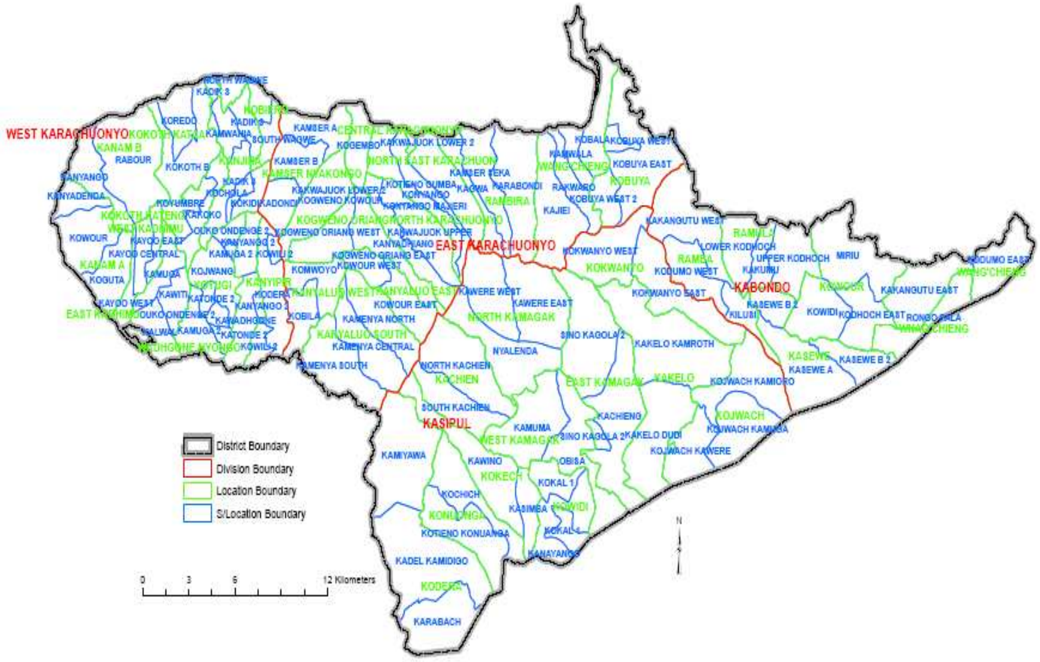

Figure 3.2 Map of Rachuonyo South Sub-County (Source: Ministry of Planning, National Development and Vision 2030)

3.3 Selection of study villages

Rachuonyo South Sub-County was purposively selected, to enable the recommendations arising from this study be incorporated into the Pan African Tsetse Trypanosomiasis Eradication Campaign Kenya (PATTEC-Kenya) project activities. Pan African Tsetse Trypanosomiasis Eradication Campaign Kenya project intends to initiate integrated/ multi-sectorial land use activities after tsetse fly suppression for the benefit of the local community. One division was randomly selected out of the two divisions in the Sub-County. One location was then chosen randomly from a list of five in the division. This was followed by random sampling of one sub location out of four in the location. Finally two villages were randomly selected from a list of seven in the selected sub location.

3.4 Study design

The whole study lasted for 14 months from July 2010 to August 2011 in three phases and involved a combination of both informal qualitative and formal structured quantitative methods. The use of a variety of data collection techniques and methods provided a more rounded and holistic approach than when one single method is used (Hakim, 1989).

Identification and prioritization of indigenous chicken constraints was carried out in the first two phases. The two phases lasted for two months; from July to August 2013. The first phase was a rapid rural appraisal study (described in Chapter 4) that was followed by cross-sectional survey, in the second phase (Chapter 5). Cross-sectional study provided a snap shot quantitative data that informed the formulation of longitudinal studies (chapters 6 and 8), i.e. the third phase. The third phase that ran for one year (September 2010 to August 2011) assessed and quantified the constraints, and the benefits of controlled interventions.

Post mortem examination and laboratory analysis were conducted on sick and fresh dead chickens to establish causes of deaths throughout the study period whenever such cases arose (described in chapter 5.4).

Participatory rural appraisals (PRA) and Participatory Learning and Action (PLA) that complemented the above study methods ran concurrently throughout the study period (described in section 5.3 and chapter 6).

The data were obtained by actual measurements, on spot observation, interview of household members directly responsible for management of chickens, community and focus group discussions, post mortem examinations and laboratory analysis.

3.5 Data management and analysis

All the data obtained from the field were entered in Microsoft access programme (Microsoft Corporation, 2000). Analysis was done using Epi-Info statistical package software and Microsoft Excel for Windows (Version XP). The analysis involved generating descriptive statistics for the various productivity measures (parameters). Chi-square (x^2) and t-tests were used to compare the effects of intervention between intervention groups.

CHAPTER 4

4.0 Identification and prioritization of the indigenous chicken constraints

4.1 Introduction

Most of the rural households keeping indigenous chickens have been experiencing heavy production losses arising from deaths and other causes; despite implementing mitigation measures recommended by previous research studies.

Rapid rural appraisal (RRA)) approach was used to assess factors that persistently constrain indigenous chicken productivity in the study area. The RRA method was qualitative in nature, enabled the research team to understand the farmers' experiences and perception on the indigenous chicken production. Weaknesses of previous interventions were identified and later avoided in the subsequent phases, saving valuable time and other resources for relevant activities aimed at addressing farmers' concerns.

Research team used the phase as an entry point into the community, as trust was rapidly enhanced by the participatory engagements (Catley *et al*, 2002).

4.2 Materials and methods

4.2.1 Study site

As described in section 3.2 of the thesis

4.2.2 Study design

A rapid rural appraisal (RRA) study that uses participatory epidemiological (PE) tools as described by Townsley, (1996); Catley *et al*, (2001); Catley *et al*, (2002); Okuthe *et al*, (2003); Bhandari, (2003) was conducted in each of the two study villages to identify and prioritize the indigenous chicken productivity constraints and to capture the farmers' perception of the indigenous chicken production in the study area. This phase also acted as an entry point for the research team into the community, allowed free interactions, created trust and built confidence between the farmers and research team.

The PE tools used included secondary data collection on indigenous chicken production situation in the Sub-County, from relevant Government (Ministries of Livestock Development, Agriculture etc.) and Non-Government Organisations in the area, semi-structured interviews (SSI) guided by checklists (Appendix 1), transect walks, seasonal calendars, matrix scoring, simple ranking, time lines, Venn diagrams, participatory mapping and proportional piling.

One community group discussion (CGD) consisting 30 farmers (men and women), was held in each of the two study villages; Migwa and Kagak. A focus group discussion (FGD) consisting 10 farmers (men and women) followed in each village, hence two CGDs and two FGDs exercises were conducted.

During the CGD and FGD exercises, the farmers were given chance to freely present their views on indigenous chicken production with minimum restrictions. The group discussions were conducted in the local *Luo* language that was understood by all farmers participating in the exercises.

The facilitators played a more passive role of listening and learning whilst farmers played more active roles of teachers. This led to active participation by farmers in the form of production of community maps, seasonal calendars, Venn diagrams and constraints ranking using local materials i.e. maize and beans. The active participation resulted in a free flow of information as the farmers felt they were part of the discussion.

The farmers' experiences and perception of the indigenous chicken production were then captured and recorded. These experiences and felt needs were then incorporated into subsequent study activities, giving the farmers a sense of belonging in the whole study. This approach greatly helped in motivating the farmers and improving their level of participation in the project activities and cooperation with the research team.

Key informant interviews involving local provincial administration officials, Ministry of Livestock extension officials, prominent farmers, agro-veterinary shop owners and private animal health service providers were conducted before or after the group discussions.

The selection of participants for the discussions was random, and invitations were sent through village leaders two weeks before the exercise date. The venues for the community group discussions were agreed upon after consultations between the research team and village leaders (three from each study village). The research team consisted of the author, two animal health assistants (AHA) and a village leader.

Disease diagnosis and ranking

The farmers presented clinical signs of the diseases present in the area; these were subsequently used by veterinary specialists (investigators) to give tentative diagnosis. Farmers then ranked the diseases in order of prevalence and mortality rate. Where possible, samples were collected from either sick birds or fresh carcasses (fresh deaths), for laboratory confirmation of the diseases.

Weighting of constraints and disease rankings

All responses to indigenous chicken production constraints and disease rankings were tabulated. Constraints and disease ranking were then weighted by awarding scores from 1-6 and 1-3, respectively, to each respondent. Thus, the first, second, third, fourth, fifth and sixth ranking constraint was awarded 6, 5, 4, 3, 2, and 1 scores, respectively, while the first, second and third major disease was awarded 3, 2 and 1 scores, respectively. The cumulative sum of all the responses was then considered as the weighted score for the particular constraint. Thus the constraint with largest score was considered to be the most important.

4.3 Data management and analysis

Several ways were used to cross-check, validate, and analyse the data at different stages of the process of information gathering:

- Probing was done during the semi-structured interview (SSI) to determine internal consistency of the information provided by the informants. Analysis was being conducted by asking additional questions that were not in the check list initially to get clarification on certain issues.

- Triangulation was used to compare evidence collected by different methods and sources of information. The analytical process was used to explore the patterns and coherence between all information provided, as well as to understand the bias of different informants. Triangulation was very useful when comparing observations and information collected while conducting a transect walk with 1 or 2 key informants through the village with information collected during SSI and/or a participatory mapping exercise.

4.4 Results

4.4.1 Duration of rapid rural appraisal study

The whole study duration, running from the preparation stage to the last activity was about two weeks. The time for the group discussions was two and a half and three hours in Migwa and Kagak, respectively. Transect walks (covered on separate dates) lasted about three hours in both villages.

4.4.2 Response from farmers

One Community Group Discussion (CGD) followed by a FGD was conducted in each study village. The groups consisted of both men and women. All the 30 and 10 farmers invited for the CGD and FGD respectively, attended the group discussions, in each study village. The facilitators played a more passive role of listening and learning whilst the farmers played a more active role of teachers. This led to active participation by farmers in the form of production of seasonal calendars, Venn diagrams, ranking using local materials and through Semi Structured Interviews (SSI). The active participation was a stimulation factor that resulted in a free flow of information as the farmers felt they were part of the discussion although the dominant farmers had to be controlled by the facilitator.

4.4.3 Farmers awareness on some of the indigenous chicken production aspects

Indigenous chicken production was important to the farmers in terms of rural poverty and food insecurity alleviation in both study villages. The chickens were reared under free-range system, whereby birds of all age categories fed together (Figure 4.2). The farmers had a lot of information on major constraints to indigenous chicken production in the study area that included common diseases.

They used clinical syndromes/signs to describe most of the diseases i.e. *aput* (pox lesions) for fowl pox, *ajujo* (drooping wings/ ruffle feathers) for Gumboro, *diep ralum* (green diarrhea) for Newcastle, *diep rachar* (white diarrhea) for fowl typhoid, *diep remo* (bloody diarrhea) for coccidiosis, *njoha* (worms) for helminthes, *okwodo* for ticks, *oywech* for mites and *nywogo* for lice.

Most of the farmers exhibited good knowledge on seasonal pattern of most of these diseases.

4.4.4 Constraints ranking

Table 4.1 presents lists of indigenous chicken constraints ranked in order of importance in the two villages. The ranking of constraints by the stakeholders was generally similar in the two study villages. Diseases were ranked as the most important constraints in both villages. Predation in chicks was ranked second most important, while scarcity of feed came third in ranking. Other important constraints identified were theft, poor animal health service delivery, inadequate poultry management skills among farmers, poor housing, neglect by Government, poverty amongst farmers, farmers low attitude and poor breeding; in that order.

Table 4.1 Constraints ranking by indigenous chicken farmers in Migwa and Kagak villages

Constraints	Community group discussions				Key informant interviews			
	Migwa	Kagak	Score	Ranking	Migwa	Kagak	Score	Ranking
Diseases	1	1	12	1	1	1	12	1
Feed scarcity	3	3	8	3	3	3	8	3
Predation	2	2	10	2	2	2	10	2
Theft	4	4	6	4	4	4	6	4
Poor housing	7	8	-	-	7	7	-	-
Poor animal health services	5	5	4	5	5	6	3	5
Inadequate skills	6	6	2	6	6	5	3	5
Poverty	9	9	-	-	9	9	-	-
Neglect by Government	8	7	-	-	8	8	-	-
Farmers low attitude	10	10	-	-	10	10	-	-

4.4.5 Disease ranking

In the constraint ranking, disease emerged as the most important challenge in the indigenous chicken production.

Table 4.2 presents the ranking of indigenous chicken diseases by farmers in the two study villages. Newcastle was the most important disease in terms of prevalence and mortality.

Gumboro disease ranked second and third most important killer and most prevalent, respectively, while Fowl pox ranked second and third most prevalent and most important killer, respectively. Fowl typhoid was ranked as the fourth most important disease. Other important diseases/ or conditions were non-specific coughing, helminthosis and ascitis respectively.

Table 4.2 Farmers' ranking of indigenous chicken diseases in Kagak and Migwa villages

Diseases/ Conditions	Prevalence				Mortality			
	Migwa	Kagak	Score	Rank	Migwa	Kagak	Score	Rank
Newcastle	1	1	6	1	1	1	6	1
Fowl typhoid	4	4	-	-	4	4	-	-
Gumboro	3	3	2	3	2	2	4	2
Fowl pox	2	2	4	2	3	3	2	3
Coughing	5	5	-	-	6	5	-	-
Helminthosis	6	6	-	-	5	7	-	-
Ascitis	7	7	-	-	7	6	-	-

4.4.6 Seasonal changes and occurrence of indigenous chicken diseases

Table 4.3 presents the seasonal changes and occurrence of indigenous chicken diseases in Migwa and Kagak villages, developed during group discussions in the two villages. Seasonal patterns of the diseases were similar in the two villages.

Table 4.3 Seasonal occurrence of indigenous chicken diseases in Migwa and Kagak

Disease	Time of the year
Newcastle	February-May and October to December
Gumboro	March-July
Fowl pox	April- July
Fowl typhoid	As Newcastle disease
Coccidiosis	Throughout the year

Periods between December to mid-February and late June to mid-August are always dry. Long rains fall from late February to late June, while short rains are received from late August to November i.e. planting and crop weeding seasons respectively. Sometimes erratic rainfall comes in December, but it is always not much. Crop harvesting is usually done in the months of August, September and January; the months of abundant food for both human and chickens. Cold weather usually occurs in June and July each year.

4.4.7 Disease control

The study revealed that animal health service delivery was poor in both Migwa and Kagak villages. Proportional piling techniques indicated that less than 30% of the indigenous chicken farmers received animal health services from either Government or private sector, while about 60% of the farmers used herbs (mainly *Aloe Vera*, pepper and sisal leaves) for the treatment and control of indigenous chicken diseases. About 6% of the farmers used human drugs (particularly tetracycline capsules and *flagyl* tablets) for the treatment of their chickens.

The same techniques showed a proportion of 30% Newcastle vaccine, 30% oral antimicrobial drugs and 30% oral multivitamin products; as products farmers bought on their own from Agro-veterinary shop for indigenous chicken disease control.

The study further established that 100% of the farmers had knowledge of the availability of Newcastle and fowl pox vaccines, while only 50% and 10% were aware of the availability of fowl typhoid and Gumboro vaccines, respectively, in the market.

4.4.8 Predation and housing situation

Common predators identified were the mongooses, hawks, eagles, stray dogs and cats. The hawks and eagles were found to be the second major killers of young growers and chicks after diseases. The mongooses and stray cats and dogs, though second to hawks and eagles, were important predators across all the age categories, some even eat eggs.

Only a few households had some housing structures for the indigenous chickens; most of which were tiny and sketchy in make (made of pieces of old iron sheets) and were only used to shelter few birds from hot sun during the day (Figure 4.1). All households allowed their chickens of all age groups to roam about in the home stead during day time and housed them at night; either in the human dwellings or kitchens. The birds were never left alone in the chicken houses at night because the structures were not strong enough to keep away thieves and night predators.

Figure 4.1 Indigenous chicken house in Migwa village

4.4.9 Feeding situation

The chickens got most feed requirements from scavenging; around the home stead, where they could eat plant leaves and seeds, insects and any other edible within range (Figure 4.2). The birds got plenty of food during harvesting seasons; in August and September, and January each year. The birds lived mainly on scavenged food during the other months of the year, except in some few households where they received little quantities of grains and kitchen left over as supplements, but inconsistently. Most of the households provided drinking water for their birds throughout the year.

Figure 4.2 Indigenous chickens on free-range in search of food on the ground in Kagak village

4.4.10 Ectoparasites

External parasites were observed in most of the farms. These parasites included the stick tight flea (*Echidnophaga gallinacea*) (Figure 4.3), red mite (*Dermanyssus gallinae*), depluming mite (*Neocnemidocoptes gallinea*), scaly leg mite (*Knemidocoptes mutans*) and fowl tick (*Argus persicus*).

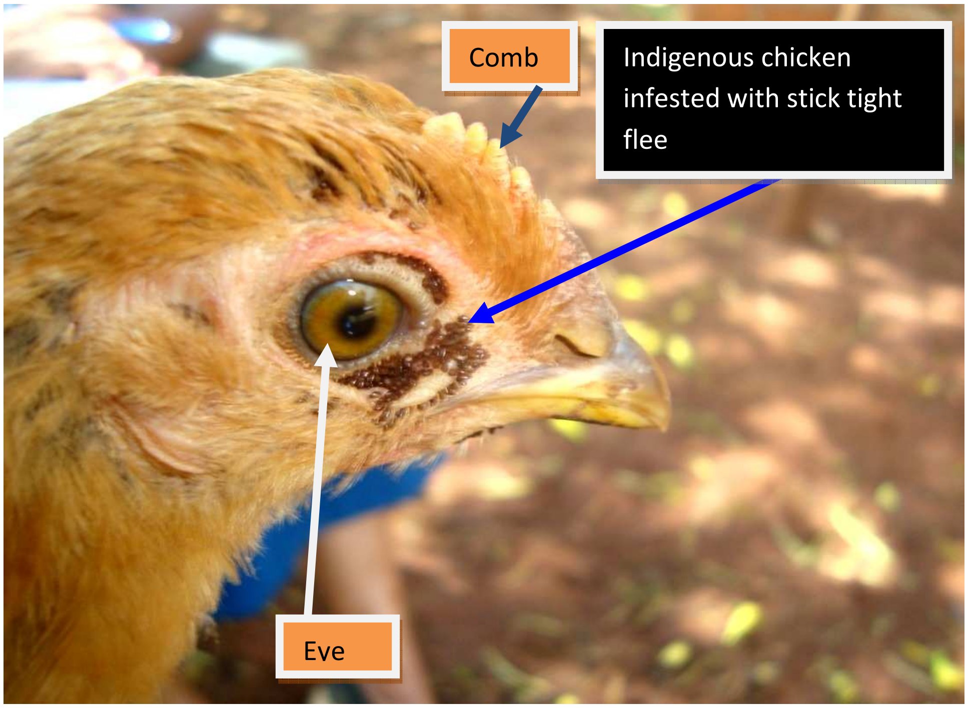

Figure 4.3 Head of indigenous chicken showing infestation of stick tight fleas (arrow)

4.5 Discussions

Indigenous chickens contribute to household income and malnutrition alleviation and are kept by almost every household in the study area. Most of these households are resource-poor and mainly depend on subsistence agriculture for a living.

This study identified and prioritized important constraints to indigenous chickens and at the same time determined the farmers' general perceptions on the production of the chickens in the study area.

The study established that indigenous chicken farmers have vast knowledge on the chicken production that should always be considered in all strategies aimed at improving the productivity of the birds.

This study duration of two weeks agrees with Catley *et al*, (2002) and Bhandari (2003) that rapid rural appraisals take less time compared to quantitative approaches that usually take few to several months to be concluded. The RRA approach managed to provide quick over view of indigenous chicken production that informed the formulation of the subsequent formal and structured studies; cross-sectional and longitudinal studies.

The RRA method was found to be introductive and boosted the morale of the farmers who were very active and generously offered information that enriched the outcome of the survey. This agrees with the finding by Catley *et al*, (2002) that farmers feel appreciated and become positive, when their ideas are respected.

In this study, diseases were ranked as the most important constraint to indigenous chicken production, comparing well with several other findings including Okitoi *et al*, (2006), Siamba *et al*, (2002) and Okeno *et al* (2011) in Kenya, Aboe *et al*, (2006) in Ghana and Yakubu, (2010) in Nigeria. Predation was ranked as second most important constraint agreeing with the findings by Okuthe, (1999). Other important constraints identified such as scarcity of feeds, poor housing, poor animal health service delivery among others are typical to the free-rage indigenous chicken production; as reported by others including Wachira *et al*, (2010) and Ondwasy *et al*, (2006) in Kenya and Gondwe and Wollny, (2005) in Malawi and Mohammed *et al*, (2005) in Sudan.

The use of RRA tools was justified by the fact that the productivity of the indigenous chickens has persistently remained low over the years, despite improvement efforts. In addition to coming up with the prioritized constraints, the use of the RRA tools enabled the research team to capture farmers' views and suggestions on possible way forward for productivity improvement. Previous efforts and possible reasons for their failure to improve productivity were scrutinized with a view of not repeating the past mistakes.

This study was the first to construct a comprehensive seasonal pattern of major indigenous chicken diseases for the region, with a view of providing basis for mitigations for improved productivity. The pattern showed that most indigenous chicken diseases occurred during feed scarcity and wet and cold months of the year. All these months are usually associated with stressful conditions that compromise the immunity of the birds. When birds are starved during feed scarcity, their immunity to most diseases is lowered (Wachira *et al*, 2010). Apart from low temperatures directly stressing the birds, especially chicks during rainy seasons (planting seasons), farmers usually tie theirs birds to avoid crop destruction and conflicts with neighbours, thereby exacerbating the already bad situation. Several studies including Njagi *et al,* (2012), Njue *et al*, (2001) and others have shown that stressed birds have poor immune response to infections to the extent that, even less virulent pathogens can cause severe clinical disease in the stressed birds.

When animal health services, housing and feeding are improved, heavy losses currently associated with indigenous chicken production will be reduced, and hence improve mean household flock size.

Housing structures currently used by most households are not appropriate for deterring common night predators. In certain cases, poorly housed hens lay and incubate the eggs on spots unknown to owners, and often end up being eaten by wild animals or stolen (Ndegwa *et al*, 1998). This reduces the number of eggs that could be used for hatching, sales and home consumption. When chicken housing is improved these losses would be reduced.

Improved feeding will also improve productivity, well fed birds are resistant to most infections and hence deaths from diseases will go down. This was demonstrated by the seasonal patterns of diseases constructed in this study. Low or no major disease prevalence was shown to be occurring in the months of August, September and January; the harvesting months with plenty of food for the chickens.

Ectoparasites lower production of the chickens through blood loss by the blood suckers, competing for nutrients with birds and reduction of the effective feeding time since the affected birds spent most of their time scratching due to irritations.

The study noted that qualitative procedures enabled the investigator to fully interact with farmers, a phenomenon that enhanced the development of confidence between farmer and researcher and continuity of commitment, by stakeholders in the project. This agrees with report by Okuthe, *et al*, (2003).

CHAPTER 5

5.0 Quantification of Indigenous Chicken Constraints

5.1 Introduction

The indigenous chicken constraints were quantified using cross-sectional study (phase two) and a one year prospective longitudinal study (phase three) (chapter 6). Post mortem examination and laboratory analysis (chapter 7) were conducted on sick and fresh dead chickens to establish causes of deaths throughout the study period whenever such cases arose.

This chapter presents cross-sectional study that was conducted in the second phase of this study. Cross-sectional study followed the RRA survey to triangulate the findings and generate quantitative baseline data on the indigenous chicken production. Its findings informed the formulation of longitudinal studies that followed in the third phase (chapter 6).

5.2 Materials and methods

5.2.1 Study site

As described in section 3.2

5.2.2 Study design

Random sampling method was used to select study households in the two study villages (Migwa and Kagak). There were a total of 87 and 95 households in Migwa and Kagak villages, respectively. A total of eighty (80) households were selected; forty in each of the two villages.

Primary data collection was carried out through personal interview of household members responsible for the indigenous chickens. A structured closed questionnaire (Appendix 2) was used for the interviews. The questionnaire was pre-tested in ten farms, five in each village to estimate the time required to administer the questionnaire. Necessary corrections were made and any queries concerning the questionnaire were sorted out.

The author and two enumerators carried out the interviews, counting and weighing of birds and eggs and direct observations. The data collected included: socio-demography of chicken keepers, flock and clutch sizes, flock structure, ownership, type of housing, feeds and feeding practices, diseases and perceived flock mortalities, utilization of chicken products and animal health service provision. Flocks were categorized as follows: Chicks (aged between 0- 3 months), growers (aged >3-9 months) and adult (aged > 9 months) (Swai *et al.*, 2007).

5.2.3 Data management and analysis

All the data obtained from the field were entered in Microsoft access programme (Microsoft Corporation, 2000) as described in section 3.5.

Descriptive statistics for the productivity parameters

Descriptive statistics that included mean number of chickens by age, clutch and egg sizes, and mortality, hatchability and off-take (consumption and sales) rates, among other descriptive parameters were generated using Microsoft Excel for Window (Version XP).

Comparison of continuous data between the two villages

The ANOVA test using Epi-info statistical package was used to compare mean flock sizes between Migwa and Kagak villages.

5.3 Results

5.3.1 Household characterization

Mean household farm sizes were 4.0 acres in both villages; with ranges of 1-10 and 1-14 acres in Kagak and Migwa respectively. Males headed 80% of the households in both villages. Over 80% of the household heads in both study villages had primary education or below. Over 90% of children left school mainly at primary level in both villages and never joined college. Women and chicken were responsible for about 80% of indigenous chickens' daily management activities in both villages. In 60% of the cases, women (in both villages) made decision to dispose indigenous chickens and their products.

All interviewed farmers kept indigenous chickens. Some of the farmers kept other livestock species (Table 5.1) that were managed under extensive system. Maize, sorghum, ground nuts, vegetables and sweet potatoes were grown in both villages in most of the households. Mixed farming was preferred because most farm enterprises are complementary in terms of input sources, and hence a strategy of lowering the overall cost of production. The proportion of income from the indigenous chickens to that of all the farm enterprises were 14% and 22% in Migwa and Kagak, respectively. Farmers in both villages kept the indigenous chickens for food (meat and eggs) and cash income.

Table 5.1 Number and percentage of households keeping various types of livestock in Kagak and Migwa villages

Village	Indigenous Chickens	Cattle	Sheep	Goats	Ducks	Quails
Kagak	40 (100)	32 (80)	20 (50)	10 (25)	0 (0)	0 (0)
Migwa	40 (100)	32 (80)	17 (43)	15 (38)	3 (8)	1 (2.5)

5.3.2 Flock sizes by village

Mean indigenous flock sizes were 15.83 birds for Kagak and 17.45 for Migwa village. The mean flock sizes were statistically similar (P-value = 0.478). The overall mean flock size was 16.67 chickens.

5.3.3 Indigenous chicken flock structure by village

The mean household numbers of chicks, growers, hens and cock were similar in Migwa and Kagak villages as shown in Table 5.2. Chicks were the majority in both villages, followed by growers and hens, while cocks were the fewest. The ratios of cocks to hens were 1:4 and 1:3 in Migwa and Kagak, respectively.

Table 5.2 Indigenous chicken flock structure by village in Migwa and Kagak villages

Chicken category	Migwa	Kagak
	Flock mean size	
Chicks	9.20	8.20
Growers	3.95	3.78
Hens	3.38	2.90
Cocks	0.93	0.95
Total	17.45	15.83

5.3.4 Reproduction and production parameters

The indigenous chicken reproduction and production statistics for the study villages are given in Tables 5.3 and 5.4. Pullets and cocks reached sexual maturity at an age ranging from 6-10 months. Seventy two per cent of farmers in both villages reported the maturity age of their indigenous chickens as ranging from 6-8 months. Approximately 20% of the farmers in Kagak and Migwa reported maturity age of 9-10 months. Nine per cent of the farmers in both villages could not remember. Farmers used broody hens for incubation in both villages. Forty per cent and 39% of the farmers in Kagak and Migwa, respectively, reported 2 clutches per hen per year. Approximately 40% and 42% of farmers in Kagak and Migwa, respectively reported 3 clutches per hen per year. Between 19-20% of the farmers in both villages could not remember.

Table 5.3 Proportion of farmers' responses to age at first laying and clutches per year of indigenous chickens in Kagak and Migwa

Farmers responses	Kagak	Migwa
Number clutches per year:		
Two	40	39
Three	40	42
Do not know	20	19
Age at first laying in months:		
6	35	37
7	23	24
8	13	11
9	11	10
10	9	9
Do not Know	9	9

Egg weighed were 44.07g and 43.13g in Kagak and Migwa villages, respectively. The hatchability rates and egg sizes for both villages are presented in Table 5.4.

Table 5.4 Productivity parameters of indigenous chickens in Kagak and Migwa villages

Variable	Kagak village	Migwa village
Mean clutch sizes	13.35	13.05
Mean hatchability rates (%)	85.52	88.90
Mean egg sizes (g)	44.07	43.13

Key:
% - Percentage
g - grams

5.3.5 Management system characterization

Table 5.5 presents the proportion of management practices for the indigenous chickens in the study villages. All the interviewed farmers reared their indigenous chickens under free-range or extensive system. All the interviewed farmers provided supplement feeds to their chickens, but inconsistently and in most cases the quantity depended on season. Large quantities usually provided during harvest. Birds of all ages were fed together on the ground. During planting seasons most chickens were tethered to prevent crop destructions.

All the farmers provided night shelter for their chickens in the human dwellings. About 100% of the farmers provided water for their chickens, mostly in plastic containers and only 40% of the respondents cleaned the watering containers daily, 15 % after one week and 45% did not clean the containers at all. In several cases the container was filled once per day.

Table 5.5 Proportion of management practices for indigenous chickens in Kagak and Migwa villages

Variables	Kagak	Migwa	Overall
Housing:-			
Separate shelter	0	0	0
Human dwelling	100	100	100
Confinement:-			
Night only	100	100	100
All time	0	0	0
Feeding:-			
Scavenging/leftover	15	10	12.5
Grain/red herrings	15	15	15
Both	70	75	72.5
Water provision:-			
Yes	100	100	100
No	0	0	0
Feeding chickens:-			
In container/ feeder	0	0	0
Thrown on the ground	100	100	100

5.3.6 Disease control

Table 5.6 presents the proportions of indigenous chicken farmers who used various disease control methods and animal health service provision in Kagak and Migwa villages. Animal health service delivery was poor in the two villages, with less than 30% of the farmers receiving services from either Government or private sector in both villages. About 60% of the farmers in the study area (Migwa and Kagak) used herbs that included Aloe vera, pepper, cow peas and sisal leaves for treatment and control of chicken diseases.

Major veterinary products bought were ND vaccines and oral antimicrobials and multivitamins. About 6% of the farmers in the two villages used human antibiotics, particularly tetracycline capsules for treating their chickens.

All the interviewed farmers were aware of fowl pox but never took any control measures. Fewer farmers knew about Gumboro disease (10%) and helminthosis (10%) but took no action.

Table 5.6 Proportion of farmers using animal health services in Kagak and Migwa

Disease control method/ animal health service source	Kagak	Migwa
Farmers who knew where to get animal health services for their indigenous chickens	15	15
Farmers who received either Government or private animal health service delivery	<30	<30
Farmers using herbs for treatment/disease control	60	60
Farmers who bought veterinary products on their own from agro veterinary shops for treatment/ or disease control:		
Antimicrobial and multivitamins	30	30
Newcastle vaccine	30	30
Fowl typhoid	0	0
Farmers using human antibiotics to treat sick birds	6	6
Farmers who knew about other indigenous chicken diseases and took no action:		
Gumboro	10	10
Helminthosis	10	10
Fowl pox	100	100
Fowl typhoid	45	50

5.3.7 Constraints ranking

Diseases were ranked as the most important constraint in both villages. Predation and scarcity of feed ranked second and third most important constraints in both villages, respectively. Other important constraints identified were theft, poor animal health service delivery, poor housing, poor breeding and inadequate poultry management skills and poverty among farmers. Newcastle was the most important disease in terms of prevalence and mortality in the two villages. Gumboro and Fowl pox diseases ranked second and third, respectively, in both villages. Other diseases/ or conditions identified were fowl typhoid, cough, helminthosis, infectious coryza and coccidiosis.

5.3.8 Dynamics of the indigenous chickens

Indigenous chicken came into and exited household flocks through different modes.

5.3.8.1 Entries

Chickens entered into the household flocks mainly through hatchings, purchases, entrustments and gifts. In both villages, hatching was the most important mode of entry into the household flocks; accounting for over 70% of the total flock entries. Purchases followed, with the last position being entrustments in and gifts.

5.3.8.2 Exits

The birds left the household mainly through deaths (diseases, predations and accidents), sales, home consumptions and thefts. Deaths from diseases and predation were the most important mode of exit across all age categoriess of the birds in both villages. The proportion of birds consumed and sold depended on disease out breaks (particularly of ND). In most cases diseases cleared all the household flocks; leaving the family with nothing to sell or consume.

5.3.8.3 Indigenous chicken mortality

5.3.8.3.1 Causes of mortality

Table 5.7 presents the total and mean indigenous chicken deaths in Kagak and Migwa villages. Diseases, mainly ND, Gumboro, fowl pox and fowl typhoid, followed by predation were the major causes of deaths; with relative mortality proportion of about 85%, 8%, 4%, 1% and 2%, respectively. All deaths reported from Gumboro and fowl pox diseases and predations in both villages were in chicks. Newcastle disease and fowl typhoid were important killers across all age categories in both villages.

Table 5.7 Total and mean indigenous chicken deaths in Kagak and Migwa

Variables	Kagak		Migwa	
	Total	Mean	Total	Mean
Deaths from Newcastle disease	607	15.18	474	11.85
Deaths from Gumboro	55	1.38	47	1.18
Deaths from fowl pox	20	0.5	26	0.65
Deaths from fowl typhoid	10	0.25	9	0.23
Deaths from predations	12	0.30	14	0.35
Deaths from other causes	3	0.08	1	0.03

5.3.8.3.2 Season with highest indigenous chicken mortality

Nearly 55% of the farmers in both villages reported that the highest number of chicken deaths occurred in the wet season, while 35% associated dry season with high chicken mortality. About 10% claimed that chicken deaths occurred uniformly in all seasons.

5.3.9 Utilization of indigenous chicken eggs

Table 5.8 shows the utilization of chicken eggs in the study area. Largest proportions of the chicken eggs were naturally incubated in both Kagak and Migwa villages. Consumption was second to incubation, while sales ranked last in egg utilization in the two villages.

The egg market was readily available in the neighbourhood and the nearby market centre and towns like Manyoro and Oyugis, respectively.

Table 5.8 Number and proportion of egg utilization in Kagak and Migwa villages

Egg use	Kagak	Migwa
Consumption	155 (10%)	176 (10%)
Sales	77 (5%)	89 (5%)
Incubation	1317 (85%)	1499 (85%)
Total	1549 (100%)	1764 (100%)

5.4 Discussions

5.4. 1 Household characterization

Over 80 % of the households in both Kagak and Migwa villages were male headed; this is typical of rural households in most parts of Africa and agrees with findings by Okeno *et al.*, (2011) in Siaya County, Kenya, Missohou *et al.*, (2002) in Senegal, Muchadeyi *et al.*, (2004) in Zimbabwe, Swai *et al.*, (2007) in Tanzania and Yakubu (2010) in Nigeria.

Cultural beliefs that always put men head of households in most African countries are responsible for this kind of trend. The case is always that, household heads have to give approval before any decisions are undertaken in the households, including utilization of household resources.

Men always considered indigenous chicken production women affair and hence kept their distance from it. Men (headed 80% households) would in most cases prefer to allocate resources for the improvement of other livestock species; especially cattle, instead of indigenous chicken improvement (MLD, 2010). This probably could explain the slow pace at which improvement of the indigenous chicken has progressed in most parts of Africa.

This study revealed that majority of the indigenous chicken keepers in the study area only acquired primary education and below. This agrees with findings of Mandal *et al.,* (2006) in India and Swai *et al.,* (2007) in Tanzania. Both studies revealed that over 90% of indigenous chicken owners acquired low level of education (primary level and below). Low or complete lack of education of majority of the chicken farmers is an important constraint to indigenous chicken production in the study area. Education is an important factor for growth and development of any enterprise, it catalyses the overall behaviour change for quick adoption of new technology for improvement of any production enterprises (Mandal *et al.,* 2006). Education is also an impetus for the need to search for information for development.

Women and children did most of the indigenous chickens' daily management activities, at the same time women did most of decision to dispose of chickens and their products. This agrees with most research findings on indigenous chicken in many parts of Africa including those by Mapiye and Sibanda (2005) in Zimbabwe, Olwande *et al.*, (2010) in Kenya and Yakubu (2010) in Nigeria. Men could be giving little attention to indigenous chickens probably due to low income associated with the enterprise (14-22% of total farming income) and instead concentrated on other better paying farming enterprises such as crop farming and cattle production.

5.4.2 Farm characterization

The study findings showed that indigenous chicken farmers owned farms of mean sizes of 4.0 acres and practiced mixed farming of crops and livestock. Keeping indigenous chicken was however subsidiary to other farming activities. Similar mixed production systems had been reported by Muchadeyi *et al*, (2004) in Zimbabwe and Yakubu (2010) in Nigeria. Mandal *et al.*, (2006) in India reported that 27%, 48%, 20% and 5% of poultry farmers owned 0, 2.5, 2.5-5 and above 5 acres of land respectively and that poultry production was subsidiary to other farm enterprises.

Most farmers in the study area preferred integrated (mixed) farming approach because the various farm enterprises complemented each other. Indigenous chicken fed on cereal grains, crops benefited from manure from livestock and income from the sale of chickens was sometimes used to buy drugs for other livestock species (mainly cattle).

Indigenous chicken production though subsidiary to other farm enterprises, was still practised by most farmers, due to its low investment requirement and its importance as source of animal protein and cash income for the family (Bebora *et. al.*, 2005).

5.4.3 Characterization of management systems

The study showed that most farmers managed their chickens under free-range system with irregular and inconsistent supplementation (cereal grains and kitchen left over) and night housing in human dwellings. Similar findings have been reported by Okeno *et al.*, (2011) in Siaya County, Kenya, Yakubu (2010) in Nigeria and Youssouf *et al.*, (2011).

Findings by Muchadeyi *et. al*., (2004) and Mapiye and Sibanda (2005) in Zimbabwe showed that most farmers provided cereal grain supplements to their chickens and night housing in separate chicken houses made from local materials, indicating that majority of them were aware of the importance of chicken housing and feeding. Farmers in the study area preferred housing their chickens in human dwellings at night in order to keep away thieves and predators.

Although all indigenous chicken owners in the study area favoured free-range management due to its low input requirements, it is associated with heavy production losses. This type of management exposed birds to harsh conditions such as inadequate feeding, diseases, predation and extreme weather changes. The losses resulted from massive deaths, thefts and delayed maturity.

5.4.4 Disease control

The study revealed that animal health service delivery was poor and most of the indigenous chicken farmers used herbs for both treatment and control of chicken diseases. Some farmers bought veterinary products on their own from agro veterinary shops and used them without any technical advice while others took no action at all. This agrees with the findings by Okitoi *et al.*, (2006) and Okeno *et al.*, (2011).

The reasons for not using veterinary services were quite diverse; some farmers believed that indigenous chickens were resistant to most diseases and never required any health care. Majority of the farmers claimed they were poor and could not afford to pay for the veterinary medicine and therefore resorted to herbs that were locally available and cheap; though the efficacy was debatable. Other farmers generally had low attitude towards indigenous chickens and it was like wasting time treating the birds. Such attitude is a drawback to production and needs to be changed through acquiring the right knowledge on the indigenous chicken production and particularly on disease control.

Veterinary personnel on the other hand blamed the poor health care in the indigenous chicken production on small flock sizes per household (10-20 birds) that makes it uneconomical to visit individual household for animal health care and other extension services.

Farmers who vaccinated their flocks against Newcastle disease (30%) never followed recommended guidelines. Important diseases like Gumboro and fowl pox were ignored and this explains the high prevalence of deaths, even in the households that vaccinated against Newcastle disease.

5.4.5 Identification and prioritizing of constraints

In this study, diseases particularly ND were ranked as the most important constraint to indigenous chicken production. This agrees with the findings by Wachira *et al.*, (2010) in Kenya and Yakubu, (2010) in Nigeria. Poor animal health care associated with indigenous chicken production was the reason for high prevalence of the diseases. Most of the farmers in the study villages resorted to the use of herbs, which they confessed never worked. Few farmers who vaccinated their birds against ND never followed the recommended vaccination regime making it difficult to control the disease.

Predation was ranked as the second most important, agreeing with the findings by Muchadeyi *et al.*, (2004) in Zimbabwe and Olwande *et al.*, (2010) in Kenya. Swai *et al.,* (2007) in Tanzania ranked predation fourth after mortality, housing and ectoparasites. Predation was an important issue due to the fact that the birds were on free range during the day in search of food and all ages of the birds were therefore exposed to predators.

Inadequate feeding was ranked third most important constraint in this study. Poor feeding in the indigenous chicken flocks had been reported by several studies including Okeno *et al.*, (2011), Wachira *et al.*, (2010) and Olwande *et al.*, (2010) in Kenya and Yakubu (2010) in Nigeria. Poorly fed chickens always take longer time to reach maturity and produce fewer eggs (Wachira *et al.*, 2010). This explains why indigenous chickens take longer time to start laying (6-10 months) compared to the well fed commercial chickens that start producing eggs at 5 months of age. It also explains why the indigenous chickens lay fewer eggs (36- 60 eggs a year) compared to the commercial birds (over 250 eggs a year (Okuthe, 1999)). Well-fed chickens always develop adequate immunity to disease infections (Njagi *et al.*, 2012).

5.4.6 Flock structure

The overall mean flock size for the study area of 16.67 chickens (Kagak, 15.83 chickens and Migwa, 17.45 chickens were statistically similar; p-value > 0.05) is typical of smallholder indigenous chicken production system as found by other researchers. Siamba *et al.,* (2002) and Okeno *et al.*, (2011) reported mean flock sizes of 16 and 22 chickens, respectively, in different studies in Kenya. In Tanzania, Swai *et al.*, (2007) reported a flock size ranging from 1-64 birds per family. In Zimbabwe, Mapiye and Sibanda, (2005) and Muchadeyi *et al.*, (2004) reported mean flock sizes of 30 and 17 chickens, respectively. The mean flock size reported by this study was low due to high death prevalence from diseases and predations. Low inputs as regards feeding, housing and health care contributed to the heavy losses experienced in the indigenous chicken production. Several studies including Wachira *et al.*, (2010) and Okeno *et al.*, (2011) in Kenya and Nahamya *et al.*, (2006) in Uganda associated low production input with the indigenous chicken production.

5.4.7 Reproduction and production parameters

The present study reported average clutch sizes (13.35 and 13.05 eggs for Kagak and Migwa, respectively) and egg sizes (44.0 and 43.0 g for Kagak and Migwa, respectively) that are typical to the free-range indigenous chicken production system. Studies with similar findings include Siamba *et al.*, (2002) in Kenya (clutch size of 11.1 eggs), Njenga, (2005) in Kenya (clutch and egg sizes of 13.9 eggs and 42.7 g respectively), Olwande *et al.*, (2010) in Kenya (clutch and egg sizes of 12 eggs and 48.0 g), Okeno *et al.*, (2011) in Kenya (clutch size of 15.6 eggs), Mapiye and Sibanda, (2005) in Zimbabwe (clutch and egg sizes of 10 eggs and 52 g respectively), Missohou *et*. *al*., (2002) in Senegal (reported a lower egg size of 37.5 g), Fisseha *et al.*, (2010) in Ethiopia (egg size of 43 g) and Yakubu, (2010) in Nigeria (clutch of 11.9 eggs).

This study revealed hatchability of 85.52 % and 88.9 % for Kagak and Migwa villages, respectively. The hatchability reported by this study is higher than the hatchability of 77% reported in Senegal by Missohou *et al.*, (2002); but close to those of 84% and 84.6% reported in Kenya, by Siamba *et al.,* (2002) and Njenga, (2005). The hatchability rates reported in this study were high probably because of the high ratio of cocks to hens (1 cock to 3 hens) observed in most of the households; the recommended ratio for optimum reproduction is 1 cock to 10 hens (MLD, 2010).

The overall adult male and female body weight (2127 and 1426 g, respectively) is similar to 1348.0 ± 243.9 g and 1948.1± 380.3 g (adult female and male body weight respectively) reported by Mwalusanya (1998) in Tanzania. The chicken weights reported by the present study are higher than those reported by Youssouf *et al.*, (2011) in Chad (cocks and hens; 1176 g and 957 g, respectively).

This study reported that pullets and cockerels reached sexual maturity at 6-10 months of age. Similar finding was reported by Okeno *et al.*, (2011) in Kenya (6-11 and 5-10 months for pullets and cockerels, respectively) and Mandel *et al.*, (2006) in India (6-10 months).

The observed parameters in this study though typical to extensive management of indigenous chickens, they are lower than those observed in semi-intensive management system, where improved breeds and complete diets are used. In such an improved management system, one hen (cross breed) can produce 160 to 180 eggs annually with an egg weighing more than 60 g (Sonaiya and Swan, 2004). The low productivity in this study is a result of heavy losses from deaths and delayed maturity due to the prevailing poor husbandry and management practices.

Poor health care and housing contributed to the largest number of chicken deaths and poor feeding on the other hand slowed chicken growth thereby delaying their maturity (Njue *et al.*, 2001; Wachira *et al.*, 2010). A lot of production is usually lost during the extra time taken before maturity (Mandal *et al.*, 2006) and during natural incubation and brooding as practised in the study area (Ondwasy *et al*., 2006). Better feeding contributes to about 30% chicken growth potential (Gondwe and Wolly, 2005).

5.4.8 Indigenous chicken exits from household flocks

Findings from this study agree with others by Olwande *et al.,* (2010), Wachira *et al.,* (2010) and Okeno *et al.,* (2011) that most of the indigenous chickens left the household flocks through deaths. The high mortality of the birds was a result of poor management practices and was the main cause of low productivity. The farmers were usually left with very few or nothing for sales, consumptions and social activities. Eggs laid, therefore, were mostly incubated for hatching and chickens that survived were mostly retained for maintenance of the household flocks.

5.4.9 Utilization of the indigenous chicken products

The study showed that farmers used chickens as ready source of cash income, animal protein in terms of eggs and meat and for social purposes. This finding is in line with reports by others including Njenga (2005), Fisseha *et al.*, (2010) and Youssouf *et al.,* (2011).

It was easier for the farmers to sell chickens for quick cash needs or to slaughter chickens to serve visitors than other species of livestock. The birds were therefore kept by all families in the study area.

It was observed in the study that the farmers preferred incubating the eggs for hatching to maintain the family flock sizes that usually went down due to deaths and other losses. This observation agrees with the findings by Missohu *et al.,* (2002) in Senegal who reported that most farmers never consumed or sold eggs but incubated them for hatching.

The study reported very low home consumption of poultry meat; 1 chicken consumed per household in 5.6 months. In Tanzania, study by Mwalusanya (1998) reported an average home consumption of one chicken per month per family. The rate of indigenous chicken sales was reported by this study as 1 chicken per household in 2.8 months. For the farmers to fully benefit from the indigenous chicken production, strategies that would reduce chicken deaths and other losses need to be identified and recommended. And this was one of the objectives of the present study; to identify and test intervention(s) for improved and sustainable indigenous chicken production.

CHAPTER 6

6.0 Longitudinal study

6.1 Introduction

An observational study was carried out alongside controlled interventions (Chapter 8) for a year (September 2010 to August 2011) to monitor health and productivity parameters of the birds in the 80 households (section 5.2.2). Generated data was used to determine incidence rates that explained associations between exposure and outcome variables in the production. Seasonal variations were also captured. The cross-sectional study (in phase two) was limited in that observations/ or measurements were done at one point in time and therefore, it was not easy to determine whether or not putative cause (exposure) preceded the outcome.

This chapter mainly presents and discusses the control group (19 households) of the controlled intervention study (chapter 8).

6.2 Materials and methods

6.2.1 Study site

As described in section 3.2 of the thesis.

6.2.2 Study design

This involved repeat visits to the 80 study households (section 5.2.2) over a period of 12 months to monitor productivity parameters in treatments (61) and control (19) households (chapter 8). The data were generated using a questionnaire (Appendix 3) to collect active information, direct observation, weighing of live chickens and eggs, and necropsy and laboratory analysis on sick and dead birds (chapter 7).The questionnaire was derived from the cross-sectional one (Appendix 2) and was therefore not pre-tested as this was done earlier. The number of chickens and eggs weighed depended on the availability of chickens and eggs at the time of taking the measurements.

During the study period, each household was visited twice a month by the enumerators. The author also visited each household twice a month to confirm production and productivity monitoring.

Various PRA tools were applied to gather information on indigenous chicken production depending on the opportunity that came by. The tools included direct observation, semi structured interviews, and transect walks. Multiple tools were used as a means of triangulation. Issues that were not clear during the informal rapid rural appraisals and cross-sectional surveys were sorted out during informal discussions that were free and open. Farmers were very conversant with many issues related to indigenous chicken production and they freely shared knowledge among themselves and with the research team during the discussions.

The enumerators recorded the following information since the previous visit by administering the questionnaire.

- Flock structure by age and sex.
- Exits in the form of deaths, consumptions, sales, gifts and entrustments.
- Entries in the form of purchases, gifts, entrustments and births.
- Tentative causes of death.
- Types of housing for the indigenous chickens.
- Types of feed and their source.
- Animal husbandry practices that included:
    - Vaccination done (disease vaccinated against)
    - Treatment done and the amount of drugs used
- Sales and purchases of chickens and eggs.
- Prices of chickens and eggs

The enumerators had field notebooks to record other observational data and any other miscellaneous findings. Farmers were given hard covered field notebooks to record any events that occurred between visits. The farmers worked very closely with their school age going children in data management who were present during the study period as they were very key in the management of chicken.

6.2.3 Data management and analysis

The data obtained from the field were entered in Microsoft access programme (Microsoft Corporation, 2000) as described in section 3.5.

Descriptive statistics for the productivity parameters

Microsoft Excel for Window (Version XP) and Epi-Info statistical package were used to generate descriptive statistics that included mean number of chicken by age category, clutch and egg sizes, mortality rates (incidence), chick survival hatchability rates, among other descriptive parameters.

Bird days

Bird days at risk were used to calculate daily, monthly or annual true incidence rates of disease, productivity parameters and flock structures. Each day a bird is present represents one bird day. Therefore the total number of bird days at risk is the sum of the number of days that each bird in the observed flock was present during the observation period.

Rates

Rates provide comparable measurements of the frequency of the events occurring over a period of time. It is defined as the number of individuals acquiring a particular characteristic (events) during a period of observation divided by the total number of individuals (population) at risk of having or acquiring that characteristic during the observation period (Dohoo *et al*, 2003). The rates were computed according to Martin *et al*, (1987):

$$\text{True rate} = \frac{\textit{Total number of cases (events)}}{\textit{Total number of bird days at risk}}$$

6.3 Results

6.3.1 Indigenous chicken flock size and structures

Indigenous chicken flock size

Mean flock size was 15.90 birds per household. The mean flock size was statistically similar to the one established in the cross-sectional study (chapter 5).

Indigenous chicken flock structures

Table 6.1 presents the indigenous chicken flock structures for the study area. Chicks were the majority followed by growers then hens, while cocks were the fewest.

Table 6.1 Indigenous chicken flock structure

Age category	Mean Flock size	Percentage (%)
Chicks	8.58	54
Growers	4.32	27
Hens	2.32	15
Cocks	0.68	4
Total	15.90	100

Indigenous chicken flock structures in terms of bird days at risk

Chicks contributed the highest bird days at risk, followed by the growers' age group, while the adults contributed the lowest (Table 6.2).

Table 6.2 Bird days at risk of various age categories of indigenous chickens in Migwa and Kagak villages

Chicken category	Bird days
Chicks	62,770
Growers	32,597
Adults	26,398
Total	121,765

6.3.2 Reproduction and production parameters

The findings on the reproduction and production aspects were similar to the cross-sectional ones (section 5.3.4). Pullets and cocks were reported to reach sexual maturity at an age ranging from 6-10 months, with over 70% of the farmers reporting maturity age ranging from 6-8 months. Breeding was uncontrolled, through natural mating as cocks and hens mixed freely during free range feeding. About 80% of the farmers reported number of clutches per hen per year, between 2 and 3.

Overall mean clutch size, hatchability rate and egg size were 13 eggs, 87% and 44g, respectively.

6.3.3 Feeding and general management

Feeding and general management was found to be similar to the cross-sectional findings (section 5.3.5). The preferred production system was free range. Birds roamed about within and without the homestead to feed on anything palatable to them. Inconsistent grain and kitchen left over supplementations and water were provided for chickens by most of the farmers.

All the farmers provided night shelter for their chickens in the human dwellings.

Animal health service delivery was reported to be poor with less than a third of the farmers receiving veterinary services from either Government or private sector and over 60% using herbs and other preparations, that included human medicine, paraffin, fresh milk and ash, for treatment and disease control.

6.3.4 Weights of growers and adult chickens

Table 6.3 presents the mean live weights for chicks, growers and adult chickens. Cocks were the heaviest.

Table 6.3 Weights of chicks, growers and adult chickens in Migwa and Kagak villages

Chicken category	Kagak village	Migwa village	Overall
Adult cock mean live body weight (g)	2124	2130	2127
Adult cock range of body weights (g)	1580 - 2760	1578 - 2732	1578 - 2760
Adult hen mean live body weight (g)	1409	1445	1427
Adult hen range of body weights (g)	1100 - 1980	1000 - 1940	1000 - 1980
Grower chicken mean live body weight (g)	785	775	780
Grower chicken range of body weights (g)	600 - 1000	670 - 1000	600- 1000
Day old chick live body weight (g)	26	28	27
Day old chicks range body weight (g)	21 - 26	18 - 34	21 - 34

Key:
g - grams

6.3.5 Dynamics of the indigenous chickens

6.3.5.1 Exits of indigenous chickens from the household flocks

Table 6.4 presents the descriptive statistics of exits of indigenous chickens. Death was the most important mode of exit, representing over 84% of all exits. Other important means of exits were sales and home consumptions that accounted for 7.3% and 3.7% of all exits, respectively. Gifts out, entrustments out and thefts took away 2.5%, 1.1% and 0.8%, respectively.

Table 6.4 Number and relative proportions of various modes of exits of indigenous chickens from the household flocks in Migwa and Kagak villages

Variables	Number	Proportion (%)
Deaths	940	84.6
Sales	81	7.3
Home consumptions	41	3.7
Gifts out	28	2.5
Entrustments out	12	1.1
Theft	9	0.8
Total	1111	100

Key:

% - per cent

Table 6.5 presents number and relative proportions of indigenous chicken deaths by cause. Diseases and predation were responsible for 79.5% and 20.3%, respectively, of the total indigenous chicken deaths. The most important diseases were Newcastle (36.1%), Gumboro (21%), fowl pox (16.9%) and fowl typhoid (5.5%).

Table 6.5 Number and relative proportions of indigenous chicken deaths by cause in Migwa and Kagak villages

Variables	Number	Proportion (%)
Newcastle	339	36.1
Gumboro	197	21.0
Fowl pox	159	16.9
Fowl typhoid	52	5.5
Predation	191	20.3
Other causes of deaths	2	0.2
Total deaths	940	100

Key:

% - per cent

Figure 6.1 presents seasonal occurrences of indigenous chicken diseases in the study area. The pattern nearly followed that constructed in section 4.4.6 by the farmers during the RRA study.

Apart from Newcastle and fowl typhoid diseases that occurred almost all year round, Gumboro and fowl pox mostly occurred in February to August.

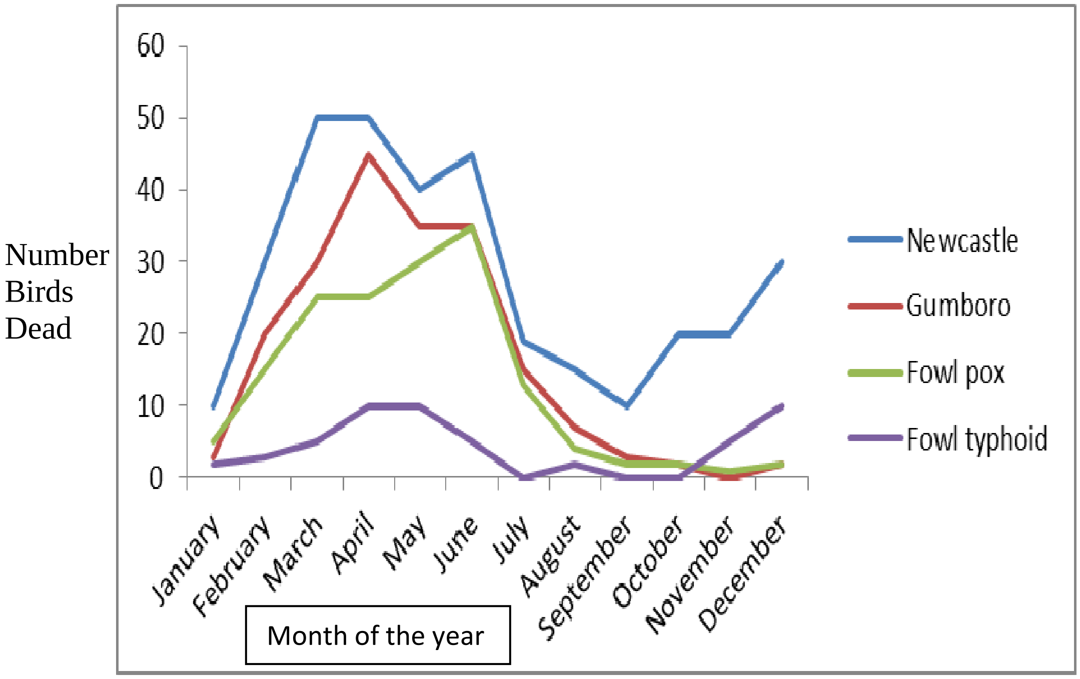

Figure 6.1 Occurrence patterns of the indigenous chicken diseases in Migwa and Kagak villages

Chick mortality

Newcastle disease was an important killer across all the age categories of the indigenous chickens in the study area. Highest mortality rates of the disease were reported in the young chickens. The disease severity, however, seemed to be decreasing with age (0.1080, 0.0653 and 0.0477 per bird months at risk in chicks, growers and adults, respectively) (Tables 6.6, 6.7 and 6.8).

Table 6.6 Number, relative proportions and case specific mortality rates of chicks in Migwa and Kagak villages

Diseases	Number	Monthly true rates	Percentage (%)
Newcastle	226	0.1080	41.2
Gumboro	159	0.0760	29.0
Fowl pox	132	0.0631	24.0
Fowl typhoid	32	0.0153	5.8
Total	549		100

Gumboro and fowl pox were important diseases in young chickens having monthly mortality rates of 0.0760 and 0.0631 per bird months at risk in chicks and 0.0304 and 0.0221 per bird months at risk in growers. Adult birds suffered less from Gumboro (0.0057 per bird months at risk) and fowl pox (0.0034 per bird months at risk) compared to chicks and growers (Tables 6.6 to 6.8).

Table 6.7 Number, relative proportions and case specific mortality rates of growers in Migwa and Kagak villages

Diseases	Number	Monthly true rates	Percentage (%)
Newcastle	71	0.0653	51.1
Gumboro	33	0.0304	23.7
Fowl pox	24	0.0221	17.3
Fowl typhoid	11	0.0101	7.9
Total	139		100.0

Fowl typhoid monthly mortality rates (0.0153) were higher in chicks (Table 6.6) than in adults (0.0102 per bird months at risk) and growers (0.0101 per bird months at risk (Tables 6.7 and 6.8).

Table 6.8 Number, relative proportions and case specific mortality rates of adults in Migwa and Kagak villages

Diseases	Number	Monthly true rates	Percentage (%)
Newcastle	42	0.0477	71.2
Gumboro	5	0.0057	8.5
Fowl pox	3	0.0034	5.1
Fowl typhoid	9	0.0102	15.2
Total	59		100.0

The monthly predation rates in chicks (0.0707 per bird months at risk) were about 2 times higher than in the growers (0.0359 per bird months at risk) and about 16 times higher than in adults (0.0045 per bird months at risk). Eagles and hawks were the most important chick predators, while the mongooses and wild dogs were major threats to growers and adults (Table 6.9).

Table 6.9 Number and predation monthly true rates in indigenous chicken by age in Migwa and Kagak villages

Age categories	Number	Monthly true rates
Chicks	148	0.0707
Growers	39	0.0359
Adults	4	0.0045

Other causes of deaths included accidents (motor vehicles, motor cycles, bicycles and heavy rain storms), poisoning and extreme cold weather; that claimed a very small proportion (0.2%) of the total indigenous chicken deaths. All deaths were reported in chicks, with monthly true rates of 0.001 per bird months at risk in the age group category (chicks).

Tables 6.10, 6.11 and 6.12 present number, monthly true rates and relative proportions of sales, home consumptions, gifts out, entrustments out, transfers out and theft in the indigenous chickens in the study area. Farmers rarely used the chicks for home consumptions, sales and entrustments out. Chick transfers out (0.1118 per bird months at risk) were the second most important means for exits from the chicks' age category, after deaths. Chick gifts out (0.0062 per bird days at risk) ranked third most important mode of exists for the age category.

Table 6.10 Number, monthly rates and relative proportions of entrustments out, gifts out and transfer out of chicks in Migwa and kagak villages

Various exits	Number	Monthly rates	Percentage (%)
Gifts out	13	0.0062	5.2
Consumptions	3	0.0014	1.2
Transfers out	234	0.1118	93.6

Growers and adult chickens were preferred for home consumptions and sales (Tables 6.11 and 6.12). The monthly home consumption rates for growers (0.0230 per bird months at risk) were about 1.6 times higher than for adults (0.0148 per bird months at risk). Gifts out monthly true rates for growers were nearly similar to the rates in adults. Growers mainly left household flocks through sales (Table 6.11).

Table 6.11 Number, monthly rates and relative proportions of sales, consumptions, entrustments out, gifts out, transfer out and theft of growers in Migwa and Kagak villages

Various exits	Number	Monthly rates	Percentage (%)
Home consumptions	25	0.0230	17.6
Sales	56	0.0515	39.4
Gifts out	8	0.0074	5.6
Entrustments out	11	0.0101	7.7
Transfers out	33	0.0304	23.2
Theft	9	0.0022	6.3
Total	142		100

Theft problem was only reported in the growers category (Table 6.11).

Table 6.12 Number, monthly rates and relative proportions of sales, consumptions, entrustments out, gifts out and theft of adults in Migwa and Kagak villages

Various exits	Number	Monthly rates	Percentage (%)
Home consumptions	13	0.0148	28.8
Sales	25	0.0284	55.6
Gifts out	7	0.0080	15.6
Total	45		100

6.3.5.2 Entries of indigenous chickens into the household flocks

Table 6.13 presents the descriptive statistics of entries of indigenous chickens into the household flocks of the study villages. Entries into household flocks were through hatchings, purchases and gifts in. Hatchings were the most important mode of entry and accounted for about 94% of all household indigenous chicken entries into the household flocks. Purchases, entrustments in and gifts in combined represented 6% of the total entries. Farmers mostly purchased or received as gifts female growers and hens.

Table 6.13 Descriptive statistics of entries of indigenous chickens into the household flocks in Migwa and Kagak villages

Variables	Number	Proportion (%)
Hatchings (transfers in of chicks)	978	93.9
Purchases	45	4.3
Gifts in	5	0.5
Entrustments in	14	1.3
Total	1042	100

Chick entries

Hatching (transfer in) was the only mode of entries for the chicks into the household flocks; with monthly true rates of 0.4674 per bird months at risk. Chicks were never purchased by farmers. The mean chick survival rate was estimated as 23.9%.

Grower entries

Most farmers used own growers (grower transfers in) to either increase or replace their breeding stock (hens and cocks). Transfers in of growers accounted for over 88% of all grower entries. Purchases, entrustments in and gifts in were other modes of entries.

Table 6.14 Number, monthly true rates and relative proportion of various modes of entries of growers in Migwa and Kagak villages

Modes of entries	Number	Monthly rates	Percentage (%)
Purchases	16	0.0147	6.0
Gifts in	4	0.0037	1.5
Entrustments in	11	0.0101	4.2
Transfers in	234	0.2154	88.3
Total	265		100

Adult entries

Transfers in was the most important means of entry into the adults' age category; accounting for over 51% of all adult entries (Table 6.15). Purchases were second most important mode of entry (Table 6.15). Other modes of entry were entrustments in and gifts in. Rates of transfers in were lower in adults (0.0375 per bird months at risk) than in growers (0.2154 per bird months at risk) and chicks (0.4674 per bird months at risk) (Tables 6.13, 6.14 and 6.15).

Table 6.15 Number, monthly true rates and relative proportions of various modes of entries of adults in Migwa and Kagak villages

Modes of entries	Number	Monthly rates	Percentage (%)
Purchases	29	0.0330	44
Gifts in	1	0.0011	1.5
Entrustments in	3	0.0034	4.5
Transfers in	33	0.0375	50
Total	66		100

6.3.6 Utilization of indigenous chicken eggs

The trend for the utilization of the produced eggs was similar to findings in the cross-sectional survey (section 5.3.9); whereby the largest proportion of the produced eggs (80%) was incubated. Consumption (about 10%) was second, while sales (5%) ranked last. The egg market was readily available in the neighbourhood and the nearby town centres of Manyoro and Oyugis.

6.3.7 Qualitative research findings

The participatory tools used involved farmers in all stages of the study; leading to high level of interest and 100% response rate among respondents as they felt that they owned the study too. This in turn enhanced close interaction between the farmers and the research team that enabled free flow of information between the two groups.

During PLA, farmers demonstrated good knowledge on many issues related to indigenous chicken production. These included seasonal occurrence of diseases; optimum hen to cock ratio (10:1) for improved hatchability rates and relation between the sizes of the incubating hens and hatchability rates (hens with big body sizes were able to incubate more eggs compared to the small ones), among others.

6.4 Discussions

Deaths from diseases and predation were the most important mode of exit across the age categories of the indigenous chickens; with higher rates reported in young birds. This agrees with most research findings on indigenous chickens including Nyaga, (2007), Wachira *et al.,* (2010) and Okeno *et al.,* (2011) in Kenya. The chicken mortality especially in chicks is a major constraint to indigenous chicken production and strategy meant to improve productivity, should aim at reducing chick mortality.

It was reported by this study that only very few chickens and eggs were left for sales, home consumptions and social activities, after selections of chickens and eggs for breeding and incubation for hatching, respectively, were done. This is typical of indigenous chicken production under free-range management (Siamba *et. al*., 2002; Okitoi *et. al*., 2006). The reason for this is the heavy production losses associated with indigenous chicken production. Most farmers react by retaining more eggs and chickens for hatchings and breeding, respectively, than they dispose, to make up for heavy losses from chicken deaths.

Hatchings were the main mode of chick entries whereas growers, hens and cocks entered mainly through purchases and gifts; agreeing with the report by Okuthe (1999) in Kenya. Most farmers in an attempt to maintain their flocks after losses (deaths or thefts) incubated eggs laid for hatching or purchased or received chickens as gifts.

Most of the purchases and gifts in were growers (mostly females) and hens. Most farmers never bothered about having own cocks but were still able to start off and build their flocks from females alone since the cocks from the neighbourhood easily served their chickens during free range feeding.

This study reported relative proportions of indigenous chicken deaths across the three age categories; chicks, growers and adults as 74%, 19% and 7%, respectively. Findings by Missohou *et al*, (2002) in Senegal indicated mortality rates of 43%, 16% and 3% for chicks, growers and adults, respectively. Report by Mapiye and Sibanda (2005) in Zimbabwe showed that chick deaths were 63.3% of total indigenous chicken mortality. The mentioned findings agree with the present study in that the mortality was highest in chicks. This present study further indicated that high chick mortality was due to diseases (mainly ND) and predation; agreeing with the findings by Njue *et al.*, (2001) and Swai *et al.*, (2007).

The high chick mortality probably resulted from stress the chicks were exposed to during free range feeding. The chicks were left to compete with older birds for food during free range, exposing them to starvation, extreme weather changes, predators and diseases pathogens. High mortality rates were likely to be observed, considering the underdeveloped immune system of the chicks (Mapiye and Sibanda, 2005) and the poor health care associated with indigenous chicken production in the study area.

The number of chicks dying represents eggs that would have otherwise been consumed and chickens that would have been available as replacement stock or for consumption and sale.

It was evidence from the Participatory Learning and Acton (PLA) component of the study that farmers were part and parcel of the study processes. They freely demonstrated their knowledge on many issues related to indigenous chicken production that was passed to the investigation team. They constructed seasonal pattern of occurrence of indigenous chicken diseases in the study area. This study confirmed the pattern as correct. They accurately indicated the optimum hen to cock ratio (10:1) for improved hatchability. The farmers were able to logically relate the sizes of the incubating hens and the number of eggs set for hatching. They explained that bigger hens were able to incubate more eggs compared to small ones. The farmers however had inadequate knowledge on indigenous chicken diseases control; this probably explains the high rates of chicken mortality from diseases observed by this study.

CHAPTER 7

7.0 Laboratory diagnosis of diseases of the indigenous chickens

7.1 Introduction

Diseases have been ranked as the most important constraint lowering productivity in the indigenous chicken flocks. Post mortem examination and laboratory analysis were conducted on sick and freshly dead chickens to establish causes of deaths throughout the study period whenever such cases arose.

7.2 Materials and methods

7.2.1 Study site

As described in section 3.2

7.2.2 Study design

Picking of chickens for post-mortem examination was geared towards getting those that showed signs of disease and fresh carcasses. A total of 45 chickens from 31 households appropriately fell under this study component where the study team managed to collect the ideal samples.

7.2.2.1 Post-mortem examination and sample collection

Post-mortem examinations were done following standard procedures; according to Chalton *et al.* (2006) on sick and dead chickens (fresh carcasses); and appropriate laboratory samples taken to the Virology, Bacteriology and Parasitology laboratories, Department of Veterinary Pathology, Microbiology and Parasitology, University of Nairobi, for confirmatory diagnosis.

Samples for both viral and bacterial isolations included pooled oropharyngeal-cloacal swabs, and swabs from liver and/or other organs showing pathology. The samples for virology and bacteriology were transported in minimum essential medium (MEM) and Stuart medium, respectively. The entire gastrointestinal tract (GIT) system and the whole or part of the skin (depending on size of the bird) were collected and transported in 70% alcohol (for preservation) for the isolation of endoparasites and ectoparasites, respectively. The birds' serum separated from respective clotted blood samples for the determination of the respective antibody titres. The laboratory samples were transported and stored under recommended temperatures 0^0 to 4^0C

7.2.2.2 Newcastle disease diagnosis

7.2.2.2.1 Newcastle disease serological testing

Blood from the jugular vein was collected into universal bottles without anticoagulant. Serum samples were separated from respective clotted blood samples by centrifugation at 500 rpm for 15 minutes, and then heated at 56^0C for 30 minutes to inactivate nonspecific haemagglutination inhibitors. The serum samples were then decanted, aliquoted into screw capped vials. The serum samples were used for the determination of the Newcastle antibody titres using haemagglutination- inhibition (HI) test. Titre is positive if there is inhibition at a serum dilution of 2^4 or more against 4 HA units, or 2^3 or more against 8 HA units (OIE, 2000). Positive serology and clinical signs in unvaccinated birds are strong diagnostic evidence of ND especially in situations where virus isolation is not possible. For the use of HI and other tests in measuring immune status of vaccinated birds, mean level of HI titres ranging from 2^4 – 2^6 after a single live vaccine to 2^9 – 2^{11} with multiple programme are expected (Alexander, 2003).

7.2.2.2.2 Newcastle disease virus isolation

A mixture of cloacal and oro-pharyngeal swabs was prepared and inoculated into Allantoic sac of 10 to 12 day-old specific pathogen free (SPF) embryonated eggs for virus isolation as described in OIE (2000) manual. Virus detection was done using haemagglutination test as described by OIE (2000).

7.2.2.3 Gumboro disease diagnosis

Diagnosis of Gumboro disease was based on post mortem findings. Haemorrhagic streaks on thigh and/or breast muscles; enlarged bursas of Fabricius; distended urinary tubules filled with urates; liver showing/exhibiting a cooked appearance (Saif *et al,* 2003).

7.2.2.4 Fowl pox disease diagnosis

Fowl pox disease diagnosis was based on clinical findings. Proliferative lesions in the skin (cutaneous form) of the head, neck, legs and other parts of the body; that progressed to thick scabs and by lesions in the upper Gastro-intestinal and respiratory tracts (diphtheritic form) (Saif *et al,* 2003).

7.2.2.5 Bacteriological and parasitological isolations and characterization

Bacteria were isolated and characterized according to Krieg and Holt (1994). Parasites, both ecto- and endo-, were characterized as per Permin and Hansen (1998).

7.3 Results

7.3.1 Newcastle disease

Most of the sick birds had green diarrhoea and respiratory distress and on post mortem examinations, proventriculus had haemorrhages. Of the 45 chickens tested, Newcastle disease virus was isolated from 9 birds (20 %), while 20 birds (44.4 %) were sero-positive; 19 (42.2 %) having protective titres, that were higher than 1:8. The titres ranged from 1:8 to 1:512. The positive cases of Newcastle disease mostly occurred in the months of February to June and late October to late December; during rainy and cold seasons.

7.3.2 Gumboro disease

About 80 % of birds examined showed typical lesions for Gumboro disease at post mortem; these included haemorrhagic streaks on thigh and/or breast muscles (Figures 7.1 and 7.2), enlarged bursas of Fabricius, extended urinary tubules filled with urates and liver showing a cooked appearance (Figure 7.3) (Saif *et al*, 2003). Most cases occurred in the months of February to July; during rainy and cold seasons.

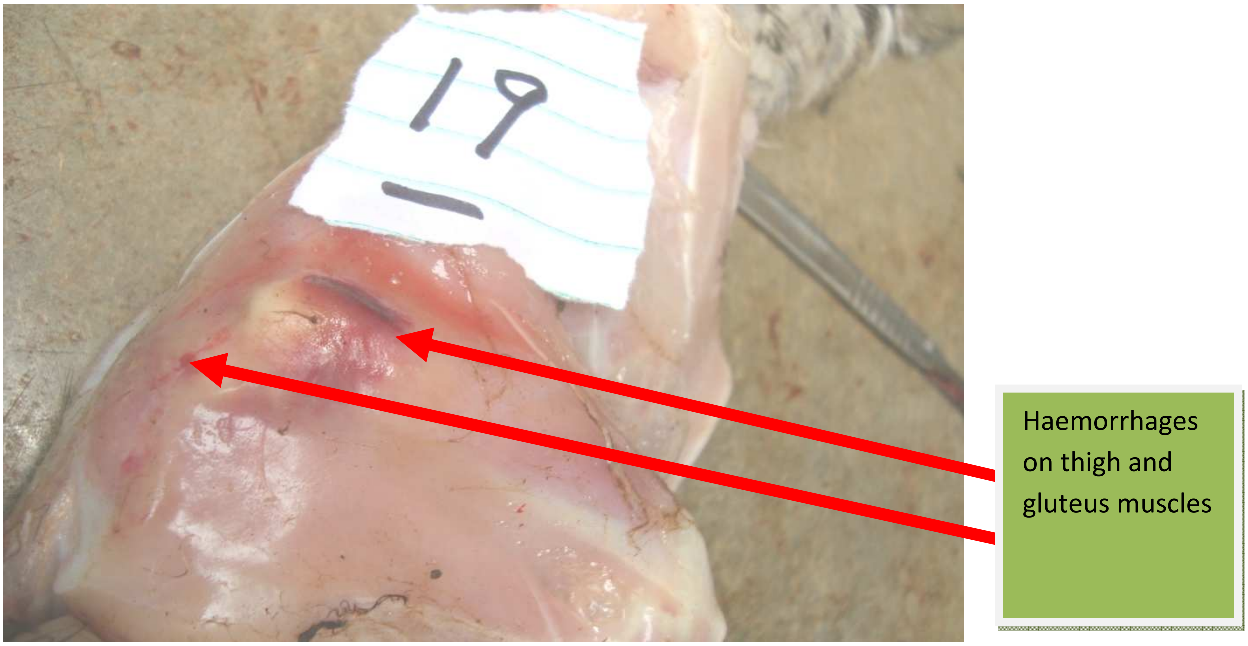

Figure 7.1 Petechial and echymotic haemorrhages (arrows) on the thigh and the gluteus muscles of indigenous chicken suspected to be sick of Gumboro disease

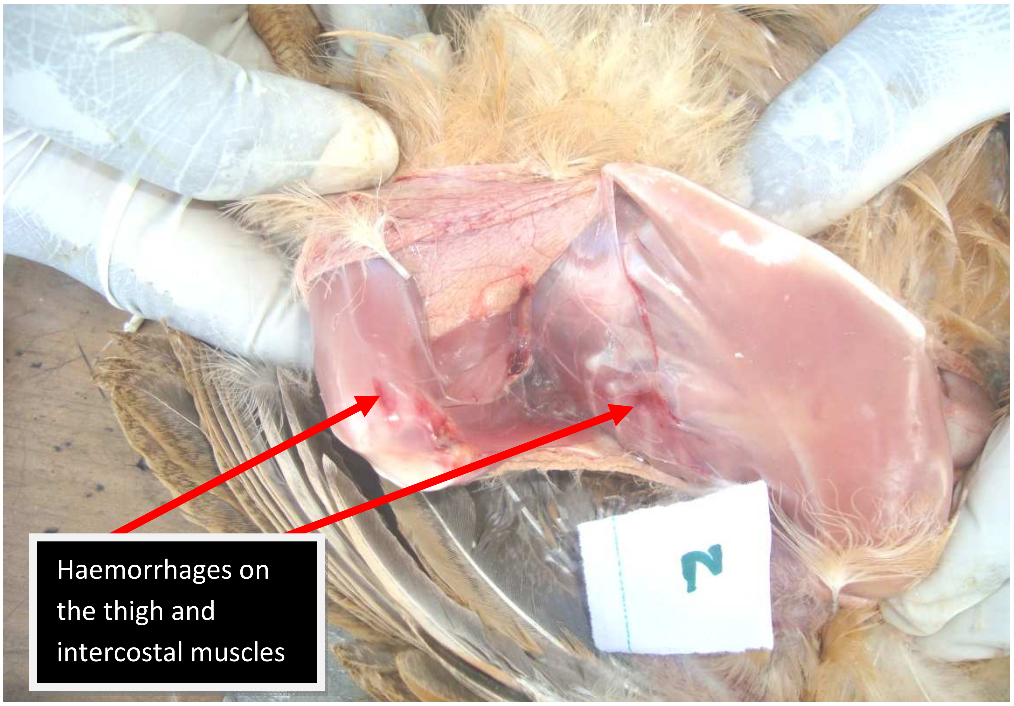

Figure 7.2 Haemorrhages (arrows) on the thigh and intercostal muscles of an indigenous chicken that was suffering from Gumboro

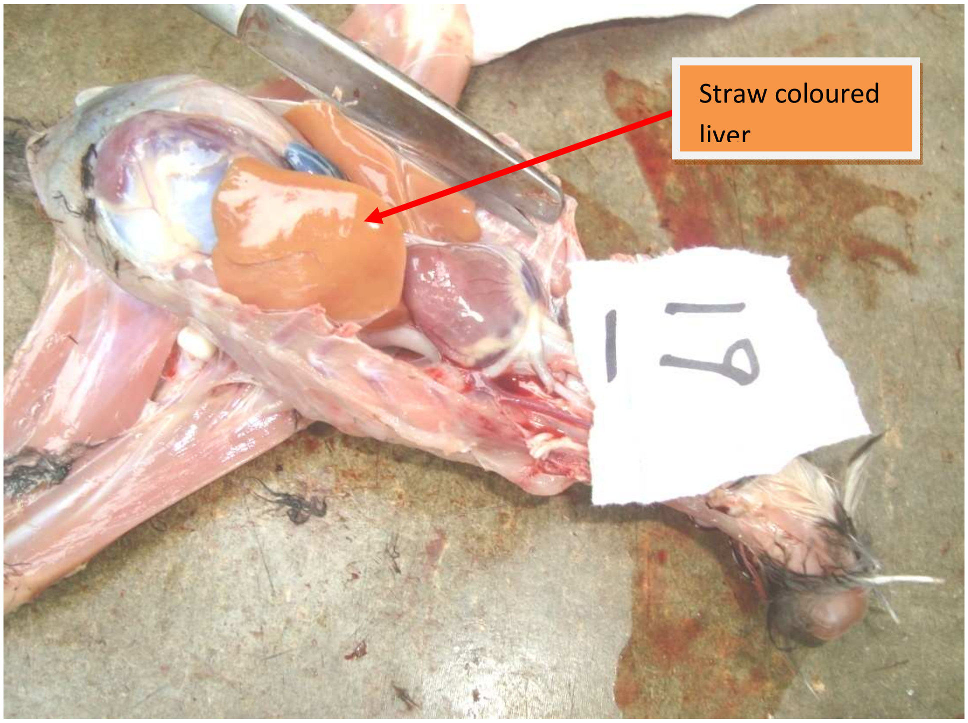

Figure 7.3 Liver (arrow) showing straw colour in chicken that was suffering from Gumboro infection

7.3.3 Fowl pox

Approximately 40% of the birds sampled for post mortem exhibited typical pox lesions. These included proliferative lesions in the skin of the head, neck and legs that progressed to thick scabs (Figure 7.4) and diphtheritic lesions in the upper gastro-intestinal and respiratory tracts. Most cases were observed in the months of March to July during the study period; cold and rainy seasons. Fowl pox disease diagnosis was based on pox lesions on the head, neck, legs and upper gastro-intestinal and respiratory tracts.

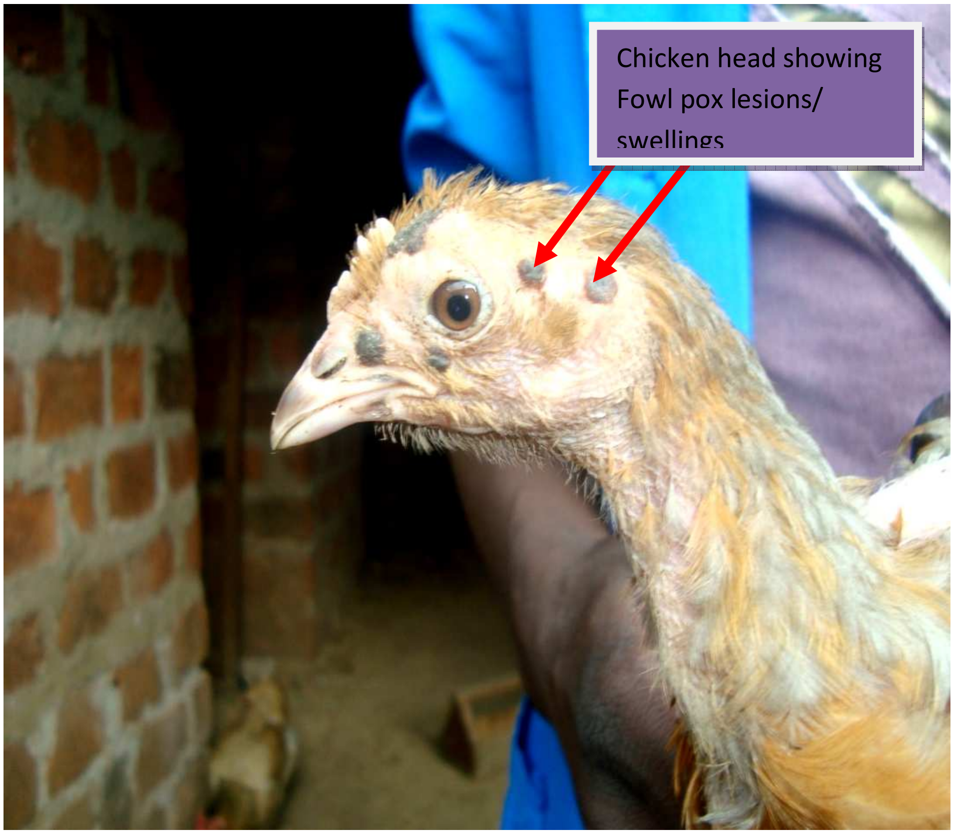

Figure 7.4 Head of one of the indigenous chickens infected with fowl pox (arrows showing pox lesions/ swellings)

7.3.4 Parasitological isolations

Parasitological isolations were done from skins and gastro-intestinal tracts. Prevalence of parasitological isolations is presented in Table 7.1. These organisms were associated with various pathological lesions as indicated in Table 7.3. Over 70% of the parasitic infestations were mixed infections. Approximately 80%, 70% and 65% of adults, growers and chicks, respectively, were infected with ectoparasites; the infestations could either be single or mixed.

Parasites were isolated whenever samples were taken for laboratory analysis; meaning the infections in the chickens occurred almost throughout the year.

Table 7.1 Prevalence of parasitological isolations in indigenous chickens in Migwa and Kagak villages

Parasites	Prevalence (%)	Where isolated from
Ectoparasites		
Knemidocoptes nutants (mite)	33	Scaly legs
Echinophaga gallinacea (stick tight flea)	33	Mainly around the eyes
Endoparasites		
Ascaridia galli	50	Small intestine
Heterakis isolonche	67	Caecum
Tetrameres fissispina	17	Proventriculus
Dispharynx nosuta	33	Proventriculus
Tapeworms		
Raillietina echinibothrida	33	Intestine
Flukes		
Echinostoma revolutum	16	Caecum

7.3.5 Bacteriological isolations

Table 7.2 shows the bacteria (and their respective prevalence) isolated from the indigenous birds in the study area. Respiratory involvement was mainly caused by *Pasteurella multocida* and *Klebsiella spp. Salmonella gallinarum* was also isolated from liver and spleen swabs of a few birds showing signs of peritonitis. Other bacteria isolated included: *Staphylococcus spp, Bacillus spp* and *E. coli*; they were mainly visceral. The prevalence of *Bacillus spp* and *Pasteurella multocida were* 66.7% and 50%, respectively. Most of the birds had mixed infections. Bacteriological isolation from yellowish granules observed in the abdomen in some of the chickens yielded *Bacillus* species. Some chickens had whitish diarrhoea (33%). Various bacteria were isolated from the indigenous chickens almost all the year round (the project duration); whenever samples were taken for laboratory analysis.

Table 7.2 Prevalence of bacterial isolates from indigenous chickens indicating organs from which isolated in Migwa and Kagak villages

Organism	Prevalence (%)	Organs isolated from
Salmonella gallinarum)	17	Liver and spleen swab; Peritonitis
Staphyylococcus spp	17	Oro-pharyngeal swab; Liver
Pasterella multocida	50	Oro-pharyngeal swab; Respiratory tract
Klebsiella spp	33	Oro-pharyngeal swab; Lung
Bacillus spp	67	Oro-pharyngeal swab; Lung
Escherichia coli	17	Oro-pharyngeal swab; Liver

7.3.6 Lesions seen at post-mortem examination of indigenous chickens

Table 7.3 presents various pathological lesions that were observed when post mortem examination of the birds was done. These included fibrinous pneumonia/ air sacculitis; scaly legs; enlarged/congested spleen (at 33%); yolk sac infection and thickened proventriculus with darkened spots; yellowish granular substances along neck and all over abdomen; skin wounds/ defeathering; febrinous pericarditis and endocarditis (at 18%); signs of jaundice/ liver involvement (60%); Prominent kidney tubules packed with urates (56%); Enlarged bursa of fabricious (44%) and Peritonitis – egg (29%).

Table 7.3 Prevalence of lesions seen at post-mortem examination of indigenous chickens in Migwa and Kagak villages

Lesion/ causative agent	Prevalence (%)
Fleas around eyes/ *Echinophaga gallinacea*	33
Scaly legs/*Knemidocoptes mutans*	33
Signs of jaundice/liver involvement/ *Bacillus spp*	60
Enlarged/congested spleen/ *Pasteurella multocida*	33
Upper respiratory tract infection/pneumonia/air sacculitis/ *Pasteurella multocida/ Klebsiella spp*	33
Yolk sac infection/fragile ova/ *Salmonella gallinarum*	18
Thickened proventriculus/ tetrameres	18
Yellowish granular substances along neck/all over abdomen/ *Bacillus spp*	18
Peritonitis – egg/ *Salmonella gallinarum/ Bacillus spp*	29
Pericarditis and endocarditis/ Pasteurella multocida	18
Prominent kidney tubules packed with urates/ Gumboro	56
Enlarged bursa of fabricious/ Gumboro infection	44
Diarrhoea/ *Salmonella gallinarum/ Gumboro/ E.coli*	33
Skin wounds/ defeathering/ Neocnemidocoptes gallinea	18
Haemorrhagic proventriculus/ Newcastle disease	20
hemorrhagic streaks on thigh and/or breast muscles/ Gumboro	80

7.3.7 Fungal isolation

Aspergillus fumigatus was isolated from one chicken with signs of defeathering and wounds.

Screening of the chickens for mange gave negative results.

7.4 Discussions

Results showed carriage of various viruses, bacteria, endoparasites and ectoparasites by the chickens that were studied. These organisms were associated with various pathological lesions seen at post-mortem examination. Some birds showed mixed infections of worms, in addition to the viral and bacterial loads; some had lots of worms. Parasites are known to cause stress through nutrient consumption, blood sucking and irritations. Stress in birds is associated with immunosuppression (Njagi *et al.*, 2012).

The severity of other conditions like pneumonia, fibrinous pericarditis, salmonellosis, may be as a result of the Gumboro disease, clinical and/or subclinical, since it destroys immune-competent cells leading to immunosuppression (Saif *et al., 2003*). This may have been coupled with the effect of the heavy parasite burden observed. Apart from immunosuppression, stress caused to the birds as a result of viral, bacterial, endo- and ecto-parasitic heavy burdens reduces the birds' productivity, be it number of off-springs, meat or egg (Otim *et al.*, 2005; Njagi *et al.*, 2012). Thus efforts need to be made to reduce the stress so as to allow the birds yield more products. It is important to note that most of the diseases identified and prioritized by farmers in the rapid rural appraisal study as most important indigenous chicken killers were confirmed to be so by the post mortem examinations and laboratory investigations. The monthly occurrences of the diseases as shown by the results of the post mortem examinations and laboratory investigations take similar pattern to the one previously constructed by the community group discussions in the rapid rural appraisal study. This strongly suggests that farmers are rich in knowledge and their opinion in production should be listened to by researchers and extension agents.

CHAPTER 8

8.0 Quantification of the impact of intervention measures on indigenous chicken constraints

8.1 Introduction

The controlled intervention study was carried out in the third phase for 12 months in the 80 study households (described in section 5.2.2 of the thesis). It quantified the impact of six intervention strategies on the productivity of the indigenous chickens. This being a longitudinal study, its data was useful in explaining exposure-outcome associations (as described in section 6.1).

8.2 Methods and materials

8.2.1Study area

As described in section 3.2

8.2.2 Study design

The study was conducted for 12 months in the 80 study households (described in section 5.2.2). Controlled intervention trials were carried out against the three most important indigenous chicken constraints that included diseases (three most important; Newcastle, Gumboro and fowl pox), predations (in chicks) and inadequate feeding (prioritized in chapters 4 and 6 of the thesis). The study was conducted in six designated intervention groups and one control group. The name of each group was derived from its intervention programme. Allocation of the groups to the interventions was randomly done. The group that only practised Newcastle disease vaccinations during the study was designated as *Newcastle vaccination only* (NVO) group. The one that only vaccinated against Gumboro disease became *Gumboro vaccination only* (GVO) group. The group that only vaccinated against fowl pox was designated as fowl *pox vaccination only* (FPVO) group. The group that only confined chicks from day old to 3 months of age was named *chick confinement only* (CCO) group and the one that only provided grains and kitchen left over supplementations was designated as *consistent grain and kitchen left over supplementation only* (CGKSO) group. The group that concurrently practised all the interventions; the three vaccination programmes, day old chick confinement to 3 months of age and consistent provision of feed supplementation was designated as *combined intervention* (COIN) group. The group that never practised any of the interventions became the control for the six intervention groups.

The COIN and NVO groups comprised of 11 households each, CGKSO, GVO and FPVO groups had 10 households each, CCO group had 9 households and control group comprised of 19 households (described in chapter 6). All the households in the six intervention groups and the control were monitored during the study for one year.

The impact of the six intervention trials were assessed by comparing their mean household flock sizes and chick survival, mortality and off-take rates with that of the control group. The intervention strategy that resulted in the largest mean household flock size and chick survival and off-take rates and lowest mortality rate would be the most appropriate.

Post mortem and laboratory analysis were done on sick and freshly dead chickens for the confirmation of diagnosis throughout the phase, whenever such cases arose (chapter 7).

Data was obtained by questionnaire administration, measurement of productivity parameters (such as flock sizes and chick survival, off-take and mortality rates), direct observations, focus group discussions and necropsy and laboratory analysis. Details are presented in sections that follow.

8.2.2.1 Interventions against Newcastle, Gumboro and fowl pox diseases

Routine vaccinations against Newcastle, Gumboro and fowl pox diseases were carried out for one year in the indigenous chickens in NVO, GVO and FPVO groups (section 8.2.2), respectively. Vaccinations were randomly assigned to the three intervention groups. The groups were then monitored for key indigenous chicken productivity parameters that included flock sizes and chick survival, off-take and mortality rates.

8.2.2.2 Intervention against chick predation

This intervention trial was carried out in CCO group (section 8.2.2) for one year. Day old chicks were housed/ confined during day time in *Osera* (special basket for protecting/ confining chickens) for up to three months of age to protect them from predators. The chicks were provided with a mixture of commercial chick feeds and locally available feeds; grains and kitchen left overs, and water given *ad libitum*. At the age of three months the birds were expected to be able to escape from the birds of prey and other predators. Productivity parameters as listed in section 8.2.2.1 were monitored throughout the intervention period.

8.2.2.3 Consistent maize grains and kitchen left over supplementations intervention

The intervention trial was conducted in CGKSO group (section 8.2.2). Farmers were supplied with maize grains for one year, to use as supplement for their indigenous chickens, alongside kitchen left overs. These households were visited at least twice a month to ensure that consistent supplementations were being done. The productivity parameters (listed in section 8.2.2.1) were monitored for the one year period.

8.2.2.4 All the interventions combined

The COIN group concurrently implemented all interventions (section 8.2.2) for one full year and monitored productivity parameters (listed in section 8.2.2.1) for the same period.

8.2.2.5 Control group

The control group consisted of 19 households. No interventions were carried out, but productivity parameters were observed for one year. The control group also provided the indigenous chicken production baseline data for the study (chapter 6).

8.2.3 Data management and analysis

The data obtained were entered in Microsoft access programme (Microsoft Corporation, 2000) for storage before analysis, as described in section 3.5.

8.2.3.1 Bird days

As described in section 6.2.3

8.2.3.2 Comparison of the intervention strategies

The ANOVA and Pearson's Chi-square tests were used to compare the means and proportions, respectively, in the six designated intervention groups and the control.

Analysis of variance (ANOVA)

The test was done using Epi-Info statistical package. The analytical method was used for analysis of continuous data with categorical determinants. Mean flock sizes, bird days and number of chickens by age category were tested for differences between the six intervention groups (COIN, CGKSO, FPVO, GVO, CCO, and NVO) and the control.

Chi-square

This analysis was carried out using Epi Info to compare the rates between the seven groups. The compared rates included that of crude and case specific mortality, off-takes (sales and consumptions), purchases, hatchings, among others. The null hypothesis in this test assumes that the true incidence of the event in question is the same in the groups being compared. Thus, the observed counts are compared with the expected counts to calculate Pearson's Chi-square (χ^2) and p-value.

8.2.4 Participatory evaluation of the interventions

Focus group discussions were held in the last month of the study with the objectives of evaluating the whole programme and determine the relative effectiveness of the interventions carried out. The fulfilment of this objective would show whether the farmers had been empowered as per the definition of the PRA (Chambers, 1994). Participants were chosen to represent all the designated treatment groups as described in section 8.2.2. Two focus group discussions were carried out; one in each of the two study villages (Kagak and Migwa).

A total of 12 farmers chosen at random were invited for each focus group discussion. The participants in each site were the farmers, the author and two enumerators. Firstly, the final documented report on the RRA and PRA findings were freely and exhaustively discussed by the farmers (participants) while the process was being facilitated by the research team, and any changes since the first RRA discussions were covered. Secondly farmers' perceptions on the intervention measures carried out were captured through discussions and sharing of experiences. The process was facilitated through questions (checklists), answers and narration of events. Consensus on various issues was reached at by voting. The last part of the discussion was on farmers' suggestion on the way forward and sustainability as part of participatory recommendations by the community. Farmers did most of the talking based on the probes in the outline facilitated by the moderators.

8.3 Results

A total of eighty households were followed during the intervention study; nineteen as control and sixty one as treatment households.

8.3.1 Indigenous chicken flock sizes and structures

8.3.1.1 Indigenous chicken mean household sizes and structures

Tables 8.1 presents mean indigenous chicken flock sizes per household (household details in the appendix 4). Intervention group that carried out a combination of all the five interventions (COIN) recorded the largest mean household flock size. This mean household flock size was statistically different from those recorded in all the other intervention groups and the control (p<0.05). Mean flock sizes in the NVO and CGKSO groups were similar (p-value = 0.770), and second largest (Table 8.1). Mean flock sizes in FPVO, GVO and CCO groups were smallest and were similar to the control (p-value > 0.05).

Table 8.1 Mean household flock sizes by interventions in Migwa and Kagak villages

Interventions	Number of households	Mean flock size	Range
COIN	11	43.00^{a}	29 - 57
CGKSO	10	28.17^{C}	11 - 46
FPVO	10	17.50^{b}	0 -30
GVO	10	19.73^{b}	11 - 33
CCO	9	19.59^{b}	10 - 27
NVO	11	29.24^{c}	20 - 37
Control	19	15.90^{b}	3 - 25
Total number of households	80		

Key:
Means with different superscript letters are statistically different at 95% confidence level
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8.2 presents mean indigenous chicken flock structures per household. The COIN group had the highest mean household numbers of chicks, growers and hens compared to the other groups and the control (p < 0.05). The mean numbers of birds within the three age categories (chicks, growers and hens) in NVO and CGKSO groups were similar (p > 0.05) and second largest. The mean household numbers of chicks, growers and hens were similar in the control, CCO, GVO and FPVO groups (p > 0.05). Cocks were the fewest with mean flock sizes similar across all the intervention groups and the control.

8.3.1.2 Descriptive statistics on flock structures in terms of bird days in Migwa and Kagak villages

Table 8.3 presents bird days by age category for the study area (household details in the appendix 4). COIN group recorded the highest mean bird days compared to the other groups ($p < 0.05$). Mean bird days in NVO and CGKSO were second largest and similar ($P > 0.05$). The mean bird days in the other intervention groups were smallest and never different from the control.

Table 8.2 Indigenous chicken household flock structures by interventions in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Cocks	Hens
COIN	Mean	20.91^{a}	14.73^{d}	0.82^{g}	6.73^{h}
CGKSO	Mean	14.10^{c}	9.20^{f}	0.60^{g}	4.10^{k}
FPVO	Mean	8.50^{b}	5.90^{e}	0.40^{g}	2.70^{j}
GVO	Mean	9.90^{b}	6.80^{e}	0.50^{g}	2.30^{j}
CCO	Mean	10.89^{b}	4.89^{e}	0.56^{g}	3.44^{j}
NVO	Mean	15.18^{c}	9.36^{f}	0.73^{g}	3.91^{k}
Control	Mean	8.58^{b}	4.32^{e}	0.68^{g}	2.32^{j}

Key:
Means with different superscript letters within age group are statistically different at 95% confidence level
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only; Control –No interventions
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only

Table 8.3 Bird days in Migwa and Kagak villages

Interventions	Chick bird days	Grower bird days	Adult bird days	Total bird days
COIN	76407	50008	29202	155617
CGKSO	48301	33331	17765	99397
FPVO	31746	21403	12167	65316
GVO	35760	23352	12778	71890
CCO	34065	15083	13384	62532
NVO	57529	33574	19837	110940
Control	62770	32597	26398	121765

Key:
Means with different superscript letters are statistically different at 95% confidence level
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only;
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.2 Chick survival rates

Chick survival rates for the intervention groups are given in Table 8.4. The COIN group recorded the highest chick survival rates (82.64%), followed by NVO (41.9%). The other intervention groups; CCO, control, FPVO, GVO and CGKSO recorded lowest survival rates ranging from 22.9 to 36.8 %

Table 8.4 Mean household chick survival rates by interventions in Migwa and Kagak villages

Interventions	Survival rate (%)
COIN	82.6
CGKSO	36.8
FPVO	33.8
GVO	35.0
CCO	22.9
NVO	41.9
Control	23.9

Key:
Means with different superscript letters are statistically different at 95% confidence level
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only;
FPVO -Fowl pox disease vaccinations only
GVO - Gumboro disease vaccinations only;
CCO- Chick confinements only;
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3 Indigenous chicken exits from household flocks

8.3.3.1 Indigenous chicken deaths

Table 8.5 presents number and monthly crude mortality true rates of the indigenous chickens in the study villages (household details in the appendix 4). The monthly crude mortality true rates were lowest in the COIN group (0.0191 per bird months at risk) compared to the other groups ($p < 0.05$). The control group recorded the highest mortality rates compared to the other groups ($p < 0.05$). Mortality rates in the other groups (NVO, CGKSO, FPVO, GVO and CCO) were statistically similar ($p > 0.05$).

8.3.3.1.1 Indigenous chicken deaths due to Newcastle disease

Table 8.6 presents the mean, number and monthly mortality true rates for Newcastle disease in the indigenous chickens. There were no deaths from Newcastle disease across all age categories in the COIN group. The monthly mortality rates of Newcastle disease were lower across all age categories in the NVO group compared to CGKSO, FPVO, GV O, CCO and control groups ($p < 0.05$). The disease mortality rates were lower in the growers and adults in CGKSO group compared to FPVO, GVO, CCO and control groups ($p < 0.05$). The disease mortality rates across all age categories in GVO, FPVO, CCO and control were similar.

Table 8.5 Mean, number and monthly true rates of crude mortality of the indigenous chickens by interventions in Migwa and Kagak villages

Interventions	Mean	Number	Monthly crude mortality true rates
COIN	9.00^{a}	99	0.0191
CGKSO	39.60^{b}	396	0.1195
GVO	41.20^{b}	412	0.1719
CCO	44.11^{b}	397	0.1905
NVO	39.27^{b}	432	0.1168
FPVP	32.90^{b}	329	0.1511
Control	49.47^{c}	940	0.2316

Key:

Means with different superscript letters are statistically different at 95% confidence level
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only

Control – No interventions

Table 8.6 Mean, number and monthly true rate mortality for Newcastle disease in indigenous chickens by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	.00	.00	.00
	Number	0	0	0
	Rates	0	0	0
CGKSO	Mean	16.30	2.80	1.60
	Number	163	28	16
	Rates	0.1012	0.0252	0.0270
GVO	Mean	17.60	5.50	2.40
	Number	176	55	24
	Rates	0.1477	0.0707	0.0563
CCO	Mean	15.78	2.67	1.78
	Number	142	24	16
	Rates	0.1251	0.0477	0.0359
NVO	Mean	2.18	1.09	.09
	Number	24	12	1
	Rates	0.0125	0.0107	0.0015
FPVO	Mean	13.70	3.60	1.90
	Number	137	36	19
	Rates	0.1295	0.0505	0.0468
Control	Mean	11.89	3.68	2.21
	Number	226	71	42
	Rates	0.1080	0.0653	0.0477

Key:

COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.1.2 Indigenous chicken deaths due to Gumboro disease

Table 8.7 presents the mean, number and monthly mortality true rates for Gumboro disease in the indigenous chickens. No deaths were recorded in the GVO and COIN groups. There were also no deaths in the growers and adult chickens in the FPVO group. The disease mortality rates in the chicks were higher in the control group than in the FPVO, CCO and CGKSO groups ($P < 0.05$). The disease mortality rates in growers were higher in the control than in the CCO and NVO groups ($p < 0.05$). The disease mortality rates in the growers and adults were similar in the control and CGKSO groups ($p > 0.05$).

8.3.3.1.3 Indigenous chicken deaths due to fowl pox disease

Table 8.8 presents the mean, number and monthly mortality true rates for fowl pox disease in the indigenous chickens in the study area. No deaths from fowl pox were recorded in the COIN group. No deaths from the disease were recorded in adult chicken in all the intervention groups, except for the control group that recorded mortality rates of 0.0034 per bird months at risk. No chicken grower deaths were recorded in FPVO and CGKSO groups. The Chick mortality rates from the disease were higher in the control group than in the FPVO, GVO, NVO, CGKSO and CCO groups ($p < 0.05$). Mortality rates in the grower birds were higher in the control group than in the CCO, GVO and NVO groups.

Table 8.7 Mean, number and monthly true rate mortality for Gumboro disease in indigenous chickens by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	.00	.00	.00
	Number	0	0	0
	Rates	0	0	0
CGKSO	Mean	5.80	2.20	.20
	Number	58	22	2
	Rates	0.0360	0.0198	0.0034
GVO	Mean	.00	.00	.00
	Number	0	0	0
	Rates	0	0	0
CCO	Mean	6.11	.67	.44
	Number	55	6	4
	Rates	0.0484	0.0119	0.0090
NVO	Mean	12.73	1.73	.55
	Number	140	19	6
	Rates	0.0730	0.0170	0.0091
FPVO	Mean	1.50	.00	.00
	Number	15	0	0
	Rates	0.0142	0	0
Control	Mean	8.37	1.74	.26
	Number	159	33	5
	Rates	0.0760	0.0304	0.0057

Key:

COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8.8 Number and monthly true rate mortality for Fowl pox disease in indigenous chickens by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	0.00	0.00	0.00
	Number	0	0	0
	Rates	0	0	0
CGKSO	Mean	2.10	0.00	0.00
	Number	21	0	0
	Rates	0.0130	0	0
GVO	Mean	1.00	0.20	0.00
	Number	10	2	0
	Rates	0.0084	0.0026	0
CCO	Mean	5.89	0.11	0.00
	Number	53	1	0
	Rates	0.0467	0.0020	0
NVO	Mean	3.91	1.18	.00
	Number	43	13	0
	Rates	0.0224	0.0116	0
FPVO	Mean	0.20	0.00	0.00
	Number	2	0	0
	Rates	0.0019	0	0
Control	Mean	6.95	1.26	0.16
	Number	132	24	3
	Rates	0.0631	0.0221	0.0034

Key:

COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.1.4 Indigenous chicken deaths due to fowl typhoid disease

Table 8.9 presents the mean, number and monthly mortality true rates for fowl typhoid disease in the indigenous chickens in the study area. No deaths from fowl typhoid disease were recorded in the FPVO, CCO and CGKSO groups. The chick and grower mortality rates in the control group were higher than in the GVO and COIN groups ($p < 0.05$). The disease mortality rates in the two age categories were similar in the control and NVO groups. Adult deaths from fowl typhoid were more in the control than in the GVO group.

8.3.3.1.5 Indigenous chicken deaths due to predations

Table 8.10 presents the mean, number and monthly mortality true rates for predations in the indigenous chickens in the study area (household values in the appendix 4). Predation was a major problem in the chicks compared to the other age categories of the indigenous chickens. No predations were recorded in adult chickens in the CGKSO, GVO and CCO groups. The COIN group recorded the lowest Chick mortality rates from predations compared to the other groups ($p < 0.05$), followed by the CGKSO group. Highest chick mortality rates were reported in the other intervention groups; the rates were never different with the control group ($p > 0.05$).

Table 8.9 Number and monthly true rate mortality for fowl typhoid disease in indigenous chickens by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	0.55	0.64	0
	Number	6	7	0
	Rates	0.0024	0.0042	0
CGKSO	Mean	0	0	0
	Number	0	0	0
	Rates	0	0	0
GVO	Mean	0.20	0.20	0.20
	Number	2	2	2
	Rates	0.0017	0.0026	0.0047
CCO	Mean	0	0	0
	Number	0	0	0
	Rates	0	0	0
NVO	Mean	2.09	1.82	0
	Number	23	20	0
	Rates	0.0120	0.0179	0
FPVO	Mean	0	0	0
	Number	0	0	0
	Rates	0	0	0
Control	Mean	1.68	0.58	0.47
	Number	32	11	9
	Rates	0.0153	0.0101	0.0102

Key:

COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8. 10 Number and monthly true rate mortality for predations in indigenous chickens by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	2.55	0.73	0.09
	Number	28	8	1
	Rates	0.011	0.0048	0.0010
CGKSO	Mean	7.60	1	0
	Number	76	10	0
	Rates	0.0472	0.009	0
GVO	Mean	11.10	0.70	0
	Number	111	7	0
	Rates	0.0931	0.0090	0
CCO	Mean	9.22	1.44	0
	Number	83	13	0
	Rates	0.0731	0.0259	0
NVO	Mean	10.27	.55	0.18
	Number	113	16	2
	Rates	0.0589	0.0143	0.0030
FPVO	Mean	10.10	1.60	0.3
	Number	101	16	3
	Rates	0.0954	0.0224	0.0074
Control	Mean	7.79	2.05	0.21
	Number	148	39	4
	Rates	0.0707	0.0359	0.0045

Key:

COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.1.6 Indigenous chicken deaths due to other causes

Table 8.11 presents the mean, number and monthly mortality true rates for other causes of deaths (mainly accidents and rain storms) in the indigenous chickens in the study area. Deaths were only recorded in the chicks' category in other intervention groups apart from the NVO, CGKSO and CCO groups that recorded no deaths at all (household values in the appendix 4).

Table 8.11 Number and monthly true rate mortality for other causes of deaths in indigenous chickens by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	4.45	0	0
	Number	49	0	0
	Rates	0.0192	0	0
CGKSO	Mean	0	0	0
	Number	0	0	0
	Rates	0	0	0
GVO	Mean	2.10	0	0
	Number	21	0	0
	Rates	0.0176	0	0
CCO	Mean	0	0	0
	Number	0	0	0
	Rates	0.0070	0	0
NVO	Mean	0	0	0
	Number	0	0	0
	Rates	0.0057	0	0
FPVO	Mean	.10	0	0
	Number	1	0	0
	Rates	0.0009	0	0
Control	Mean	.11	0	0
	Number	2	0	0
	Rates	0.001	0	00

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.2 Home consumptions, sales, entrustments out, gifts out, transfers out and theft of indigenous chickens

8.3.3.2.1 Home consumptions of indigenous chickens

Table 8.12 presents the mean, number and monthly true rates for home consumptions of the indigenous chickens in the study area (appendix 4 gives more details). Mainly growers and adult birds were used for home consumptions in all the intervention groups and control. The COIN group reported the highest rates of home consumptions of the birds compared to the rest of the groups ($p < 0.05$). The second largest home consumption rates were reported in the NVO group (0.0286 per bird months at risk). Home consumption rates of the indigenous chickens in the other intervention groups were almost similar to the control group.

8.3.3.2.2 Sale of indigenous chickens

Table 8.13 presents the mean, number and monthly true rates for the sales of the indigenous chickens in the study area (household details in appendix 4). Chicks were never sold. Mostly more growers were sold than the adults (p-value < 0.05). The monthly rates of sales for growers in the COIN group were highest compared to the intervention groups and the control ($p < 0.05$). Monthly rates of sales for growers in the other intervention groups were similar to the control group. The rates of sales for the adults’ category were nearly similar in all the groups.

Table 8.12 Mean, number and monthly true rates of indigenous chicken home consumption by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults	Total
COIN	Mean	0	5.91	1.82	7.73
	Number	0	65	20	85
	Rates	0	0.0390	0.0205	
FPVO	Mean	0	0.8	0.7	1.5
	Number	0	8	7	15
	Rates	0	0.0112	0.0173	
GVO	Mean	0	1.6	0.6	2.2
	Number	0	16	6	22
	Rates	0	0.0206	0.0141	
CCO	Mean	0	1.44	0.77	2.22
	Number	0	13	7	20
	Rates	0	0.0259	0.0157	
NVO	Mean	0	2.91	1	3.91
	Number	0	32	11	43
	Rates	0	0.0286	0.0166	
CGKSO	Mean	0	2.2	0.6	2.8
	Number	0	22	6	28
	Rates	0	0.0198	0.0101	
Control	Mean	0.16	1.32	0.68	2.16
	Number	3	25	13	41
	Rates	0.0014	0.0230	0.0148	

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8.13 Mean, number and monthly true rates of indigenous chicken sales by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults	Total
COIN	Mean	0	15.55	1.91	17.45
	Number	0	171	21	192
	Rates	0	0.1026	0.0216	
FPVO	Mean	0	3.4	0.9	4.3
	Number	0	34	9	43
	Rates	0	0.0477	0.0222	
GVO	Mean	0	2.6	1.8	4.4
	Number	0	26	18	44
	Rates	0	0.0334	0.0423	
CCO	Mean	0	2.33	0.67	3
	Number	0	21	6	27
	Rates	0	0.0418	0.0134	
NVO	Mean	0	2.73	0.63	3.36
	Number	0	30	7	37
	Rates	0	0.0268	0.0106	
CGKSO	Mean	0	4.2	1.2	5.4
	Number	0	42	12	54
	Rates	0	0.0378	0.0203	
Control	Mean	0	2.95	1.32	4.26
	Number	0	56	25	81
	Rates	0	0.0515	0.0284	

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.2.3 Gifts out of indigenous chickens

Table 8.14 presents the mean, number and monthly true rates for the gifts out of the indigenous chickens in the study area. Gift out of indigenous chicken was never a popular practice in the study area. Few reports of gifts out were mainly in the growers' category in all the groups.

8.3.3.2.4 Transfers out of indigenous chickens

Table 8.15 presents the mean, number and monthly true rates for the transfers out of the indigenous chickens in the study villages. Monthly rates of transfers out of chicks (appendix 4) and growers in the COIN group were highest compared to the other intervention groups and the control (p-value < 0.05). Transfers out of chicks and growers in the other intervention groups were never different from the control group.

Table 8.14 Mean, number and monthly true rates of gifts out of indigenous chicken by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults	Total
COIN	Mean	0.64	1.18	0	
	Number	7	13	0	20
	Rates	0.0027	0.0078	0	
FPVO	Mean	0	0	0	0
	Number	0	0	0	0
	Rates	0	0	0	0
GVO	Mean	0	0.2	0	0.2
	Number	0	2	0	2
	Rates	0	0.0026	0	
CCO	Mean	0	0.22	0	0.22
	Number	0	2	0	2
	Rates	0	0.0040	0	
NVO	Mean	0	0.36	0	0.36
	Number	0	4	0	4
	Rates	0	0.0036	0	
CGKSO	Mean	0	0.6	0.1	0.7
	Number	0	6	1	7
	Rates	0	0.0054	0.0017	
Control	Mean	0.68	0.42	0.37	1.47
	Number	13	8	7	28
	Rates	0.0062	0.0074	0.0080	

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.2.5 Entrustments out of indigenous chickens

Table 8.16 presents the mean, number and monthly true rates for the entrustments out of the indigenous chickens in the study villages. Entrustment out of indigenous chickens was not a common practice in the study area. A few entrustments out were, however, reported mainly in the growers' category and COIN group recorded the highest number compared to all other groups ($p < 0.05$).

Table 8.15 Mean, number and monthly true rates of transfers out of indigenous chicken by age in Migwa and Kagak villages

Interventions	Variables	Chicks	Growers
COIN	Mean	46.45	7.55
	Number	511	83
	Rates	0.2006	0.0498
CCO	Mean	11.67	2.22
	Number	105	20
	Rates	0.0925	0.0398
FPVO	Mean	13.40	1.70
	Number	134	17
	Rates	0.1266	0.0238
CGKSO	Mean	18.40	3.40
	Number	184	34
	Rates	0.1143	0.0306
GVO	Mean	18.00	2.20
	Number	180	22
	Rates	0.1510	0.0283
NVO	Mean	23.91	3.27
	Number	263	36
	Rates	0.1371	0.0322
Control	Mean	12.32	1.74
	Number	234	33
	Rates	0.1118	0.0304

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8.16 Mean, number and monthly true rates of entrustments out of indigenous chicken by age in Migwa and Kagak villages

Interventions	Variables	Chicks	Growers	Adults
COIN	Mean	0.36	0.73	0.18
	Number	4	8	2
	Rates	0.0016	0.0048	0.0021
CGKSO	Mean	0.00	0.60	0
	Rates	0	0.0005	0
	Number	0	6	0
GVO	Mean	0	0	0
	Number	0	0	0
	Rates	0	0	0
CCO	Mean	1.22	0.11	0.11
	Number	11	1	1
	Rates	0.0097	0.0020	0.0022
NVO	Mean	0	0.09	0
	Number	0	1	0
	Rates	0	0.0009	0
FPVO	Mean	0	0.10	0.10
	Number	0	1	1
	Rates	0	0.0014	0.0025
Control	Mean	0	0.58	0.05
	Number	0	11	1
	Rates	0	0.0101	0.0011

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.3.2.6 Thefts of indigenous chickens

Table 8.17 presents the mean, number and monthly true rates for thefts of the indigenous chickens in the study villages (details in the appendix 4). Highest monthly rates of thefts were recorded in the CCO group (0.0110 per bird months at risk). Second highest rates were reported in the NVO group. No thefts were reported in CGKSO. The COIN group recorded the second lowest rates of the thefts (0.0002 per bird months at risk).

Table 8.17 Mean, number and monthly true rates of thefts of indigenous chicken by age in Migwa and Kagak villages

Interventions	Mean	Number	Monthly rates
COIN	0.09	1	0.0002
CGKSO	0	0	0
GVO	0.60	6	0.0025
CCO	2.56	23	0.0110
NVO	2.73	30	0.0081
FPVO	0.20	2	0.0009
Control	0.47	9	0.0022

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
CCO- Chick confinements only
GVO - Gumboro disease vaccinations only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.4 Indigenous chicken entries into household flocks

8.3.4.1 Purchases of Indigenous chickens

Table 8.18 presents the mean, number and monthly true rates for purchases of the indigenous chickens in the study area. No purchases of chicks were reported. The monthly purchase rates for growers and adults were lowest in the NVO and COIN groups compared to the other groups. The control and CCO reported the highest purchase rates. The purchase rates in FPVO, CGKSO and GVO groups followed in that order.

8.3.4.2 Gifts in of Indigenous chickens

The mean, number and monthly true rates for the gifts in of the indigenous chickens are presented in Table 8.19. Chicks gift in was not a common practice in most of the groups. Monthly gifts in rates were highest in the growers in all the groups, with the highest figure reported in the NVO and COIN groups.

Table 8.18 Mean, number and monthly true rates of purchases of indigenous chicken by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults	Total
COIN	Mean	0	0.73	0.27	1
	Number	0	8	3	11
	Rates	0	0.0048	0.0031	
FPVO	Mean	0	0.2	2.6	2.8
	Number	0	2	26	28
	Rates	0	0.0028	0.0641	
GVO	Mean	0	0.5	0.9	1.4
	Number	0	5	9	14
	Rates	0	0.0064	0.0211	
CCO	Mean	0	1.33	2.55	3.89
	Number	0	12	23	35
	Rates	0	0.0239	0.0516	
NVO	Mean	0	0.55	0.27	0.82
	Number	0	6	3	9
	Rates	0	0.0054	0.0045	
CGKSO	Mean	0	0.1	1.7	1.8
	Number	0	1	17	18
	Rates	0	0.0009	0.0287	
Control	Mean	0	0.84	1.53	2.37
	Number	0	16	29	45
	Rates	0	0.0147	0.0330	

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8.19 Mean, number and monthly true rates of gifts in of indigenous chicken by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults	Total
COIN	Mean	0.91	1.55	0.27	2.73
	Number	10	17	3	30
	Rates	0.0039	0.0102	0.0031	
FPVO	Mean	0.1	0.2	0	0.3
	Number	1	2	0	3
	Rates	0.0011	0.0028	0	
GVO	Mean	0.6	0.7	0.3	1.6
	Number	6	7	3	16
	Rates	0.0050	0.0090	0.0070	
CCO	Mean	0	1.56	0.22	1.78
	Number	0	14	2	16
	Rates	0	0	0	0
NVO	Mean	0	1.09	0.91	2
	Number	0	12	10	22
	Rates	0	0.0107	0.0151	
CGKSO	Mean	0	0.5	0.2	0.7
	Number	0	5	2	7
	Rates	0	0.0045	0.0034	
Control	Mean	0	0.21	0.05	0.26
	Number	0	4	1	5
	Rates	0	0.0037	0.0011	

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.4.3 Entrustments in of indigenous chickens

Table 8.20 presents the mean, number and monthly true rates for entrustments in of indigenous chickens in the study villages. Chicks entrustments in were never reported in all the groups. The control and CCO groups reported the highest entrustments in rates for the growers and adults birds, respectively.

8.3.4.4 Transfers in of indigenous chickens

Table 8.21 presents the mean, number and monthly true rates for transfers in of the indigenous chickens in the study villages. The number of chicks hatched (transfers in of chicks) (appendix 4) in all the intervention groups depended on the number of eggs provided for incubation by the farmers. The monthly transfers in rates for the chicks category were highest in control (0.4674 per bird months at risk), followed by the rates in GVO (0.4320 per bird months at risk). The rates in CCO group (0.4042 per bird months at risk) ranked third highest. The growers' transfers in monthly rates depended on the survival of chicks. The COIN group reported the highest monthly transfers in rates of the growers (due to high chick survival rates) compared to the other groups ($p < 0.05$). The growers' transfers in rates in the CCO, FPVO, CGKSO, GVO and NVO were similar to the control group ($p > 0.05$).

Table 8.20 Mean, number and monthly true rates of entrustments in of indigenous chicken by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	0	0.18	0
	Number	0	2	0
	Rates	0	0.0012	0
CGKSO	Mean	0	0.2	0.2
	Number	0	2	2
	Rates	0	0.0018	0.0034
GVO	Mean	0	0.3	0.3
	Number	0	3	3
	Rates	0	0.0039	0.0070
CCO	Mean	0	0.22	1.11
	Number	0	2	10
	Rates	0	0.0040	0.0224
NVO	Mean	0	0.45	0.09
	Number	0	5	1
	Rates	0	0.0045	0.0015
FPVO	Mean	0	0	0.1
	Number	0	0	1
	Rates	0	0	0.0025
Control	Mean	0	0.58	0.16
	Number	0	11	3
	Rates	0	0.0101	0.0034

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only
FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

Table 8.21 Mean, number and monthly true rates of transfers in of indigenous chicken by age in Migwa and Kagak villages

Interventions	Statistics	Chicks	Growers	Adults
COIN	Mean	56.27	46.45	7.55
	Number	619	511	83
	Rates	0.2430	0.3066	0.0853
CCO	Mean	51	11.78	2.22
	Number	459	105	20
	Rates	0.4042	0.2088	0.0448
FPVO	Mean	39.6	13.4	1.70
	Number	396	134	17
	Rates	0.3742	0.1878	0.0419
CGKSO	Mean	50	18.4	3.40
	Number	500	184	34
	Rates	0.3106	0.1656	0.0574
GVO	Mean	51.5	16	2.20
	Number	515	180	22
	Rates	0.4320	0.2312	0.0517
NVO	Mean	57.09	25.09	3.27
	Number	628	263	36
	Rates	0.3275	0.2350	0.0544
Control	Mean	51.47	12	1.74
	Number	978	234	33
	Rates	0.4674	0.2154	0.0375

Key:
COIN - Integrated interventions (vaccinations, chick confinements and supplementations)
NVO - Newcastle disease vaccinations only
GVO - Gumboro disease vaccinations only
CCO- Chick confinements only; FPVO -Fowl pox disease vaccinations only
CGKSO – Consistent maize grains and kitchen left over supplementations only
Control – No interventions

8.3.4.5 Participatory evaluation of the interventions

Most farmers confirmed to have learnt a lot from the interventions, especially the integrated intervention technology that combined vaccinations, chick confinements and consistent grain supplementations. From the intervention results most farmers were in agreement that indigenous chicken production losses could easily be controlled by means that they realised were available and affordable. As a way forward, farmers resolved to form smaller farmer groups at the village level in order to reduce the delivery cost of veterinary services.

8.4 Discussion

8.4.1 Vaccination and combined intervention trials

Diseases and particularly Newcastle, Gumboro and fowl pox, in order of importance were identified as the most important constraints limiting indigenous chicken productivity in the study area possibly as a result of poor disease control practices in the indigenous chicken sector. Majority of the famers never vaccinated their chickens against these major diseases. A few vaccinated against Newcastle disease but never followed recommended schedules.

Three vaccination interventions; against Newcastle (NVO), Gumboro (GVO) and fowl pox (in FPVO group) diseases were separately tried in the respective intervention groups. The impact of each intervention strategy on the chicken mean household flock sizes and chick survival, off-take and mortality rates was assessed and compared with that of the combined interventions (COIN) technology and the control.

Fowl pox vaccinations (FPVO) and Gumboro vaccinations (GVO) strategies, still recorded high mean household mortality rates and low mean household flock sizes and off-takes compared to the COIN group; an indication that the two disease control options were not effective in improving the indigenous chicken productivity. Even though Newcastle vaccinations (NVO) option recorded higher chick survival rate and mean household flock size and lower mean household chicken mortality, compared to the two (FPVO and GVO) technologies and the control groups. It still recorded high production losses (from deaths and other causes), with no tangible improvement in the productivity of the birds. The off takes (household consumptions and sales) were still low and similar to that of the control group.

The COIN technology recorded the lowest production losses of all of the technologies used in the whole study. The technology recorded the highest chick survival rate (82.6%) and average household flock size (43 birds) compared to the rest. It recorded the highest household off take (household consumptions and sales) rates that were 2 times compared to the control.

The COIN technology therefore, was the only intervention strategy that managed to reduce the indigenous chicken mortality significantly by effectively controlling the major constraints to low prevalence levels conducive for survival and improved productivity of the birds. Mean household flock size reported by this study is than the value reported by Okitoi *et al.*, 2006 that reported mean household flock size of 27 birds with Newcastle disease vaccinations and feed supplementations.

8.4.2 Intervention trials on feeding

Poor nutrition, which could be attributed to low level of supplementation resulting in low growth rate and egg production, was found to be the third most important constraint to indigenous chicken productivity.

The CGKSO technology was tried as mitigation to poor nutrition, with an aim of assessing its effects on the productivity of the chicken. The impact of intervention on mean household flock size, chick survival rate, chicken mortality rate and household off takes were compared with those of COIN technology and control.

Although CGKSO strategy registered some improvement on chick survival rate (36.8%) and mean household flock size (28 birds) compared to the control (23.9% and 16 birds, respectively, for chick survival rate and flock size). High production losses from deaths were recorded in the households that applied the technology (CGKSO). The chicken productivity in the CGKSO group (in terms of household flock size and chick survival and off-take rates) was lower than that of the COIN technology group.

The slight improvement on chick survival and household flock sizes (in the CGKSO group) might have come as a result of improved health from consistent supplementations. Higher productivity would come by routine vaccinations against the major chicken diseases and protection against major predators, in addition to improved feeding. All these were only provided by the COIN technology. It consistently provided feed supplements and protected the birds from major diseases and chick predators and hence, highest productivity.

The COIN technology was therefore more desirable than CGKSO technology for the improvement of the productivity of indigenous chickens.

8.4.3 Intervention trials against indigenous chicken predations

Predation in chicks was identified as a major constraint to indigenous chicken production in all phases of the study. The first two phases of this study ranked chick predation second most important constraint in the chicken production.

The impact of chick confinements only (CCO) strategy on prevention of chick predation and indigenous chicken productivity improvement was assessed. The benefits of CCO technology was compared with those of COIN technology and control in terms of productivity parameters (described in sections 8.4.1 and 8.4.2). The CCO technology recorded low chick survival rates and flock sizes, arising from high mortality rates. The technology protected chicks from predators but major diseases remained a big challenge for the CCO group. Massive chicken deaths from Newcastle, Gumboro and fowl pox diseases across all ages were reported in most of the households practising CCO technology. Some two households (farmers) in the CCO group got discouraged towards the end of the programme, by heavy losses from diseases. They were no longer consistent in confining their chicks and lost some to predators.

The COIN technology successful controlled chick predations and major indigenous chicken diseases (Newcastle, Gumboro and fowl pox). The technology recorded lower mortality rates and higher chick survival rates (82.6%) and flock sizes compared to the CCO technology.

8.4.4 Hatchings, transfers in and purchases of the indigenous chickens

The COIN group reported the lowest hatching rates compared to the other intervention groups and the control. These groups reported higher indigenous chicken deaths compared to the COIN group. Farmers in these groups would always hatch more chicks (compared to the COIN group) to compensate for losses from deaths in order to maintain their household flocks.

There were more purchases in the other groups compared to the COIN group, probably because of the same reasons; to compensate for losses from deaths, in order to maintain household flock sizes. There were higher rates of transfers in of growers in the COIN group than in the other groups because of higher chick survival rates in the group. More chicks survived and were transferred to the growers' category in the COIN group compared to the other groups. Transfers in of adults (growers' category to adults' stage), however, depended on other factors in addition to growers survival rates. These majorly included home consumptions and sales (off-takes).

8.4.5 Home consumptions and sales of the indigenous chickens

The rates of indigenous chicken home consumptions and sales were higher in the COIN group compared to the other intervention groups and control. This was because COIN group managed to reduce the chicken deaths, leading to increase in household flocks and availability of surplus birds for sales and home consumptions, after the selection of the breeding stock.

8.4.6 Participatory evaluation of the interventions

Most farmers were happy that their skills on the indigenous chicken management have been enhanced by the study; an indication of empowerment that is the core objective of PRA studies.

The data generated from the participatory evaluation richly informed the final recommendations from this study.

CHAPTER 9

9.0 General discussion, conclusion and recommendations

9.1 General discussion

Efforts to improve the productivity of the indigenous chickens have been tried in the past, with several studies coming up with recommendations that farmers have been implementing, but with no significant improvement on productivity. The productivity of the birds has therefore remained low over the years, an indication that certain factors and constraints that lower the productivity of these birds are not yet fully addressed by the previous studies (MLD, 2010; Siamba *et al.,* 2002).

Major constraints and factors that lower the indigenous chicken productivity are multiple and biological. Effective mitigation would require an integrated intervention approach that concurrently addresses the constraints and factors at the same time. Previous studies have always focused on single or few factors, and recommendations made as per the objective of the respective studies. Several but stand-alone recommendations have therefore resulted from these different studies with no significant improvement on productivity shown for them (Okitoi *et a.l*, 2006; Mutinda, 2011).

This study was an attempt to identify the factors and constraints that persistently hindered the productivity of the birds, irrespective of improvement efforts and, to provide accurate basis for appropriate and sustainable mitigation measures. The strength of this study was that farmers were involved all the way from constraints identification and ranking, through interventions to evaluation. The recommended interventions were therefore relevant and sustainable, because they were built on the principal stakeholders' (farmers) perception.

Diseases, particularly Newcastle, Gumboro and fowl pox diseases; in order of importance, were identified as the most important indigenous chicken constraints. Predations (especially in chicks) and inadequate feeding were second and third most important constraints, respectively, and this formed the basis for designing intervention studies that were later carried out.

This study is the first to report Gumboro as an important disease of the indigenous chickens after Newcastle disease in this production system. A number of previous studies have always ignored the disease in this category of chickens and only considered it as important in the exotic breeds (commercial layers and broilers).

Although it was evidenced from participatory learning and action that farmers had knowledge on many issues related to indigenous chicken production, participatory rural appraisal carried out during the study established that majority of them were ignorant of appropriate disease control methods. This was exacerbated by the fact that most of the farmers had low levels of education and lacked the ability to adopt modern disease control techniques (Mandal *et al.*, 2006). This probably explains the high rates of chicken mortality from diseases observed by this study. Most farmers relied mainly on the use of herbs for the treatment and control of chicken diseases. There is need for farmers' education on disease control in the study area.

This study carried out various intervention trials and assessed their benefits. It emerged that intervention strategies that mitigated on just one specific constraint did not produce much benefits to the farmers; in terms of improved productivity and reduced chicken mortality.

The integrated intervention strategy that concurrently controlled all the three most important indigenous chicken constraints; diseases (Newcastle, Gumboro and fowl pox), predation (in chicks) and poor nutrition, recorded the highest flock size, chick survival rate and reduction in chicken mortality, and proved to be the most appropriate for the improvement of the productivity of the indigenous chickens in this production system as it could be adapted by farmers easily.

The involvement of farmers in all stages of the study boosted their morale and enhanced close interaction between them and the research team; resulting into free flow of information between the two groups. Farmers owned the study processes and gave valuable information that richly informed the recommendations from this study.

The participatory rural appraisals and intervention trials on the other hand enhanced the farmers' skills and empowered them on the indigenous chicken management, as was evidenced during the evaluation process carried through focus group discussions at the end of the study period.

9.2 Conclusions

Indigenous chicken production is an important undertaking in southern Nyanza region and is being practised by most of the rural households. The chickens play key socio-economic role and largely contribute to community livelihood and alleviation of protein malnutrition at house hold level. Women and children did most of the daily management activities related to indigenous chickens. Most decisions to dispose the chickens were done by women. Although most of the chicken owners attained low level of education and lacked appropriate knowledge on the improved indigenous chicken production, they owned valuable knowledge on management aspects of the birds.

The major production system was free-range; where all ages of chickens fed together during the day and were housed together in one locality at night in human dwellings. Free-range was the major feeding system although most of the households practised supplementary feeding albeit in an irregular and inconsistent manner. Feeds used for supplementation were locally produced and available (maize grains and kitchen left overs).

The indigenous chicken production suffers from the constraints of diseases (particularly Newcastle disease, Gumboro and fowl pox), predation (mainly in chicks), insufficient feeding, lack of housing, inadequate knowledge and skills in the management of indigenous chickens amongst the farming community and unavailability of reliable veterinary and extension services.

Death from diseases was the major cause of loss in the indigenous chicken production in the study area. Major killer diseases were Newcastle, Gumboro and fowl pox, in that order. Predation was an important killer in the chicks. Housing, feeding, health systems and extension are the opportunities for the improvement of indigenous chicken production in southern Nyanza.

9.3 Recommendations

Strategy towards improving productivity of indigenous chickens should include enhancement of knowledge and skills of indigenous chicken farmers on technologies related to disease control, housing and feeding improvement. The recommendations from the study are:

1. All farmers' useful knowledge on the indigenous chicken production (seasonal patterns of diseases, the direct proportional relationship between the size of incubating hen and

number eggs for hatching, among others) that were identified and documented by this study should inform future strategies aimed at improving the productivity of the birds.

2. An integrated approach that concurrently mitigates on the major indigenous chicken constraints; diseases, predation (in chicks) and poor nutrition should be initiated and sustained for the improvement of the indigenous chicken productivity.

3. Since women and children dominated most of the activities around indigenous chicken production, extension programmes targeting women and children in the form of farmer field schools (FFS) and school agriculture clubs, respectively, should be initiated and subsequently established, developed, implemented and sustained.

4. Routine vaccinations (against Newcastle, Gumboro, fowl pox and fowl typhoid diseases) and pest (external and internal parasite) control should be implemented in the indigenous chickens to improve productivity.

5. There is need for the government to support indigenous chicken farmers by providing subsidized vaccines against major diseases such as Newcastle, Gumboro and fowl pox that were listed by the farmers as important disease constraints to indigenous chicken production. The vaccines should be packed in small quantities (50 doses) in order to take care of the interest of the small-scale indigenous chicken farmers.

6. Since traditional medicine was widely used by farmers, studies under controlled conditions are needed to determine the efficacy and appropriateness of the ethno-veterinary medicine in indigenous chicken production.

7. Social economic impact studies should be undertaken to determine the benefits of the intervention measures.
8. There is need for more studies on Gumboro disease in smallholder indigenous chicken production to generate more data on the disease.
9. Farmers need to be advised and facilitated to form smaller farmer groups at the village level in order to reduce the delivery cost of veterinary services.

CHAPTER 10

10.0 References

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CHAPTER 11

11.0 Appendices

Appendix 1 Indigenous chicken constraints assessment check list

Key informant and community group interviews:-

1. Introduction and purpose of visit
2. What livestock species do you keep?
3. Why do you keep chickens?
4. What are the indigenous chicken production constraints in the area?
5. What are the indigenous chicken diseases in the area?
6. Why do you perceive the above-mentioned diseases to be important?
7. Treatment:
   - Do you treat your chickens? When and why?
   - What treatment do you use for the different diseases mentioned earlier in the interview?
   - Do you use any commercially available drugs?
   - If so, which drugs do you usually use?
   - How do you administer the drugs?
   - Where do you get your drugs from?
8. What is the animal health service delivery like in this area?
9. Marketing of chickens?
   - Where do you get your chickens?

- Where do you sell the chicken?
- If the places are different why?

DVO/VO/LO and AHA

1. Introduction and purpose of visit
2. What is the general indigenous chicken production situation in the area?
3. What are the indigenous chicken production constraints?
4. What are the indigenous chicken main diseases?
5. Do people usually come for veterinary services?
6. Do you keep records in case they do come?
7. Any other significant issue in reference to indigenous chicken farming?
8. What are the major players in the poultry sector in your district?
9. Any other comment.

Agro veterinary shop owner

1. Introduction and purpose of visit
2. What are the commonly bought poultry drugs? Is there seasonality?
3. Who buys the drug, veterinarian, farmer or both?
4. In case the farmer buys, who makes the prescription?
5. Any other comment.

Appendix 2 Indigenous chicken production baseline data questionnaire

Enumerator		
Household number		
Date		
Village		
Sub location		
Location		
Division		
Global Position System (GPS) reading	Latitude	
	Longitude	

1. Background information

1)	Farmers name	
2)	Sex of farmer	
3)	Respondent	
4)	Sex of respondent	
5)	Total number in family	
6)	Number in school	
7)	Number in college	
8)	Address	
9)	Telephone	
10)	Education level	
11)	Employment	
12)	Farm size	

13)	Total income from farming	
14)	Income from indigenous poultry	

2) **Management practices**

Chicken population

	Chicks	Growers	Hens	Cocks
Number				

Who is responsible for the following activities?

	Responsibility (household head)	
	Rearing (feeding)	
	Decision to treat	
	Decision to dispose	

Production system ……………………………………………………………..

Farmers experience in indigenous chicken production (years) …………..

3) **Productivity Constraints to Indigenous Chicken Production and Ranks**

Constraints	**Rank**	**Reason(s)**

4) **Ranking of indigenous chicken diseases**

Disease constraints	**Rank**	**Reason(s)**

5) Has any bird suffered from any disease condition? Yes or No
If yes which disease tentatively.

Disease	Newcastle disease	Fowl typhoid	Fowl/pox	Coccidiosis	Helminthosis	Others
\Numbers						
Adults						
Growers						
Chicks						

6) List disease control measures undertaken in the farm……………………….
……………………………………………………………………………………..
………………………………………………………………………………………
………………………………………………………………………………………

7) Has any vaccination been done? Yes or No
. If yes state which ones.

Vaccination	Newcastle disease	Fowl Typhoid	Fowl pox	Others
Numbers				
Cost/bird				

8) Has any treatment been done? Yes or No
. If yes give one.

Treatment	Fowl Typhoid	Helminthosis	Coccidiosis	Indigenous	Newcastle disease	Fowl pox
Number						

Cost /bird						

9) What was the tentative cause of deaths?

	Newcastle disease	Fowl typhoid	Fowl pox	Helminthes	Coccidiosis	Predation	Others
Chicks							
Growers							
Adults							

10). Are other species of livestock present? Yes or No
If Yes, which one(s)? Quantify

Species	Cattle	Sheep	Ducks	Turkeys	Geese	Doves	Others

11) Were any birds sold? Yes or No

Type	Growers	Cocks	Hens	Ducks	Turkeys	Geese

12) Feed Inputs

Feeds used				
Type	Quantity	Origin	Time of feeding	Price if purchased

13) Veterinary and other Inputs

Veterinary drugs			Other input purchased		
Type	Quantity	Price	Type	Quantity	Price

14) Number of hens laying/sitting on eggs and looking after chicks.

Number of			
Hens in lay	Hens sitting on eggs	Hens looking after chick	Idle hens

15) Number of eggs in nests and the number of eggs being incubated

Number of	
Eggs in nests	Eggs being Incubated

16) Entries (sources)

Entries	

17) Exits

Exits	

18) Type of housing. Tick the appropriate box.

- ☐ Raised (timber walls, iron roofed)
- ☐ Raised (timber walls, grass thatched)
- ☐ Raised (mud walls, iron roofed)
- ☐ Raised (mud walls, grass thatched)
- ☐ Deep litter (mud walls, iron roofed)
- ☐ No housing (nights in the kitchen)
- ☐ Others (indicate type) ---

19) Any comments in relation to indigenous chicken production

Appendix 3 Poultry heath and productivity monitoring questionnaire

Enumerator …………………………………………………………………..
Farmer ………………………………………………………………………..
Farm No ……………………………………………………………………….
Date of Visit A ………………………………………………………………
Date of Visit B ………………………………………………………………

1. Chicken population dynamics

	Chicks	**Growers**	**Hens**	**Cocks**
Previous recording				
Sold				
Gifted out				
Consumed				
Died				
Lost				
Entrusted out				
Transferred out				
Purchased				
Gifted in				
Entrusted in				
Transferred in				
Visit A				
Sold				
Gifted out				
Consumed				
Died				
Lost				
Entrusted out				
Transferred out				
Purchased				
Gifted in				
Entrusted in				
Transferred in				
Visit B				

2. Has any bird suffered from any disease condition? Yes □ or No □. If yes which disease tentatively.

Disease	Newcastle disease	Fowl typhoid	Fowl pox	Coccidiosis	Helminthes	Others
Numbers						
Adults						
Growers						

Chicks						
Visit A total						
Numbers						
Adults						
Growers						
Chicks						
Visit B total						

3. Has any vaccination been done? Yes □or no □. If yes which one

Vaccination	Newcastle disease	Fowl typhoid fowl pox	
Visit A numbers			
Cost/bird			
Visit B numbers			
Cost/bird			

4. Has any treatment been done? Yes □ or no□ .If yes which one

Treatment	Fowl typhoid	Helminthes	Coccidiosis	Indigenous	Newcastle disease	Fowl pox
Visit A numbers						
Cost/bird						
Visit B numbers						
Cost/birds						

1. What were the tentative causes of deaths?

	Newcastle disease	Fowl Typhoid	Fowl Pox	Helminthes	Coccidiosis	Predation	Others
Chicks							
Growers							
Adults							
Visit A total							
Chicks							
growers							
Adults							
Visit B total							

6. Are other species of poultry present Yes□ or No□? If yes which one?

Species	Ducks	Turkeys	Geese	Doves
Visit A total				
Visit B total				

7. Were any birds sold? Yes □ or No□. If yes what was the average price

Type	Growers	Cocks	Hens	Ducks	Turkeys	Geese
Price						
Visit A number						
Price						
Visit B number						

8. Feed inputs since last visit

	Feed used			
	Type	Quantity	Origin	Price If purchased
Visit A				
Visit B				

9. Veterinary and other inputs since last visit

	Veterinary medicine purchased			Other inputs purchased		
	Type	Quantity	Price	Type	Quantity	Price
Visit A						
Visit B						

10. Number of hens that have laid eggs since the last visit. Number of hens currently sitting on eggs and looking after chicks

	Number of			
	Hens in lay	Hens sitting on eggs	Hens looking after chicks	Idle hens
Visit A				
Visit B				

11. Number of eggs in nests and the number of eggs being incubated. Check the number of eggs sold, eaten, and wasted since the last visit.

	Number of	
	Eggs in nests	Eggs being incubated
Previous visit		
Consumed		
Sold		
Hatched		
Wasted		
Laid		
Begun incubation		
Number of visit A		
Consumed		
Sold		
Hatched		
Wasted		
Laid		
Begun incubation		
Number of visit B		

12. Type of housing. Tick the appropriate box.

□ Raised (timber walls, iron roofed)

□ Raised (timber walls, grass thatched)

□ Raised (mud walls, iron roofed

□ Raised (mud walls, grass thatched)

□ Deep litter (mud walls, iron roofed)

□ No housing (nights in the kitchen)

□ Others (indicate type)…………………………………

Appendix 4 Indigenous chicken household productivity parameters

Table 1 Indigenous chicken household productivity parameters for the control group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes	Day old chick live weights	Cock live weights	Hen live weights	Grower live weights
27	25	1708	44	7	6	2	2	67	45	22	0	24	1578	1770	790
30	20	5966	44	20	10	1	0	21	21	0	0	34	2000	1240	800
32	11	9951	57	9	0	1	0	37	19	18	0	27	2670	1099	680
35	8	6690	27	18	1	1	0	111	111	0	0	34	2000	1940	1000
38	8	1098	73	11	5	4	0	60	24	36	0	26	1980	1546	890
44	24	7178	50	24	3	2	0	70	36	34	0	28	1700	1800	780
46	11	5732	45	7	1	0	0	46	46	0	0	31	1580	1000	670
51	20	8130	45	2	9	1	0	58	51	7	0	23	1670	1340	600
56	20	8694	20	8	7	3	0	45	43	0	2	24	2760	1000	900
57	20	6257	50	6	5	3	0	63	63	0	0	23	2732	1100	600
60	12	3289	70	23	0	2	1	59	32	27	0	29	1900	1100	720
61	24	7164	55	10	4	4	1	56	50	6	0	34	1950	1590	670
65	17	3162	70	8	3	1	1	32	32	0	0	26	2200	1700	650
68	3	8622	30	7	1	3	0	31	23	8	0	28	2000	1670	780
72	10	6083	65	22	7	4	0	20	20	0	0	21	2103	1341	720
74	17	8564	68	4	5	3	0	30	23	7	0	29	2300	1403	1000
79	24	7988	77	23	2	2	0	33	14	19	0	26	2300	1446	670
80	11	7424	10	4	8	1	0	23	23	0	0	28	2600	1458	1000
18	17	8065	78	21	4	3	4	78	71	7	0	18	2390	1570	900

Table 2 Indigenous chicken household productivity parameters for the combined interventions (COIN) group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes
12	40	8557	64	56	29	9	1	11	1	8	2
13	35	9365	57	40	29	3	0	12	2	5	5
20	42	12889	55	50	15	7	0	10	1	9	0
21	55	15062	45	40	25	8	0	2	0	2	0
24	49	16351	70	58	9	6	0	4	0	0	4
25	35	9852	61	50	21	12	0	13	3	10	0
26	29	13481	40	34	11	10	0	23	5	0	18
31	41	20416	47	42	17	11	0	8	0	0	8
36	40	14027	70	54	10	3	0	7	0	1	6
37	57	19340	50	42	19	5	0	4	0	1	3
39	50	16277	60	45	26	11	0	5	1	1	3

Table 3 Indigenous chicken household productivity parameters for the Newcastle disease vaccinations (NVO) group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes
06	25	8639	74	23	10	5	5	50	35	15	0
15	36	17181	55	17	0	0	3	31	12	19	0
17	20	9003	61	44	0	5	2	40	34	6	0
23	36	11239	78	32	0	9	7	25	14	11	0
28	27	9143	45	16	0	0	3	43	26	17	0
33	22	10335	23	12	10	0	10	46	35	11	0
40	37	9759	65	34	0	0	0	32	27	5	0
54	33	9449	34	10	0	8	0	31	24	7	0
64	32	9783	56	12	10	0	0	32	32	0	0
67	26	8876	67	20	0	7	0	46	33	13	0
76	27	7533	70	43	7	9	0	56	29	27	0

Table 4 Indigenous chicken household productivity parameters for the consistent feed supplementation (CGKSO) group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes
41	28	7905	35	15	5	7	0	45	37	8	0
42	22	9848	60	25	0	0	0	43	36	7	0
43	46	20633	55	14	7	0	0	22	22	0	0
47	14	6137	70	32	3	5	0	65	44	21	0
52	31	12427	30	22	9	0	0	10	10	0	0
55	25	5359	10	3	5	0	0	51	47	4	0
59	37	9225	80	9	10	0	0	16	15	1	0
66	34	9478	40	25	5	3	0	43	23	20	0
71	11	8634	65	15	4	6	0	61	36	25	0
77	34	9751	55	24	6	7	0	40	40	0	0

Table 5 Indigenous chicken household productivity parameters for the Gumboro vaccination (GVO) group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes
01	26	8580	67	34	5	5	3	29	7	15	7
05	13	6714	33	9	2	0	3	46	45	1	0
08	11	3516	56	23	2	0	0	38	17	21	0
10	24	7012	89	34	8	0	0	33	6	17	10
11	15	8255	27	2	6	4	0	32	10	22	0
14	33	11435	21	12	6	0	0	25	12	9	4
22	17	5855	120	41	2	0	0	57	43	14	0
48	21	8768	35	10	2	3	0	56	54	2	0
49	18	8103	45	8	3	3	0	35	18	17	0
50	19	3652	22	7	8	7	0	61	61	0	0

Table 6 Indigenous chicken household productivity parameters for the fowl pox vaccination (FPVO) group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes
02	24	10535	43	25	6	3	0	0	0	0	0
03	24	10414	0	0	4	4	0	20	0	20	0
04	30	11768	23	17	3	5	0	14	14	0	0
07	10	2558	61	11	3	0	0	60	42	18	0
09	19	6425	27	21	7	0	0	24	0	24	0
16	19	3774	70	6	7	0	0	46	31	15	0
29	25	8569	52	20	2	0	0	41	23	18	0
34	12	4709	13	2	2	0	0	41	16	25	0
62	12	3103	80	23	8	0	0	39	38	0	1
63	0	3461	27	9	1	3	0	44	44	0	0

Table 7 Indigenous chicken household productivity parameters for the chick confinement (CCO) group

Household identification	Mean flock size	Total Bird days	Chick transfers in	Chick transfers out	Chicken sales	Chicken consumptions	Chicken thefts	Total deaths	Deaths from diseases	Deaths from predations	Deaths from other causes
19	27	3774	61	13	4	5	6	57	57	0	0
45	22	4987	40	9	0	5	1	40	37	3	0
53	19	5232	52	7	5	5	2	42	35	7	0
58	15	12043	51	12	0	5	1	31	25	6	0
69	20	7179	46	20	6	0	7	56	40	16	0
70	17	10918	55	15	5	0	6	29	18	11	0
73	26	7815	67	6	0	0	0	34	34	0	0
75	10	4866	31	7	0	0	0	67	36	31	0
78	20	5718	56	16	7	0	0	41	19	22	0