A STUDY OF OPPORTUNITIES FOR IMPROVED RURAL PIG FARMING IN WESTERN KENYA: FEEDING, PRODUCTIVITY, MARKETING AND PUBLIC HEALTH

BY

Florence Kanini Mutua (BVM, MVEE)

University of Nairobi

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Department of Public Health, Pharmacology and Toxicology

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DECLARATION

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

15th July 2010

Florence K. Mutua (BVM, MSc)

This thesis has been submitted for examination with our approval as supervisors

13th July 2010

Prof. Samuel M. Arimi (BVM, MSc, PhD)
Department of Public Health, Pharmacology & Toxicology.
P.O.Box 29053-00625, Nairobi

Prof. Cate Dewey (DVM, MSc, PhD)
Department of Population Medicine, University of Guelph
ONT N1G 2W1, Canada

13.07.2010

Dr. William O. Ogara (DVM, MSc, PhD)
Department of Public Health. Pharmacology & Toxicology.
P.O.Box 29053-00625, Nairobi

Dr. Esther Schelling (Dr. Med. vet, PhD)
International Livestock Research Institute (ILRI)
P.O. Box 30709, Nairobi

DEDICATION

.....To my husband Christopher,

My parents, Esther Mueni and Aliphonce Mutua,

and to all my Brothers and Sisters.....

...................life is a journey and every step made is important, it does matter what kind of people you meet on the way...............

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LIST OF ABBREVIATIONS

FAO Food and Agricultural Organization

FAOSTAT FAO statistical database

FITCA Farming in Tsetse Infested Control Areas

FC Farmers Choice Limited

KARI Kenya Agricultural Research Institute

TOT Training of Trainers

ILRI International Livestock Research Institute

FAOSTAT Food and Agricultural Organization statistics

CBS Central Bureau of Statistics

NRS National Research of Sciences

DM Dry Matter

DFID Department of Foreign and International Development

GOK Government of Kenya

WHO World Health Organization

ELISA Enzyme Linked Immunosorbent Assay

NCC Neurocysticercosis

AFM Age at First Mating

AI Artificial Insemination

LH Luteinising Hormone

FGD Focus Group Discussion

QDA Qualitative Data Analyses

NLB Number of Live Born pigs

PWM Pre-weaning Mortality

SBA Sow Birth Age

WBI Weaning to Breeding Interval

FBI Farrowing to Breeding Interval

ADG Average Daily Gain

ANOVA Analysis of Variance

CIRAD Centre for International Research in Agriculture and Development

CIP International Potato Centre

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ABSTRACT

An integrated study to investigate rural pig farming practices was conducted in selected sub-locations of Busia and Kakamega Districts, Western Kenya from June 2006 to October 2008. Six Focused Group Discussions (FGD) were conducted in Kakamega District before beginning farm visits. A total of 288 pig farms were visited three times in the course of the study period. Data on pig management and feeding were gathered using questionnaires administered in face-to-face interviews. Pigs were weighed and length and girth body measurements were taken using tape measures (cm). Pigs were tested for *Cysticercus cellulosae* cysts using the lingual palpation. Two sets of training workshops were conducted after the initial farm visit.

Discussions during the FGD were taped, transcribed and translated from Swahili to English. Data were analyzed qualitatively using MaxQDA software; analyses involved identifying common themes. Women were responsible for the care of pigs while men played a key role in the selling. Pigs were the easiest animals to sell because they do not need to be transported to the market since buyers come to the farms. Poor market channels, poor breeds, inadequate government support, inadequate animal health support, diseases, and cultural and religious differences were some of the challenges identified during the discussions.

From the study it was found that more women (69 %; 512 / 735) than men were interviewed during the farm visits. The interviewees' age distributions were: <30 yrs 34 % (250 / 735); 30 – 50 yrs 44 % (327 / 735) and >50 yrs (23 %; 158 / 735). Only 2 % (12 / 735) of the respondents had completed college education and approximately half (54 %; 400 / 735) were Catholics. Farmers owned on average 2.33 (±2.01) acres of land; this ranged from 0.125- 10 acres. The mean

number of nursing, growing and breeding pigs owned per farm were 5.0 (±3.4), 1.8 (±1.2) and 1.5 (±0.9), respectively. Pork was consumed by 74 % (212 / 288) of the farmers. It was the most preferred of all the meats by 39 % (49 / 124) and 27% (42 / 154) ($p=0.003$) of the farmers in Kakamega and Busia Districts, respectively.

Most (73 %; 209 / 288) farms had no pig house because: they believed this was not necessary (8 %; 16 / 209); there was no time to build a pig house (13 %; 28 / 209); the farmer lacked the skill (11%; 23 / 209); the farmer lacked money to buy construction materials (45 %; 93 / 209). More pig houses were observed in Kakamega than in Busia District (OR=5.4; CI 3.1-9.7). Pig-level and household-level prevalence of porcine cysticercosis were 4 % (52 / 1290) and 15 % (43 / 288) respectively.

A total of 840 pigs were weighed during the study, including 363 young (≤ 5 months), 305 market age (5.1-9.9 months) and 172 breeding age (≥10 months) pigs. Separate weight estimation models were developed for each category of pig using a random sample of 75% of the data and then validated with the remaining 25 % of the data.These analyses were completed using Stata® statistical software. The young, market and breeding pigs weighed on average 12 (±6), 30 (±11), and 42 (±17) kg, respectively. The ADG for young, market and breeding pigs were 93 (±52) g, 125 (±58) g and 101 (±80) g, respectively. The weight estimation models were as follows: young pig weight = [0.18 (length) + 0.36 (girth) - 16]; market-age pig weight = [0.39 (length) + 0.64 (girth) -48]; breeding pig weight = [0.36 (length) + 1.02 (girth)-74]. The length and girth explained 88% - 91% of the total variation in pig weight.

The mean age at which sows farrowed for the first time was 12 months (±5.4) while the mean number of litters born to a sow before she was sold was 1.04 (±0.21). Average number of pigs born alive and weaned per litter were 7.85 (±2.55) and 6.61 (±3.25) respectively. Pigs were weaned at ≤ 4 weeks (56 %; 182 / 324), 5 – 8 weeks (36%; 117/324), or >8 weeks (8 %; 25 / 324) of age. The average price for weaned piglets was Ksh 619 (±174); however, this price was lower in Busia (Ksh 509) than in Kakamega (Ksh 777) ($p < 0.05$).

Farmers described challenges of pig keeping as: feeding (65 %; 479 / 736); diseases (46 %; 342 / 736); few breeding boars (60 %; 444 / 736); getting little money from the sale of pigs (61 %; 450 / 736); and pigs as causes of conflicts with neighbours (53 %; 395 / 736). Farmers in Busia (53 %; 231 / 434) were more likely to experience pig disease problems than farmers in Kakamega District (36%; 111/302) (OR=1.95, CI 1.4 - 2.6). The most frequently fed foodstuffs were cooked ground maize (*Ugali*) (88 %; 404 / 455), kitchen left overs (83 %; 382 / 455), dried fish (*omena*) (78 %; 357 / 455), sweet potatoes (75 %; 343 / 455), sweet potato vines (65 %; 298 / 455), cassava (57 %; 262 / 455), brewers waste which was the mash left from home made beer (*machicha*) (48 %; 220 / 455), maize (33 %; 151 / 455) and innards from fish (30 %; 138 / 455). About 37 % (46 / 124) of farmers in Kakamega and 40 % (65 / 164) of those in Busia provided their pigs with waste water from household kitchen use.

The mean age of pig farmers who attended the farmer training was higher (40.3±14.0) compared to the mean age for those farmers who had missed the training (35.4±12.7) ($p<0.05$). Feeding pigs balanced diets was the most frequently (52 %; 62 / 118) reported lesson learnt by the farmers during the workshops.

Pig farming in Western Kenya is an important sector with a rich potential to alleviate rural poverty. The current study provided baseline data on sow productivity, feeding, management, and constraints that were previously inadequate. The study has further highlighted a number of challenges that need to be addressed before reasonable gains in small-holder pig farming are realised.

CHAPTER ONE

1.0 GENERAL INTRODUCTION

The rising food prices in the recent years calls for increased investments in agriculture and rural development, particularly in the developing countries (FAO, 2008). Pig farming is one of those possible investments that farmers could use to combat the current food crisis. Pigs are among the important livestock species raised by many small-scale farmers in many low-income countries, and are often kept in small herds, using family labour and locally available feed resources (More *et al.*, 1999). The pigs are raised mainly for sale to earn income, for home consumption, festivals, and for financial security. Any increase in their productivity and profitability will directly contribute to the social and economic wellbeing of small-holder farmers in low income countries (Lanada *et al.*, 1999).

Phiri *et al.* (2003) reported a significant increase in pig production among the poor rural small-holder communities in the developing countries. This increase is partly attributed to their high fecundity rates, high feed conversion efficiencies, early maturity, short parturition intervals, and small space requirements. Pigs have a short breeding cycle (Lekule and Kyvsgaard, 2003), and are therefore seen by many as the livestock equivalent to cash cropping).

Small-scale pig farming is common in rural Western Kenya and is characterized by small herd sizes that are usually 2-3 pigs. The pigs are normally tethered and at times allowed to scavenge for food (Githigia *et al.*, 2005; Mutua *et al.*, 2005). According to the 2002 report by the Farming in Tsetse Infested Control Area project, pig population in Busia and Teso districts was estimated at 26,729 (FITCA, 2002).

Inadequate feed supply is a major challenge affecting rural pig farming in Western Kenya (Mutua *et al.*, 2007). Commercial pig feeds are too expensive for poor pig farmers to afford. Although there is a great potential for improved pig feeds in the tropics (Ly, 1993), the challenge is the limited research on the local feed resources and their nutritional worth. Some of the locally-available feedstuffs are unfit for human consumption but are deemed fit for pigs. Examples include sweet potato vines, fruit peels, spoilt avocados and *posho* mill maize flour waste. These are local feeds that could be utilized as feed for pigs. The challenge would be how to better formulate cheaper alternative diets that combine commercial and local ingredients in a bid to improve the pig's overall performance.

Exploring what diet farmers are feeding their pigs and understanding the performance of these pigs are perhaps steps toward realizing the unexploited potentials in rural pig farming. There is a need to work out different strategies in order to facilitate feed management and improve on the knowledge of combining various feed resources in order to improve the nutritive value of the whole diet for these pigs. Balancing the available feedstuffs to formulate a diet containing the major nutrient requirements of the pig is essential for the health and growth of the pig.

Farmers Choice (FC), a company that produces, buys, slaughters, and processes pigs, is known to dominate the pork industry in Kenya. The location of the company in Nairobi favours the development of the pig industry around Nairobi and in Central province (KARI report, 1996; Wabacha *et al.*, 2004). However, small-scale farmers in distant rural areas of the country are less likely to benefit from this market advantage. Farmers in Western Kenya have previously complained of market exploitations by local pig traders who are the main buyers of their pigs. The traders, usually pork butchers, move from one farm to another looking for pigs to buy.

There is no system in place that farmers could be used to gauge the weight of their pigs prior to sale. Weighing using a spring scale is perhaps the most accurate method of estimating the weight of the pig. However, most rural farmers are poor and cannot afford to buy such scales. Their only option is to guess the weight and subsequently make a guess on the sale price. From the study by Murillo and Valdez (2004), back yard farmers in the Philippines used length and girth measurements to estimate the weight of their pigs; these farmers were poor and could not afford to buy weighing scales. Estimating pigs weight by 'just looking' at the pig is unreliable, provides biased weight estimates, and farmers get less value for the pigs sold. Hence the need to develop and validate tools that are easy to use so the pig farmers could adopt the tools to estimate the pig's weight at the sale in a bid to get better values for the sold pig. Such tools would also be useful to pig butchers, who may not have access to accurate pig weighing scales.

Studies on the reproductive performance of sows in small-holder farms are scanty (Lanada *et al*., 1999). Wabacha *et al.* (2004) studied the reproductive performance of intensively managed crossbred Large White or Landrace sows in a high potential peri-urban area of Nairobi. There exists no data on the reproductive performance of indigenous pigs in Western Kenya. A complete understanding of local pig production requires a full knowledge of health, management, and the reproductive performance. Factors such as poor feeding, poor management, and poor marketing have been shown to affect the sector, but effects of these on the performance of breeding pigs are scanty.

Cysticercosis due to *Taenia solium* is endemic in many poor countries of the world where pig keeping and pork consumption occur (Phiri *et al.*, 2003). Previous studies have shown that *T. solium* cysticercosis is present in 6 -14 % of the pigs examined for the disease in Western Kenya

(Githigia *et al.*, 2005; Mutua *et al.*, 2005). Only prevalence studies have so far been done on the existence of the disease; no intervention method for the purpose of the disease control has been employed. Farmers in the study area live in close contact with their pigs and have limited knowledge on the cause and transmission of the disease. Capacity strengthening and subsequent farmer training are perhaps some of the strategies which could be employed to create awareness about the disease, improve people's health, and subsequently enhance rural pig production.

A focus group discussion is a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive non-threatening environment (Krueger, 1998). The role of these group discussions in providing in-depth investigations of views, beliefs, and perceptions about small-scale pig production in Western Kenya cannot be underestimated. Such information is necessary if people were to gain a better understanding of indigenous pig keeping and to better address the needs of the local farmers. Furthermore, the information gathered would be used to give policy makers and researchers a better understanding of small-scale pig farming. Additionally, social and cultural beliefs of any society are important in determining pig numbers in an area (Payne and Wilson, 1999).

The present study provided detailed baseline data on rural pig management including the sows' reproductive performance which was previously lacking. Focus groups provided an opportunity to create a bond between the pig farmer and stakeholders. The groups were an opportunity for the researchers to fully understand the views of the farmers and that of the local extension staff. By adapting the weight estimation tool, rural pig farmers, particularly women because they are the ones responsible for pig rearing, will benefit from better market value for pigs. Through a series of farmer trainings at the village level, and using the Training of Trainers (TOT) approach, obtained has been disseminated to rural farmers in the target villages. There is need he coverage to neighbouring areas in a bid to improve the overall productivity and e pigs.

esearch was approved by the Director of Veterinary Services in Kenya, the Board of te studies, University of Nairobi and the Animal Care Committee and the Ethics Board versity of Guelph. The thesis is organized in chapters with each of the research orming an independent chapter.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Pig production

Pigs are among the most important livestock species raised by small-scale farmers in developing countries who raise them in small herds using family labour and locally available feedstuffs (More *et al.*, 1999). Pigs are raised as a source of family income, for home consumption and in festivals. In the tropics, fresh pork continues to be among the most important type of pig meat. Pig skin has been used for manufacture of light leather goods and pig bristles, while its manure has been used as fertilizer, production of methane gas, and for culture of algae that are used as animal feeds (Hang, 1998; Payne and Wilson, 1999). Another advantage associated with pig farming is the pig's high fecundity and growth rate (Lekule *et al.*, 2003).

According to an ILRI projection (ILRI, 2000), pork consumption in the developing world is expected to rise from 39 to 81 million tonnes between 1993-2020, compared to a rise from 38 to 41 million tonnes in the developed countries. The world pig population was estimated to be 923 million, of which 552 million are found in Asia, 72 million in North America, 194 million in Europe, 81 million in Latin America, and 18 million in Africa (FAO, 2002). In 2007, the world pig population was 989,884,170; only 26,734,139 of these were in the least developed countries (FAOSTAT, 2007). Approximately 17 % of the total pig population is found within the tropics (Payne and Wilson, 1999). A significant increase in pig population in Eastern and Southern Africa has previously been reported, particularly in rural, resource poor, small-holder communities (Phiri *et al.*, 2003). Increasing poverty levels, lack of grazing land for ruminants, and the recognition by the farmers of the quicker returns on their investment have all contributed to the increased interest in raising pigs (Engels *et al.*, 2003; Phiri *et al.*, 2003; Zoli *et al.*, 2003).

Lekule and Kyvsgaard (2003) reported that pork contributed 63 % of meat from monogastric animals globally and made a further 40 - 44 % contribution of animal protein.

Most of the pigs raised in the developing countries are cross breeds or native breeds, adapted to the local climatic conditions, and raised under the traditional farming systems (Lekule and Kyvsgaard, 2003). There has been varying views about the importance of genetics in the small-holder settings, both in terms of productivity and profitability (More *et al.*, 1999). According to Lemke *et al*, (2005), improved pig breeds provide farmers with high outputs but imply an economic risk for the resource-poor farmers because of the high input requirements. In Kenya, exotic breeds are mainly kept in commercial farms. These include crosses of Large White and the Landrace (KARI, 1996; Wabacha *et al.,* 2004). Native breeds are predominantly kept in rural areas, particularly in Western Province (Mutua *et al.*, 2007).

The population of pigs in Kenya since 1961 has been increasing. The population increased from 230,600 pigs in 1995 to 415,000 in 2005. The annual population growth rate for pigs in 1990 - 2000 was remarkably higher (9 %) than that of other livestock species (FAO, 2005). It is estimated that a total of 1,426,816 pigs were slaughtered in Kenya between 1991 and 2000, converting to an estimated revenue of Ksh 8, 833.4 million (CBS, 2002). The amount of meat produced in the country has been increasing since 1980, with pork showing the greatest annual increment between 1990 - 2000. There was an increased consumption of pork (4.8-6.8 %) compared to beef (1.1 to 3 %), and small stock (sheep and goats) whose consumption declined (4.7 to 0.1 %) (FAO, 2005). Pig population in Kenya was estimated at 325,000 in 2007 (FAOSTAT, 2007).

Approximately 60 % of pig farmers in Kenya are small scale farmers owning 1 to 2 sows. Although small-holder pig farming is popular in Western Kenya (Githigia *et al.*, 2005; Mutua, 2005), the region produces only a small percent of the total pigs produced in the country. Over half of the pig population in the country is found in peri-urban Nairobi and in neighbouring Central Province (KARI, 1996; Wabacha *et al.*, 2004). According to the Ministry of Agriculture records (MOA, 2000), about 13 % of the pig population is found in Western Province. Livestock census in Western Kenya indicated that there were 26,729 pigs in both Busia and Teso districts (FITCA, 2002).

2.2 Pig feeding

According to More *et al* (1999), pigs reared by small-holder farmers are supplied with limited amounts of water. Water is vital for maintenance of the animal life and plays an important role in the thermoregulation (NRS, 1998; Payne and Wilson, 1999). Sows should not have restricted water intake since inadequate water supply reduces feed intake (Aherne *et al.*, 1999).

Feeding constitutes 75 % of the total costs in swine production. Key nutritional requirements of pigs include energy, proteins, minerals, and vitamins. Potential energy sources include root and cereal crops. Oils and fats can be used as sources of energy, but they are expensive. Other sources of energy include cereals, legumes, tuber / root crops, young green fodder, molasses / sugar, kitchen waste and agro industrial waste such as flour milling waste, waste oil and fats (Dirk and Geert, 2004). The protein content of pig feed is very important since pigs cannot produce their own protein. Potential sources of protein include young green fodder, animal waste products, kitchen waste containing soy beans, cotton, and peanut. Tubers and root crops are poor in protein and must be supplemented with protein rich feed.

Pigs are omnivorous and compete with man for food. They are therefore useful consumers of by-products and waste from human food. Pigs are found in large numbers in places where large quantities of wastes and waste by-products are available (Payne and Wilson, 1999). Interestingly, these animals thrive well on those foods that are suitable for humans but fortunately also thrive well on by-product feeds and other materials that do not constitute food for man. These products alone are not adequate to provide the pigs with a nutritionally balanced diet. The role of pigs in the recycling and value addition to many food by-products and wastes has been described. In fact, pigs are predicted to become an increasingly important viable waste management option in the future (Payne and Wilson, 1999; Austin and Lee, 2000).

Pigs are active throughout the day; they can invest 50 % of time in foraging from dawn until dusk on cloudy and rainy days (Copado *et al.,* 2004). On warm days they are active early in the morning and late at night (Graves, 1984). Pigs are frequently fed household waste complemented with limited amounts of other available feedstuffs (More *et al.*, 1999).

A number of opportunities have been identified for sustainable small-holder pig farming, including feeding. However, the formulation of appropriate and cost effective diet has been hampered by the overlaps in the feeds eaten by pigs and humans (More *et al.*, 1999). Traditionally, feed for pork production in developed countries consists mainly of cereal grains and oil seed meal. Pigs are known to utilise a wide range of feed stuffs, many of which are products from food processing, food preparation, and food service industries. Other alternative feedstuffs include those feeds that are not commonly available, but could be fed in times of surpluses. Pig diets in the tropics are generally low in protein and are frequently supplied with inadequate amounts of water (More *et al.*, 1999; Austin and Lee, 2000). The role of adequate clean water has been highlighted (Muirhead and Alexander, 2002), no wonder providing inadequate amounts of water to pigs has been shown to reduce their feed intake (Aherne *et al*., 1999).

The level of profitability in pig production is largely determined by the relationship between feed and market prices (More *et al*., 1999). It is known that 70 - 75 % of the total production costs for pigs go to feeding (Radostits, 1985). Feed prices usually increase at a greater rate per year than the pig prices. Thus, a change in pig feed price without a corresponding change in pig price could negatively impact on the profit margins. Feed costs are high because pigs grow rapidly and consequently the demand for food is high (Radostits, 1985; Payne and Wilson, 1999; de Lange and Mohn, 1999).

The traditional small-scale system is characterized by high mortality rate, minimal health care, and lack of supplementary feeding in the tropics (Radostits, 1985; Lekule and Kvsgaard, 2003). Local feeds such as cereal residues and potatoes have been cited as main sources of feeds for pigs, particularly in areas where adequate land is an issue and in large cities (Lekule and Kvsgaard, 2003). According to Ly (1993), there is more potential for pig feeds in the tropics than in the temperate regions. This potential has not been realized since studies on the use of locally available, non-conventional feed resources, and their nutritional value as animal feedstuffs have not been done.

There are many suitable pig feeds available in the tropics. Carbohydrate rich feeds include cereals and cereal by-products. Corn should not be fed alone because its protein is deficient of certain essential amino acids in particular lysine. Root crops such as cassava and cassava peelings, which are very suitable feeds, should be cooked to destroy poisonous cyanogenetic glycoside content present in the skin of many of these varieties. Dried cassava root or the flour made from it has the same energy value as maize and is widely used in Europe as imported pig feed. Irish potatoes (could be dried and fed as flour) and sweet potatoes (fed raw or as flour) are important sources of pig feed. Pigs can also be allowed in the field to lift the crop themselves and eat both the root and the leaves in areas where kidney worm is not a problem. Yams and molasses are known to increase feed palatability, however, pigs may not like them and too much of this in the feed may cause scouring (Payne and Wilson, 1999).

Sweet potatoes have previously been used as animal feeds; the crude protein content in the DM of sweet potato vines ranges from 16 – 29 %. The sweet potato root is rich in energy and the DM contains 80-90 % carbohydrates (Wanapat, 2008).

Protein sources include blood, coconut meal, cotton seed meal, fish meal, maize corn by-products, meat and bone meals, milk and milk by-products, and peanut and soy bean meal. Other miscellaneous pig feeds include avocado pearls (small amounts of waste avocado can be fed to pigs, three parts of avocado replace one part of maize). Bananas (*Musa cavendishii*) and plantains (*Musa paradisiaca*) can be fed to pigs as potential sources of energy. Chopped banana stems are a major part of ration for pigs in some parts of south East Asia and China. The high level of free active tannins in fresh green bananas and their residual presence in fresh ripe bananas is associated with poor protein digestibility. If fed non-peeled ripe bananas *ad libitum*, the pig will first eat the pulp leaving part of the peel. However, fed on a restricted basis, both the pulp and peel are eaten. Brewers and distiller's grains, pineapple, pumpkins, sugarcane, and waste tomatoes also constitute essential parts of pig diet (FAO, 1997; Rodriguez and Preston, 1997; Payne and Wilson, 1999).

The utilization of kitchen wastes from institutions such as hospitals, schools or hotels, and the use of distillery wastes, fish-processing wastes, abattoir wastes, and agricultural residues to feed livestock would help to reduce the increasingly important, problematic question of environmental pollution. The nutritive value of kitchen wastes for pigs is adequate with respect to protein and energy. However, its low dry matter content tends to affect growth due to a reduction in total dry matter intake, principally in younger animals, fed *ad libitum* (FAO, 1997). The digestibility of the nutrients contained in kitchen wastes is variable and obviously depends on the source. It is important to boil food wastes before feeding to pigs to prevent diseases such as trichinellosis (*Trichinella spiralis*) (Cui *et al.*, 2006) as well as other diseases that could be transferred from people to pigs such as *T. solium* taeniosis.

Kornegay *et al.* (1970) reviewed the performance of pigs fed heat-treated garbage residue from different sources. Pigs fed with such feedstuff should be supplemented with a 15 to 18 % crude protein concentrate in order to improve the daily live weight gain (to more than 600 g/day) and feed efficiency (FAO, 1997; Nguyen *et al.*, 1997).

The cassava plant (flour, peels, leaves and tender stems) could serve as potential sources of cheap energy and protein but their digestibilities (especially peels, leaves and tender stems) are often lowered because they have a high content of plant cell wall components, which have the attribute of locking up other important nutrients in their matrixes. Cassava peels, leaves and the tender stems are thought to be underutilized in Nigeria and often left to rot away on farms after the roots have been harvested (Akinfala and Tewe, 2004). The leaves are high in proteins and are readily available at the time of harvesting the root (Nguyen and Preston, 2004).

Sow feeding is an important aspect of pig feeding where great improvements could be achieved in swine herds (Peadar and Brendan, 2007). Gestational feeding provides nutrients in early gestation to recover body stores lost during lactation, provide enough nutrients to maintain pregnancy, and support the growth of the developing foetus (Laura, 2009). The metabolic status during lactation has great influence on the post-weaning performance; body weight loss during lactation influences weaning-to-service interval, ovulation rate, and litter size (Tantasuparuk *et al.*, 2001). Sows with higher number of pigs weaned per litter lose more weight than those with low litter sizes. Peadar and Brendan (2007) advocate for additional feeding to sows with diseases such as mange.

Voluntary feed intake during lactation is insufficient to meet the nutrient requirement in sows (Eissen *et al.*, 2000). The high energy and feed intake during lactation is associated with high embryo survival rates in the subsequent gestation period and greater litter size at the subsequent farrowing (Kirkwood *et al.*, 1988; Baidoo *et al.*, 1992; Koketsu and Dial, 1998). Increasing feed intake during lactation could reduce the negative association between lactation length and subsequent litter size (Koketsu and Dial, 1998). The number of piglets suckling on the sow influences total milk production (Hartmann *et al.*, 1997). Thus sows on a low level of nutrition will mobilise body reserves for milk production, thereby loosing weight (Peadar and Brendan, 2007). Feed intake during lactation should be maximised since sows that have lost least body weight during lactation have shorter weaning to service interval (Peadar and Brendan, 2007). Additionally, sows that have low feed intake, particularly during the first four weeks of pregnancy, have smaller subsequent litter sizes (Peadar and Brendan, 2007; Koketsu and Dial, 1998). Failure to increase feed intake on day 100 to 112 may result in sows entering a catabolic state at farrowing (Tokach *et al.*, 1999; Peadar and Brendan, 2007).

Breeding boars should be fed *ad libitum* during the growing period using protein adequate grower- finisher diets. This allows for proper boar selection based on growth, feed intake, feed conversion, and carcass quality. Nutrition during growing period has further been shown to affect pig's weight and age at puberty (Austin and Lee, 2000).

In a study in Teso District, Western Kenya, feeding was found to be poor, disorganized, and a source of neighbourhood conflicts (Mutua, 2005). This was attributed to free-ranging of the pigs as a result of scarcity of feeds, which forced most of the households to release their pigs to scavenge. However, the method was reported to be economical since pigs could easily scavenge for feeds with little or no cost to the pig farmer. Pigs left free to scavenge will destroy neighbours crops and bring conflicts within the villages. In this study, sources of pig feeds were ranked as household leftovers and scavenging. Most of the small-scale pig farmers cannot afford to purchase commercial feeds for their pigs, a sign of poverty. The challenge is to come up with alternative feed formulations which combine locally available feeds such as cassava, cassava by-products, rice bran, maize, and sweet potatoes with other available feedstuffs to make a balanced diet. Protein sources, especially those that can be produced on the farm, need to be identified and their use promoted.

2.3 Pig housing

According to Lekule and Kvsgaard (2003), housing in the tropics is characterized by poor sanitation and over crowding. This leads to unnecessary feed wastage, disease transmission, and worm infestation. Grass and timber are cheaply available in Western Kenya and could be utilized in constructing simple structures to house pigs. These are cheaper and would be sufficient to limit problems particularly those resulting from bad weather. Housing of pigs is important for disease control, in controlling for diseases caused by *T. solium*, in reducing neighbour to neighbour conflicts, and in reducing mortality in young pigs.

The types of pigs kept in the study area are indigenous breeds which are either tethered or allowed to scavenge freely (Mutua *et al.*, 2007). However, this system of keeping pigs is illegal in Kenya (GOK, Cap 364). At a 2006 conference funded by DFID Animal Health Programme, the importance of this law was discussed and reasons for its formulation given. Participants at the meeting thought if promoting pig production was considered a means of poverty alleviation, then the public needed to know how the law could be revised to enable the poor to take advantage of pig production, and subsequently issues of housing and feeding would be considered later (Anon, 2006).

2.4 Pig diseases

2.4.1 Zoonotic *Taenia solium*

Zoonotic diseases are under-diagnosed, particularly among the poor and the marginalized populations who are at the highest risk of infection. This reflects the limited capacity and coverage of the health services. Many countries in Africa have reported high prevalences of *T. solium*. The disease has emerged as an important constraint for the nutritional and economic wellbeing of the small-holder farming communities (Phiri *et al.*, 2003). Taeniosis and cysticercosis due to *T. solium* does not lead to sudden international outbreaks of the disease and therefore does not constitute an appropriate subject for international notification. Nevertheless, national authorities should be strongly encouraged to set up national surveillance and reporting systems, and adopt a more active approach towards prevention and control of the disease (WHO, 2003).

Krecek *et al.* (2008) observed that the parasite presents a potentially serious agricultural problem and public health risk in endemic areas. Populations considered to be at the highest risk of infection include persons living in rural areas, most of whom earn their livelihood wholly or partially from livestock rearing. Diagnostic methods that have been used are the lingual palpation method in live pigs, two enzyme linked Immunosorbent assays (ELISA's), which detects antiparasite antibody B158/B60 Ag-Elisa and HP-10 Ag-ELISA, and an enzyme immunotransfer blot (EITB) assay, which detects anti-parasite antibody. True prevalence could be estimated using Bayesian approach, in the absence of gold standard techniques (carcass slicing). The two Ag ELISA tests have been shown to have the same specificity but differing sensitivities that could perhaps be explained by the fact that different monoclonal antibodies are used to capture circulating antigens. These may not capture the same antigen or react with the same epitope, explaining such sensitivity estimate differences.

The life cycle and risk factors of *T. solium* have previously been described by Phiri *et al.* (2003). When cysts develop in the brain and spinal cord of either humans or pigs, neurocysticercosis (NCC) arises. Approximately 2.5 million people world- wide carry adult *T. solium*. There are about 20 million people with cysticercosis due to *T. solium,* and from these 50,000 deaths occur every year due to NCC (Mafojane *et al.*, 2003). Endemicity of *T. solium* is usually high in areas where all risk factors maintaining the life cycle of the parasite are present, such as free roaming of pigs, absence or irregular use of latrines, and absence of official pork inspection (Krecek *et al.*, 2008).

The lingual palpation method that has previously been used is thought to have low sensitivity but is highly specific in detecting *T. solium* infected animals (Gonzalez *et al.*, 1990). Visual inspection of the tongue was recently used in South Africa (Krecek *et al.*, 2008). Boa *et al.* (2006) reported a prevalence rate of 24.4 % using routine meat inspection records in Songea and Mbinga districts of Tanzania. This prevalence was higher than an earlier estimate by Ngowi *et al.* (2004a) in Mbulu district. Pigs from Mbulu were on free range and this perhaps explained the observed high prevalence. Home slaughtering of pigs without inspection was significantly associated with increased prevalence of cysticercosis (Boa *et al.*, 2006). Pigs infected by the disease were rarely transported out of the villages and these were the ones slaughtered at home (Ngowi *et al.*, 2004a; Boa *et al..*, 2006). Adult pigs are more likely to test positive than young ones because old pigs are more likely to have been exposed more compared to the young ones, and also because once the pig is positive, it remains positive.

Initial studies in Kenya have reported a cysticercosis prevalence of up to 14 % in pigs (Githigia, *et al.*, 2005; Mutua *et al.*, 2005), an indication that *T. solium* cysticercosis is present in the locally-raised pigs of Western Kenya. Meat infected with the larval cysts of *T. solium* is unfit for human consumption and should be condemned or well cooked according to the legislative requirements of most countries. In developing countries, the monetary burden of cysticercosis in pigs is substantial (Willingham and Schantz, 2004).

2.4.2 Helminth infections

Infectious and parasitic diseases affecting livestock remain important constraints to profitable livestock operations in many developing countries. Diseases reduce incomes directly by causing considerable livestock losses and indirectly by necessitating health restrictions on exports (FAO, 2002). Internal parasites are causes of considerable mortality, lack of vigour, and unthriftiness, particularly in the young pigs (Payne and Wilson, 1999). Intestinal roundworms such as *Ascaris* *lumbricoides* var *suis*, and *Stephanurus dentatus* (kidney worm) constitute important pig helminths. Briefly, the adult form of the kidney worm lives in the kidney or in the walls of the ureters. Eggs are passed in the urine to the soil, and under favourable conditions, the infective larva are produced (Payne and Wilson, 1999). Entry is through ingestion, skin penetration, or ingestion of infected earthworms (Ross and Casteel, 2001). Most of the infections are sub-clinical and infection is associated with decreased growth performance and decreased food efficiency.

Common bacterial infectious of swine include colibacillosis (*E. coli*), brucellosis (*Brucella suis*), leptospirosis (*Leptospira pomona*), salmonellosis, and swine dysentery (*Brachyspira hyodysenteria*). Viral infections include the African Swine Fever and Foot and Mouth Disease (FMD). Lanada *et al.* (2005) reported anorexia, skin diseases, mastitis, foot and mouth disease, diarrhoea, lameness, injuries, uterine prolapse, abscess, cystitis, vomiting, coughing, diarrhoea, vulval lacerations, tumours, and fever as common manifestations in small-holder pig farms in the Philippines. Diarrhoea, pruritus, skin necrosis, and gut oedema (*E. coli*) are reportedly common (Wabacha *et al.*, 2004) in Kikuyu Division, Central Kenya. Pneumonia is a major cause of mortality in weaned and adult pigs; while diarrhoea is common in suckling piglets (KARI report, 1996). Overlay and hypothermia are common causes of piglet death in the Philippines (Lanada *et al.*, 2005).

Helminth infection is a constraint to economic pig production in Kenya, thus the need to institute appropriate control measures in the country. Nganga *et al.* (2008) reported a high prevalence (67.8 %) of gastrointestinal infections in pigs in a recent study in Kajiando District. Infections reported in this study included *Oesophagostomum dentatum* (39.1 %), *Trichuris suis* (32.2%), *Ascaris suum* (28.7 %), *Oesophagostomum quadrispinulatum* (14.8 %), *Trichostrongylus* *colubriformis* (10.4 %), *Trichostrongylus axei* (4.3 %), *Strongyloides ransomi* (4.3%), *Hyostrongylus rubidus* (1.7%), *Ascarops strongylina* (1.7 %) and *Physocephalus sexalutus* (0.9 %). *Taenia solium* larval (*C. cellulosae*) is commonly being diagnosed in the country (Githigia *et al.*, 2005; Mutua *et al.*, 2007).

2.4.3 Ectoparasites

Pigs in the tropics are known to suffer from considerable mange problem caused by *Sarcoptes scabiei* var *suis* (Payne and Wilson, 1999). The parasite, *S. scabei* var *suis* is a small burrowing mite 0.5 mm in length that live and feed on the epidermal cells. The burrowing and feeding activities of the mites cause intense pruritus, which cause scratching (Taylor, 1995; Muirhead and Alexander, 1998). Infection can be passed from animal to animal by direct contact, especially between the sow and her litters soon after farrowing. Mange infested pigs are thought to be more susceptible to other diseases such as pneumonia and rhinitis (Ross and Casteel, 2001). Taylor (1995) reported reduction in production as a result of mange infestations.

Pig sucking louse, *Haematopinus suis*, is a large, yellowish to brown parasite that is commonly seen moving on the hairs of the pig's skin. Eggs are laid on the bristles and appear as yellow crust prominent in black pigs. As observed by Payne and Wilson (1999), *H. suis* causes acute discomfort in pigs. The constant irritation and itching is what causes the pig to rub against objects, this may damage the skin and expose the animal to secondary bacterial infections. Spread is mainly through contact. Lice could act as vectors for infections such as the African swine fever. Wild birds have been known to feed on lice on pigs raised outdoor. Possible treatment options for pig ectoparasites include subcutaneous use of ivermectin or doramectin, and the use of sprays such as amitaz (Taylor, 1995; Muirhead and Alexander, 1998). Allowing pigs to scavenge might predispose them to both lice and mange infestations; such pigs will continually interact with other pigs thereby further spreading the infections.

2.4.4 African Swine Fever (ASF)

African Swine Fever (ASF) is a notifiable disease, which is enzootic in many African countries. ASF causes 95- 100 % mortality in all age categories of pigs. The virus can survive in the environment for a long time. Spread is mainly through direct contact, indirectly through feeding of affected pork products and fomites, and biologically through vectors such as the soft ticks. Failure to confine the pigs would therefore be an important risk for the acquisition and spread of ASF in an area. There is no treatment or vaccine available for ASF (Taylor, 1995; Muirhead and Alexander, 2002).

2.5 Sow productivity

2.5.1 Targets of performance

Achieving certain targets of performance is essential for pig farmers raising pigs under intensive rearing systems. Basic sow production targets include number of litters /sow/year, number of pigs born alive per litter, number of pigs weaned per litter, pre-weaning mortality, number of pigs marketed/ sow farrowed/year, and average market age. According to Radostits (1985), critical factors in a sow-production cycle include:

1. Reproductive performance- A decrease in conception and farrowing rate, and a drop in number of pigs born alive can cause major economic losses due to reduced profits.
2. Neonatal mortality- it is known that the greatest loss in pigs born alive occur during the first three days of life. This can however be reduced to below 10 % under good management.

3. Number of pigs weaned per litter, which is a function of the number of pigs born alive per litter and the observed pre-weaning mortality.
4. Specific infectious diseases, which could cause mortality, increase costs of treatment, and lead to subsequent loss in production.

Litter size is affected by the number of matings per estrus and lactational length. Sows bred 2 to 3 times at 12 -24 hour intervals have higher litter size. Sows that wean their piglets at less than 18 days have smaller subsequent litter sizes (Radostitis, 1985). Boar contact after weaning can induce onset of ovarian activity and advance estrous in sows by days. However, excessive boar contact can suppress estrous behaviour in sows (Langendijk *et al.*, 2002).

According to a summary report that sourced an expert opinion from the Farmers Choice (KARI, 1996), age at weaning in commercial farms in Kenya is 56 days, weight at weaning is 12 kg, age at slaughter is 240 days, weight at slaughter is 100 kg, age at first farrowing is 365 days, weight for culled sows is 130 kg, weight for culled boars is 160 kg, number of litters per sow per year is 2, and an average number of piglets born alive per litter of 9.

The importance of multiple mating in pigs has been described (Vickie *et al.*, 1998). This may be used as an indicator of how attentive producers are to breeding management. However, estrus detection and timing of insemination are crucial in increasing productivity than the frequency of mating (Dial *et al.*, 1992).

2.5.2 Reproductive performance

The average gestation period in sows is 114 days (112-120). Pigs are poly-estrous; sows come on heat on average every 21-day interval (19-24) throughout the year. Gilts have a shorter heat period than sows, with the heat period lasting for 48 hours. Sows ovulate during the last half of their estrus period and this is important in determining when to breed them. Semen should be in the reproductive tract before ovulation occurs. A sharp reduction in litter size occurs if fertilization does not occur within the first four hours of ovulation. Sperm must have time to capacitate or mature in the tract and must be present at the site of fertilization at or very shortly after ovulation.

Sows should be served when first detected on heat and 24 hours later. Sperm can survive for 12 - 24 hours in the sows' reproductive tract. The period of maximum fertility in sows occur in mid estrus some hours before ovulation. Since the shedding of large number of ova produced by the sow takes place over a period of several hours, maximum fertilization could be achieved by mating twice during the estrous period. The use of a different boar for the 2nd service is thought to increase average litter size by approximately 1 to 1.5 pigs per litter (Hunter, 1983; Payne and Wilson, 1999; Peadar and Brendan, 2007).

Gilts from improved breeds can be selected for the breeding herd when they are 4 - 5 months old after attaining a weight of 68 - 91 kg. According to Payne and Wilson (1999), gilts should be bred for the first time after their third heat period, when they are 6 - 8 months old and when they weigh 100-115 kg. On the other hand, sows should be bred during their first heat after weaning and when they are in good body condition; otherwise they should be bred on the 2nd heat period. The majority of sows show estrus between 4 and 7 days after weaning (Kemp *et al.*, 2005). Boars should be used for the first time when they are 8 to 9 month old and when well grown (Taylor, 1995).

2.5.3 Breeding gilts and sows

Sufficiently long lactation length (21–28 days), high percentage of multiple mating, low percentage of gilts, and low female culling rate are important factors that influence sow performance in small-holder farms (Vickie *et al.*, 1998). These factors impact on the overall productivity and profitability, and further contribute to social and economic wellbeing of pig - farming households. According to Lanada *et al.* (1999), there is limited knowledge on the reproductive performance of sows in small-holder farms since many of the previous studies have been done on commercial farm settings. Effects of season in influencing sow fertility - prolongation of weaning to first service interval, decreased conception rates, high embryonic deaths resulting in decreased farrowing rate, and increased re-mating rates have previously been described (Tantasuparuk *et al.*, 2002).

The decision on when to first mate gilts has been shown to influence overall herd productivity and subsequent sow-reproductive performance. A number of earlier studies have shown a significant effect of age at first mating (AFM), age at first conception, and age at first farrowing on litter size and sow longevity (Tummaruk *et al.*, 2001). AFM of 220 – 230 days has been approved as an optimal level for many commercial farms (Schukken *et al.*, 1994; Koketsu *et al.*, 1998). In practice and under field conditions, the exact age at which gilts attain puberty is not well known. The breeding decision is therefore based on a general decision to mate on the second observed estrus and about 7 – 9 months of age. However, in some commercial farms, gilts are mated at their first estrus (100 kg body weight). This may stunt growth and produce sows with small mature body weights (Neville *et al.*, 2007). Studies by Schukken *et al.* (1994) and Koketsu *et al.* (1998) have shown that gilts mated at a young age have a smaller litter size in the first and sometimes in the second parity, but have a longer lifetime productivity compared with gilts mated at an older age.

Age at which gilts are mated for the first time also depends on pubertal age. Sterning *et al* (1998) showed that for gilts reaching puberty early (mean age 185 days), a higher percentage returned to oestrus within 10 days after weaning as primiparous sows compared with gilts reaching puberty late (mean age 226 days). From the welfare point of view, sows mated on their first estrus are less likely to develop lameness when compared to those mated in latter estrus (Le Cozler *et al.*, 1999). The disadvantage of early breeding is that sows are likely to have a shorter productive life span and subsequently produce smaller litters (Babot *et al.*, 2003; Navile *et al.*, 2007). Gilts with prolonged age at first mating show a slight decrease in litter size when they reach parities 4 and 5 while gilts with lower age at first mating show a high percentage of repeat breeding (Tummaruk *et al.*, 2001).

A genetic relationship between age at puberty and weaning-to-oestrus interval has been demonstrated (Tummaruk *et al.*, 2001). A policy of selecting gilts from prolific sows and serving them with boars from a prolific dam line gradually increases litter size over time. Thus litter size and its component traits (ovulation rate, embryonic survival and uterine capacity) have been shown to respond to selection (Johnson *et al.*, 1999). Maximizing litter size in gilts maximise sows` lifetime performance (Dewey *et al.*, 1995; Aherne, 2002). Thus careful gilt selection and management is very crucial in swine herds (Peadar and Brendan, 2007). Tummaruk *et al.* (2000) reported a one pig decrease in litter size when weaning-to-service interval was increased from 4 to 10 days. Genetic improvement programme should emphasize on the number of live born pigs and weight of live born pigs (Johnson *et al.*, 1999).

The following factors can affect litter size in sows: ovulation rate, embryonic survival, uterine capacity, lactation length, feeding, and weaning- to-conception interval (Koketsu and Dial, 1998; Tummaruk *et al.*, 2001; Peadar and Brendan, 2007). According to Spotter and Distl (2006), failure of developing foetus to survive could be associated with abnormalities in the foetal developmental process. Selection for increased uterine capacity and in particular, selection for increased placental efficiency could lead to increases in birth litter size (Peadar and Brendan, 2007). Gilts with high growth rates have a larger subsequent litter size, shorter weaning-to-service interval and higher farrowing rate as sows. Such gilts have a better nutrient status for generating subsequent reproductive performance than the lower growth rate gilts.

Effects of parity and litter size have previously been described. Increasing the age at which gilts are mated for the first time leads to subsequent increases in litter size (Dewey *et al*. 1995; Tummaruk *et al.*, 2001). In the studies by Hughes and Varley (1980) and Hughes (1998), litter size increased from first to second litter and again from second to third litter, then plateau until approximately the 7th or the 8th. This explains why a high percentage of older sows should remain in the herd in order to realize this and achieve a higher herd size. The basic recommendation is to cull sows when they are weaning fewer pigs than is expected from the replacement gilt. The numbers of piglets born dead increases at older parities while the number born a live declines and milk production decreases (Peadar and Brendan, 2007). According to Vickie *et al.* (1998) pigs weaned per breeding female lifetime increases with the increase in the average parity of culled sows.

Sow longevity is important to farmers, results of several studies have shown that long lifetime production and low culling rates in pig herds are associated with economic benefits. According to Yazdi *et al.* (2000) sows should be culled after a productive life of approximately 617 days (32 months). This is in agreement with what has been reported in French herds (Le Cozler *et al.*, 1999). Parity 1 sows have a long weaning-to-first-service interval, weaning-to-conception interval, and the lighter litter weight at weaning when compared to mid-parity sows (Dewey *et al.*, 1994). Sows in Parities 2 to 5 have large larger subsequent litter size than those in Parities 1 and $\geq$ 7 (Koketsu and Dial, 1997). Effects of litter size on weaning-to-first-service interval or weaning-to-conception interval have not been demonstrated (Koketsu and Dial, 1997).

Lactation length and the weaning-to-conception interval are two key features of reproductive efficiency in swine herds (Dewey *et al.*, 1994). Prolonged weaning-to-conception interval is related to low feed intake, short lactation length, and low parity (Koketsu *et al.*, 1996). Kemp and Soede (1996) suggested that small litter size occurring in a certain weaning-to-conception period, such as 6 – 12 days, are caused by a short duration of oestrus followed by suboptimal breeding time. In most sow herds, the majority of sows show estrus between 4 and 7 days after weaning (Kemp *et al.*, 2005). However, sows which conceive between 6 and 12 days after weaning do not have inherent reproductive problems. These sows have lower litter sizes and farrowing rates likely due to being in a catabolic state during lactation.

2.5.4 Breeding boars

The age of breeding boars is a factor in determining the number of times the boars can be mated per day or week. Peadar and Brendan (2007) recommended the use of charts to monitor boar usage and to ensure that boars are not over-worked or under-worked. Over-working or under-working boars could lead reductions in litter size, thus each boar should be used for one double service per week. The need for some boars in the herds should not be underestimated because of their role in estrus stimulation, estrus detection, and gilt mating (Hughes *et al.*, 1990; Kemp *et al.*, 2005). Mating a boar to too many females in a short period of time will deplete the sperm reserve and subsequently reduce the boar's sexual drive (Gillespie, 2004). The recommended maximum sow to boar ratio is 20:1, 50:1, and 67:1 where natural mating accounts for 100 % of the services, where AI is practiced on a 100-sow unit, and where AI is practiced on a 1000 - sow unit, respectively (Lawler, 1998). On average, only 1 or 2 boars need to be used in a herd of 50 gilts (Payne and Wilson, 1999). Boar exposure both before and after weaning has been shown to be effective and gives additive results of bringing sows back to estrus (Kemp *et al.*, 2005).

Several drawbacks on the use of AI have been reported. For example, boars ejaculate approximately 200ml of semen at one time, but a decline in the capacity of semen to fertilise the pig after only one day of storage has been reported. One boar ejaculate can be diluted to inseminate an average of 8-10 females. Care should be taken in the selection of the boars; individual records, pedigree, family information, and progeny information are all important. Payne and Wilson (1999) noted that many pig farmers, particularly in the developing world, keep few sows. Under such circumstances, it becomes costly to keep one breeding boar to serve the few numbers of sows. A single boar can serve as many as 50 sows or gilts per year. Pig producers may cooperate and share one boar amongst themselves, but there is an obvious risk of disease transmission from one farm to another. Only 5 % of farmers in Eastern Nepal owned boars (Ruth and Purna, 1991). A breeding crate should be utilized when old heavy boars are used to breed gilts.

Boar exposure is important in stimulating ovulation in pigs. In a study by Langendijk *et al* (2002), exposure of boars to gilts and sows resulted in increased number of sows ovulating within nine days after weaning. In the same study, additional boar contact resulted in increased number of sows ovulating 6.5 – 9 days after weaning. Boar contact is more effective in sows that would otherwise have had a long weaning-to-ovulation interval (Langendijk *et al.,* 2002). Early boar contact after weaning is also important in the stimulation of estrus. Walton (1986) introduced boars to sows the last week of lactation, which resulted in shorter weaning to estrus intervals as opposed to having no boar exposure during the last week of lactation. Boar exposure during weaning may induce lactational estrus. In a study by Petchey and English (1980), 10 % of the sows showed lactational estrus following boar introduction. Sows producing sufficient luteinising hormone (LH) after weaning have sustained follicle growth and therefore a shorter weaning-to-estrus interval (Kemp *et al.*, 2005). Boar contact can induce ovarian activity, advance estrous, and stimulate estrous behaviour in sows. Exposure of pre-pubertal gilts to a mature boar has been shown to reduce the age at which gilts attain puberty (Langendijk *et al.*, 2002; Kemp *et al.*, 2005). Boars with genetic defects that could potentially affect fertility should not be used for breeding (Payne and Wilson, 1999).

2.6.1 Weaning piglets

The aim of early weaning is to re-mate the sow soon after parturition and to maximise on the output of pigs weaned per sow per year (Miller *et al.*, 1994). However, weaning piglets early causes a lot of stress for the piglets, and results in post weaning lag phase, characterized by scouring and unthriftness (Austin and Lee, 2001). At weaning, the gut wall has to adapt to the sudden change from milk-based diets to a grain-only feed. The pH of the stomach rises, and the digestibility is suppressed until enzyme production by the pancreas and the gut wall has adapted to the changes in the diet. It is the undigested solid feed passing through the small intestine that causes post- weaning diarrhoea (Neville *et al.*, 2007).

Piglet immunity is low at 21 days. During this time, the digestive system is not fully developed and pigs cannot fully utilise feedstuffs fed to older animals. The observed scouring and unthriftness is due to the changes found in the morphology of the small intestine shortly after weaning (Miller *et al.*, 1986). These changes include reduction of villus height, increased depth of lamina propria, reduced disaccharidase concentrations, and reduced absorption. The decrease in villus height can be caused by pathogens, antigens, or reduced feed intake (Miller *et al.*, 1986; Vellenga *et al.*, 1992; Nunez *et al.*, 1996).

Due to the weaning stress coupled with the immature immune system, newly weaned piglets are more susceptible to infections caused by pathogens. Any infections or palatability problems could also lead to decreased feed intake, which can further influence gut histology. Early weaning is often accompanied by gastro-intestinal upset, elevated susceptibility to infection, and a higher risk of hypersensitivity reaction to food constituents in both human and domestic animals (Miller *et al.*, 1986).

The endometrium in the uterus is regenerated through the process of involution between 14 and 21 days after farrowing. This process may not be complete in sows weaning pigs at 21 days or less and could lead to a reduction in litter size during the subsequent farrowings (Koketsu and Dial, 1998). A days' increase in farrowing to conception interval could determine the subsequent number of pigs born a live. Early weaning (9–12 days) has been associated with high levels of mortality in grower- finishing period (Losinger *et al.*, 1998).

Dewey *et al.* (1994) found litter size was optimal when sows were bred on day 2-4 post weaning, but decreased progressively after day 4. Litter size begins to rise again when sows are bred on days 11-14 post weaning. Any decrease in litter size for sows with weaning-to-breeding intervals of 5 - 10 days could be attributed to decreases in ovulation rate.

2.6.2 Piglet mortality

Piglet mortality has been identified as one of the most important constraints in smallholder pig herds. According to Payne and Wilson (1999) and Lañada *et al.* (2005), mortality rates in the tropics are the same as those reported in similarly managed herds in temperate zones. Improved profit from piglet production is a direct benefit to smallholder families (More *et al.*, 1999). The number of pigs produced per sow per year affects the profitability of sow herds and is dependent on the sow's reproduction performance, neonatal mortality, number of pigs weaned per litter, and specific infectious diseases (Radostits, 1985). The number of piglets produced per sow per year can be increased by reducing the interval between weaning and conception, and by reducing the lactation period to 4 to 5 weeks. Hence, efforts made to increase the number of pigs produced per sow per year will directly increase pig farmers' income. Similarly, profitability in growing pig herds depends on the growth rate and price per kilogram of the pig. The grower-pig performance in the smallholder herds in the tropics is low compared to the commercial production systems of the subtropics and tropical areas (More *et al.*, 1999). Piglets should receive adequate amounts of colostrums at birth. Inadequate absorption of immunoglobulin has been shown to be a major cause of mortality in piglets (Klopffenstein *et al.*, 1999). Variations in birth weight is an important cause of pre-weaning mortality in swine herds.

2.7 Estimating pigs weight over time

Body measurements have previously been used to estimate live body weight in different species of animals. Thiruvenkadan (2005) used height at withers, heart girth, and length to determine body weight of goats in India, while Enevoldsen and Kristensen (1997) used length and heart girth to predict body weights of cows in commercial dairy farms in Denmark. These measurements are used to predict weight using mathematical equations, which could be adapted to other breeds. Groesbeck *et al.* (2003) showed how girth could be used to estimate the weight of pigs at the Kansas State University swine teaching centre. In this study, heart girth was highly correlated (98 %) with body weight. The results were validated using 205 pigs. Backyard farmers in the Philippines used length and heart girth measurements to predict the weight of their pigs because they could not afford weighing scales (Murillo and Valdez, 2004).

Estimating a pig's weight over time is used to determine growth rate, feed conversion, appropriate dosage of medication, and realistic economic value of livestock based on live weight at market (Enevoldsen and Kristensen, 1997; Murillo and Valdez, 2004).

A pilot study conducted in Busia District revealed the existence of a ready-market for pigs sold locally. However, local pig farmers complained of poor prices and overexploitation by the pig traders. The main method of determining the weight of animals in the absence of weighing scales is to estimate the weight using a certain number of body characteristics that are readily measured. Typically, weight is regressed on body measurements to determine a weight prediction equation (Thiruvenkadan, 2005; Murillo and Valdez, 2004).

2.8 Research Justification

Farmer's views, beliefs, and perceptions cannot be ignored in understanding pig farming in Western Kenya. Conducting focused group discussions by local pig farmers and extension staff would provide an in-depth understanding of participants' views, beliefs, and perceptions about smallholder pig production in rural Western Kenya. Such information could provide a better understanding of pig keeping in the study area, which can further be used by the policy makers in better understanding of the unexploited potential in rural farming, and perhaps even in better addressing the needs of the poor pig farmers. The approach to conducting focused group discussions was therefore adopted to capture the needed data on farmer's views, beliefs, and perceptions on rural pig farming.

In the study area, pigs are sold to pay school fees, attend to emergencies, health care, food and other household expenses. Pig keeping is therefore seen by many as an escape route from poverty with pigs being sold at varying live weights. Understanding of pig keeping in the study area coupled with training the farmers on better farming methods is thought to be one way of improving pig productivity. Most of the pigs in the study area are either tethered or left to run loose on the farms. Such management practices serve as potential risk factors for important pig diseases such as cysticercosis caused by larval stages of *Taenia solium*. Zoonotic *T. solium* is an important disease which is transmitted between pigs and humans, and has been reported in locally raised pigs of Western Kenya. Training of farmers on better pig keeping practices and life cycle of the parasite could be used as one of the strategies of combating *T. solium* taeniosis and cysticercosis, thereby safeguarding human health.

In the absence of scales, weights of non-breeding pigs destined for slaughter have been estimated using length and heart girth measurements, taken using commercial weight tapes. These tapes are only accurate for pigs that weigh 62 to 130 kilograms (Hog Weigh Tape, The Coburn Company Inc, Cambridge). The main market channel for pigs includes local butchers who move from village to village looking for pigs to buy. Farmers have previously expressed their dissatisfaction with the system citing exploitation by these buyers. Farmers currently have no system for estimating the weight of pigs at sale to ensure that they get appropriate value for their pigs. Weighing pigs using a spring scale is perhaps the most accurate method. However, the cost of scales rules this option out for many farmers. Most farmers, therefore, resort to simply guessing the weight of the pigs as the basis for deciding the selling price. Estimating pig's weight by 'just looking' at the pig is unreliable and provides biased weight estimates. Hence, there is a need to develop and validate models to estimate the weight of pigs destined for slaughter in the study area by just using a typical tape measure, which is readily available and user friendly.

Feeding accounts for most of the costs incurred in pig rearing. No wonder farmers in Western Kenya have previously singled out pig feeding as one of the challenges hindering profitable pig keeping their villages. Considering the increasing human demand for food, coupled with the soaring food prices, it becomes imperative to research and promote the use of alternative pig feeds. This would perhaps solve the existing problem of competition for human's food and feed for pigs. Commercial feeds are available in local outlets but farmers in the area cannot afford to purchase them. A variety of local crops (and fruits) are grown in the area, which could be utilized in the formulation of local feed rations. Exploring the current feeding practices and the performance of the pigs is important in providing a better understanding of how rural pig farmers can enhance their role in poverty alleviation and subsequently sustain their livelihoods.

Confining pigs in pig-proof structures is important in maintaining a healthy pig production system. However, many farmers cannot afford the high costs of building materials and so opt to engage in low cost methods such as tethering and free ranging. Farmers could be trained on how they could utilize local materials to construct simple pen structures that could house pigs. As suggested by Rodriguez and Preston (1997), the use of local feeds has received less attention in the past because of the introduction of exotic systems relying on high inputs, high technology, and better breeds.

Studies on the reproductive performance of sows in rural small-holder farms are scanty (Lanada *et al.*, 1999). Wabacha *et al.* (2004) studied the reproductive performance of commercially-raised sows in a high potential peri-urban area of Nairobi. The pigs he studied were crossbreeds of Large White or Landrace, and were intensively managed. There exists no data on the reproduction performance of locally-raised sows in Western Kenya. Factors such as poor feeding, management, and marketing have been shown to affect small-holder pig farming in commercial farms; effects of these factors on rural sow performance are yet to be studied. A complete understanding of local pig production in Busia and Kakamega districts of Western Kenya will require a complete knowledge of the general health of these pigs, management, and the reproductive performance of the sows raised.

2.9 Research objectives

The overall objective of this study was to improve the livelihood and economic returns of small-scale pig keepers in Western Kenya through enhanced management practices, increased productivity, and better economic returns. Specifically, the study was designed to achieve the following specific objectives;

1. To explore pig farmers beliefs, perceptions, and attitudes towards rural pig-keeping
2. To develop and validate weight estimation models for growing pigs using length and girth body measurements for pigs in Western Kenya
3. To compare sow performance for Busia and Kakamega districts
4. To investigate the potential sources of pig feed
5. To develop pig training manual that would be used to train the local livestock and health officers and aid in the subsequent farmer training fora
6. To provide a short-term assessment of pig farmer training on management, sow productivity, and understanding of *T. solium* after the training sessions.
7. To describe pig management practices for pigs in rural Western Kenya

CHAPTER THREE

3.0 GENERAL MATERIALS AND METHODS

3.1 Study locations

This study was conducted in Busia and Kakamega districts of Western Kenya. Kakamega has an approximate population size of 603,500 people and occupies about 17 % of the Western province; Busia has a population size of 370,600 and occupies approximately 14 % of the Western province. Kakamega district borders Vihiga district to the South, Nandi and Uasin Gishu districts to the east, Trans Nzoia and Lugari districts to the north, and Mumias and Butere Mumias districts to the west. Busia district borders Kakamega District to the east, Bungoma District to the north, Uganda to the west, and Lake Victoria and Siaya to the south.

3.2 Selection of Study Sites

The two Districts, namely Busia and Kakamega, were purposively selected for this study based on their popularity for rural pig keeping. In each district, two pig keeping sub-locations were identified based on their known popularity in rural pig rearing. A sampling frame of all small-scale pig keepers in each sub-location was established through the help of the local provincial administration. The village elders guided the researcher in locating the pig farms and played an important role in creating a strong working relationship between the researcher and the pig farmers. The number of farms to be sampled in each village was proportional to the total number of pig farms in the village. Thus farms within each village were randomly selected proportional to the number of farms to include between 65 % and 75 % of all pig farms in each village. All pigs present in the selected households at the time of the study visit were recruited in the study. Farmers who were selected to participate in the study but were not available during the initial visit were replaced. Farmers who were interviewed during the first visit but were not available for interviews in the subsequent farm visits were considered as "lost to follow up farms" and were therefore not replaced.

3.3 Study Design

3.3.1 Focus group discussions

A total of four farmer group discussions were held in four villages of Kakamega district. A senior village elder in each division assisted in recruiting the participants for the meetings. A total of 8 to 12 pig farmers, men and women, per village, were invited for the focus group discussions (FGD). The researcher, the farmers, and the village elders jointly agreed on the specific dates for the discussions. A reminder invitation was sent to the farmers one week before the arranged dates. Discussions were held in one of the pig farmer's home and were conducted in the early hours of the afternoon. Two other FGDs were done for the local extension government staff in the divisions of Ikolomani and Shinyalu. Sessions were held at the divisional headquarters. Those invited for these discussions included staff working in the following divisions: local livestock, veterinary, agriculture, health, adult education, and social services.

3.3.2 Pig Farmer Surveys

An initial cross-sectional study was conducted and three follow-up visits made to all the farms initially visited. The initial field visits, before the training intervention, were treated as the controls for the study. The number of pig farmers that were visited from each village was proportional to the total number of pig farmers in each village and included 65 - 75 % of all the farms. More pig farmers were sampled from villages where pig keeping was reportedly very popular.

A structured questionnaire was used to collect baseline household data via questionnaire interviews (Figure 1). The survey was designed to capture information on the demographics of the family living in the farms, pig feeding, housing, purchase and sale prices of the pigs, the reproductive performance of the sows, and the pig farmer's level of understanding about cysticercosis among the small-scale pig keepers (Appendix 12.1). It is important to state that some questions were asked in some visits but not captured during the other visits hence the difference in denominators in some of the parameters. During the interview, questionnaires were translated into Kiswahili language and where necessary, enumerators familiar with the local Luhya language were used to do translations into local language. The primary care taker of the pig was the one who was mostly interviewed. However, a different family member could also be interviewed in cases where the primary care taker was not available.

3.3.3 Pig Body Measurements

Larger pigs were restrained by means of a hog restrainer while small pigs were restrained by hand. All pigs in the study households were ear tagged. The ear was then sprayed with tetracycline wound spray after the insertion of the ear tag to prevent secondary bacterial infections. The pig's length and girth were measured (cm) and weight determined using a spring scale (kg). These measurements were used to develop a model that could be used to predict the weight of pigs from their length and girth measurements. Farmers were requested to estimate the weight of the pig prior to weighing the pigs. All the weight data were entered in the forms shown in Appendix 12.2. All pigs present at the time of the study were examined for lingual cysts of *C cellulosae* using the lingual palpation method. Farms were classified as either positive or negative based on the tongue test results. A positive farm was the one where at least one of the pigs examined tested positive, negative farms were farms where none of the pigs examined was positive.

The pig weight data obtained during the initial farm visit was used in generating weight prediction equations. Farmers were taught on how to use these equations to estimate pig's weight in kilograms, after taking the length and girth measurements. They were initially issued with prints containing the weight estimation formulas. This enabled the researcher to gauge the farmers' ability to do the calculations on their own and manage the record systems. At the end of the project, three weight estimation tables were developed, corresponding to the three different pig-age categories. The tables had pig measurements for length (Y-axis) and girth (X-axis); each length and girth combination produced a corresponding weight (kilograms) (Tables 4 - 6). These were issued to the farmers as tools to aid them in the estimation of pig weights during the second farmer training workshops.

The livestock and public health officials in each sub-location were invited for a one-day training seminar covering pig production, reproduction, housing, management, and feeding. The life cycle of *T solium* was also covered in detail. Participants for the staff training were expected to participate in farmer education days to provide a similar educational program to the pig farmers in the villages. Farmer training was conducted in one location per every two to three villages. Specifically, pig management, feeding, production, reproduction, record keeping, piglet care, common pig diseases, and the life cycle of *T. solium* were discussed with the farmers. Participants for the staff training thought issues of HIV and Aids control, and the formation of pig farmer groups were crucial, and needed to be included in the farmers training package.

Farmers were taught how to estimate the weight of their pigs using tape measures. Each farmer was provided with a tape measure and a weight recording sheet that they could use to measure and record the weight of their pigs once every month. At the end of the research period, a second training was done. This training was meant to disseminate research findings obtained, further train farmers on pig production, pig health, and estimation of the weight of the pigs from body measurements. During the 2nd trainings for both the staff and the farmers, additional data on pig management and sow productivity were gathered.

3.3.4 Follow-up Farm Visits

Farms were re-visited after 4 and 8 months following the initial farm visit. Data were collected on purchase price and sale price of pigs, pig housing, feeding management and constraints to pig feeding, and sow productivity. During these follow-up visits, farmers were asked if they attended the farmer training day. The farmer's knowledge about taeniosis and cysticercosis in people and pigs, pig weight estimation method, and whether the pig's weight was factored into the sale price of pigs were also determined during these visits. Farmers were asked to show the pig weight recording sheet to the interviewer. This was used as an objective measure of record keeping of the weight of the pig. Farmers who could not attend the trainings were provided with individual (one-on-one) trainings and were issued with training packages, which included tape measures, during the subsequent farm visit. The knowledge base of these farmers was compared to that of the farmers who had attended the training. Their understanding of the training materials was determined during the 3rd farm visit.

All pigs present on the farms during the 2nd and 3rd farm visits were measured and weighed. The growth rate of pigs with an ear tag was determined by comparing the weight at the previous visit to the weight of the pig at the current visit. Pigs on the farms and those that were not present during the previous farm visit were ear tagged, weighed and measured. These pigs were also examined for *C. cellulosae* cysts and blood samples were taken for serological analysis (results not presented).

3.3.5 Motivating the farmers

As a sign of appreciation to the farmers for their continued participation in the project, all pigs examined were treated for internal and external parasites, mainly lice and mange, using ivermectin. Tether wounds were also treated using tetracycline wound spray and penicillin when indicated. Farmers were advised to observe the recommended 28- day withdrawal period for ivermectin and a 30 day withdrawal period if pigs were given penicillin before sale or slaughter. Pigs that the farmers said were to be sold within one month of the research visit were not treated.

3.4 Data Management

3.4.1 Focus group data

Sessions were audio-taped, double-transcribed, and translated by the moderator who was fluent in both English and Swahili. Each tape was labelled with village names, date, and letters A or B with A indicating the beginning of the session. The transcripts were compared to the written notes from the session and the summary notes made after the discussions. MaxQDA software (Verbi software, Berlin, Germany) was used to identify similar themes across the transcripts during the analyses.

3.4.2 Household and Pig Weight data

Data were entered and cleaned in Ms Access® and was exported to Stata® and SAS® statistical software programmes for further descriptive and statistical analysis. Associations between the various pig production parameters, the district, and visit numbers were computed using chi square statistics at 95 % level of confidence. Prevalence of porcine cysticercosis was calculated as a proportion of pigs positive by the lingual palpation method divided by the total number of pigs examined.

Seventy five percent of the weight data was used in formulating a mathematical model for determining pig weight given the length and girth measurements. Validation of the model was done by using the remaining 25 % of the observations. The weight estimated by the model was compared to the actual weight of the pigs using student's t-test. Consequently, weight estimated by the farmer was compared to the actual pig weight of the pigs. This helped to determine how accurate the estimated weights were to the actual pig weights. This further helped in assessing if the pig farmers were able to adequately estimate the weight of their pigs before they sold the pigs out for slaughter.

Figure 1. Researcher conducting an oral interview in 2007 in Kakamega District. Adult farmers particularly those responsible for the care of the pigs were interviewed. Appendix 12.1 presents the questionnaire used in gathering household data during the third farm visits. Some of the questions in the questionnaire were not asked during the first farm visit and the second farms visit leading to differences in the denominator values used in the analyses. Data on the political impacts and that on the ways to improve the pig industry have not been presented here.

CHAPTER FOUR

4.0 FARMER PERCEPTIONS ON RURAL PIG FARMING

4.1 Introduction

Small-scale pig farming plays an important role in the livelihood of many families in the developing world (Lanada *et al.*, 2005). In Kenya, most pigs are of the exotic breeds and their crosses, and are concentrated mainly around Nairobi District and its environs. These areas have the advantage of favourable climate conducive for intensive pig farming, and farmers have easy access to markets (Wabacha *et al.*, 2004; Kagira *et al.*, 2008). Local pig farming is a form of pig production system that is quite popular in Western Kenya. Here, households keep an average of 1 to 2 indigenous pigs and these pigs are usually tethered or allowed to scavenge on their own (Githigia *et al.*, 2005; Mutua *et al.* 2007). The animals that one is likely going to see when one enters these homesteads is a tethered or a roaming pig plus a few scavenging chicken (Mutua *personal observation*). Pigs require minimal inputs in terms of family labour and feeding; perhaps an important motivation for farmers to raise them. Allowing pigs to roam freely is illegal and against the laws of Kenya (GOK, 1972). However, farmers in the study villages have continued to engage in local pig farming despite the governments call to confine pigs. Confining pigs increases production and safeguards the public from diseases of public health importance. The indigenous pig breed still remains the predominant breed in these areas despite numerous calls to introduce better exotic breeds.

Compared to other livestock species, pig sector in Western Kenya has a seemingly greater potential to alleviate rural poverty. This cannot be realized unless we gather data on the perceived farming challenges, fears, and benefits. The purpose of this study was to provide an in-depth investigation of the views, beliefs, and perceptions about indigenous pig farming; and to understand the constraints to a successful pig rearing enterprise as perceived by farmers and government officials who service these farmers. Data gathered for the chapter would be used by policy makers to better understand and address the needs of the local farmers and in improving future intervention strategies.

4.2 Methodology

4.2.1 Focus Group Discussions (FGDs)

A total of four farmer focus group discussions (FGD) were held in four villages of Western Kenya: Buhuli and Mundulu in Ikolomani Division; and Ikuhywa and Shilutsi in Ikolomani Division. A senior village elder in each division assisted in recruiting the participants for the meetings. A total of 8 to 12 pig farmers, men and women, per village, were invited for the FGD. A date for discussion was set jointly and a reminder invitation was sent to them one week before the date. Discussions were held in one of the pig farmer's home and were conducted in the early hours of the afternoon. Two other FGDs were done for the local extension government staff in the divisions of Ikolomani and Shinyalu. Sessions were held at the divisional headquarters. Stakeholders invited for these discussions included staff in the following divisions: local livestock, veterinary, agriculture, health, adult education and social services.

4.2.2 Organization of FGDs

In order to ensure that all topics for discussion were included in each FGD, a checklist and interview catalogue was developed to guide discussions. Questions were designed to help the researchers in understanding community perceptions of smallholder pig keeping prior to biomedical studies. Topics explored by the farmers included responsibilities for pig keeping, reasons for pig keeping, challenges affecting the industry, and the possible contents of a proposed farmer training programme. The staff was asked about the challenges affecting pig farming in their divisions and what they thought needed to be taught to the farmers if pig farming was to be promoted.

Discussions began by general introductions led by a senior village elder. The group then identified one of the participating pig farmers to lead the group with an opening word of prayer. Seating arrangements were organized to facilitate identification of key points raised by each farmer and also ensured full participation from all the participants. The moderator gave a brief overview of the research and summarized key expectations for the meeting. All farmers were encouraged to participate and consider each answer as relevant. The moderator called for open discussions in any language that the farmers were comfortable with.

Participants were informed about the use of a tape recorder that would be used to record the entire session. The FGDs with the staff was in English. Farmers' discussions were mainly in Swahili, whereby some farmers chose to combine both local Luhya language and Swahili, in which case the accompanying livestock officer translated the words to Swahili. Sessions lasted for an average of 90 minutes. Refreshments were offered to the farmers at the end of each discussion. Unique observations made during the discussions were recorded in writing by an assistant moderator during the discussions. Additional notes were written after the session.

4.2.3 Data management

Sessions were audio-taped, double-transcribed and translated by the moderator who was fluent in both English and Swahili. Each tape was labelled with village names, date and letters A or B with A indicating the beginning of the session. The transcripts were compared to the written notes from the session and the summary notes made after the discussions. MaxQDA (Verbi software, Berlin, Germany) was used to identify similar themes across the transcripts during the analyses.

4.3 Results

4.3.1 Group participants

There were eight farmers in three focus groups and 12 in the fourth. The village with the 12 farmers included some who had not been invited for the discussion but turned up for the meeting and insisted they wanted to participate since they also owned pigs. Below (Figure 2) is a photograph of participants for a focused group discussions in one of the villages in Kakamega.

Figure 2. Participants for the farmer focus group discussion in Kakamega District, Western Kenya

4.3.2 Pig keeping responsibilities

In three of the villages studied, women were identified as the ones responsible for the management of pigs particularly in the feeding. Men were rarely at home and could not therefore be entrusted with the responsibility of managing the pigs. This was an observation from a female participant. Men defended themselves, arguing that pig management required combined efforts of all, "*We use bicycles to go looking for the feeds, and women do the actual feeding*" one male participant commented. In Shinyalu Division, a female participant said she was a widow and she did everything by herself, implying that it was possible for women to do all the work of managing the pigs on their own.

Marketing of pigs was a man's responsibility; a woman could only sell her pig when her husband was not available. One male participant said "*She can even be chased away,*" implying that her husband could chase her away if she tried to sell the pig alone. But a participant in a different village said he couldn't just sell his pig without informing his wife. Yet in a different village, women argued differently and said they were exploited when they went to sell their pigs, and therefore, preferred their men doing the selling instead. Anybody could sell the family pig, but the selling again depended on who owned the pig, whether it was a child, wife or husband, and who was at home when the pig buyer came around looking for pigs to buy. "*It is important for the family to agree before any selling is done*", commented a male participant from Buhuli village.

4.3.3 Reasons for keeping pigs

In all the farmers groups, income generation and faster growth rate compared to other livestock were mentioned as key reasons to keep pigs. Some farmers described pig keeping as a business like any other, while to others; pig farming was comparable to operating a bank account. One farmer said she used returns from pig farming to pay for her children's high school fees. Another farmer in a different village concluded by saying: "*A home with a pig cannot complain*". To realize good returns, participants thought one needed to keep pigs in large numbers, at least 10 pigs and above. Pigs were reported to reach market weight easily and therefore provided pig farmers with faster returns than farmers raising other livestock.

Farmers knew pigs could be bred easily, had a gestation period of three months, could farrow twice in a year and produced many piglets in a single farrowing. One farmer observed that pigs were not comparable to other livestock species with regard to fecundity "... *for example a cow that can calve approximately once in a year ...* " In two villages, marketing of pigs was said to be good in the sense that there were many potential buyers making it easy for the farmer to sell her pigs. Pigs could be sold at home and farmers did not have to bother transporting the pig to the market or wait for market days to come: '*I don't have to look for movement permits to transport the pig to the market*". Provided management was good, pigs could be marketed as early as six months of age.

There were additional reasons for keeping pigs that were mentioned in a few of the villages. These included; pigs require less space compared to other livestock species such as cattle and could be raised by anybody, including children; some farmers had a special preference for pigs because pigs did not get sick easily, had fewer enemies than other livestock and were thus able to walk within the villages freely; while some families kept pigs for security purposes, adding that pigs could guard their homes at night: "*At night a pig is able to differentiate between strangers such as a thieves*" said one farmer; for some farmers, the local climate was favourable for pig keeping; farmers said the high rainfall was good for pigs. Others kept pigs because a pig is a good source of manure.

According to the local staff, pigs were believed to offer protection and acted as a charm to protect against evil ones in the neighbourhood. This was said to have had an impact on the price of the pork with some specific pork sections costing more. One staff participant said "A *tail of a pig can cost up to Ksh 200"*. Unlike the staff who openly talked about the cultural belief, farmers were reluctant to discuss this. In one of the villages, for instance, this topic was openly discussed at the end of the sessions and when the participants were taking refreshments. This happened after the livestock officer requested that one of the farmers shed some light on the belief that had previously been mentioned during the meeting. One farmer participant explained that some specific parts of pork were thought to be more valuable and offered more protection. Another male participant explained how he carried a piece of pork in his wallet for fear of being bewitched by neighbours who perhaps were not happy with him.

4.3.4 Rural pig rearing challenges

In response to the question on small-holder pig farming challenges in the divisions, both farmers and the staff admitted there were many challenges that faced the pig sector. Farmers thought pig marketing was a huge problem as local buyers preferred white- coloured pigs because the black ones - which farmers commonly kept - were thought to have a low market value. Pig farming attracted little financial attention from the government and farmers lacked resources to improve the enterprise. A farmer participant called this *"lack of sponsorship"*.

Regarding the potential in local pig farming, one staff participant pointed out that "*Pig keeping is an enterprise that, if taken care of can be exploited, many farmers' book piglets very early"*. This implied a shortage of piglets in the neighbourhood if one wanted to raise more pigs. The staff emphasized on lack of organized market channel for pigs which in turn forced pig farmers to accept prices offered by the middle men. One staff member said, *"A pig worth Ksh 4,000 could be sold at Ksh 1,000, after being managed by the farmer for a year or even more"*. Lack of a local pork processing plant was thought to be one of the leading causes of the poor marketing. There were also concerns of unnecessary wastage of by-products at slaughter. The staff thought the leading pig processing plant, Farmers Choice Ltd (FC) failed to buy pigs from their division because the pigs were eating grass, which was thought to have detrimental effects on the quality of local pork.

There had been less supply of pork in the local markets but according to participating staff members, the trend was changing with an upward growth of both demand and supplies. The price of pork was for instance said to have had increased from Ksh 100 to Ksh 140 per kilogram in 2007. Housing was a serious problem during rainy seasons and pig farmers lacked necessary resources to construct houses for pigs. Some farmers were reluctant to tether their pigs; they argued that tethering denied pigs exercise, which farmers believed was crucial for pig's healthy development. Furthermore, the tethers weakened fast and so some farmers could not afford to replace them promptly. The staff thought tethering was a bad management practice and needed to be discouraged. Pigs were destructive when left free and noted that roaming pigs could be poisoned. Farmers had realized this when they complained about attacks on their pigs. A case of salt poisoning by a neighbour was reported in one of the villages. They observed that free-range pigs were common sources of neighbourhood conflicts within villages.

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A cultural belief about pig keeping exists in the study area, which the staff thought could potentially impact pig farming in the area. This topic drew heated debates among the participants. "*......some people refuse to be involved in anything to do with pigs. They give funny excuses but they don't just want to keep pigs. Others say they have demons in their homes whose power could be diluted by pigs*", said a female participant working as a social worker in one of the divisions. Others thought there was a biblical interpretation behind pigs and pig keeping, and citing an example in the bible where pigs possessed by demons were cursed.

Interestingly farmers did not know that pigs could be treated whenever they became sick. They could not identify common pig diseases and further discussed about the lack of doctors for pigs in the area "*We have only doctors for cows*", one farmer commented. External parasites were thought to be common in most of the villages. According to the staff, this problem was as a result of few veterinary staff delivering animal health services in the two divisions. They further discussed about the poor infrastructure that affected the accessibility of some pig keeping villages and thus hindered the delivery of these services in such villages. They gave an example of a village in Shinyalu district that becomes completely inaccessible during the rainy seasons; "*Some villages have pigs but one cannot get there to attend to the pigs*" noted one of the participants.

Farmers further complained of lack of knowledge on different pig breeds and wondered which breed of pig could grow faster in their local setting. They were not satisfied with the common practice of pig farmers having to pay a piglet to boar owners after their sows had successfully been bred. Farmers did not know about the existence of other methods of breeding pigs such as the use of artificial insemination. The staff admitted having received complaints from farmers with regard to pig breeding. Inbreeding was thought to be very common. Mabanga Farmer training Centre in Bungoma District was thought to be the only centre that served as a source of improved breeds in the whole of Western province. They further noted the particular lack of knowledge on breeding among the pig farmers. Most of rural pig farmers were women *"who are not even aware of the signs shown by pigs on heat, when to serve and how to serve"* was a concern from one of the staff. In one of the farmer groups, a participant talked of his sow that had only farrowed once in the year and wondered why that had happened. Sows with insufficient teat numbers were also reported to be common.

Some thought pigs were very destructive and dirty, and could eat anything if they were hungry to the point that they, *"can even bite your child"*, noted one of the participants. Only the staff discussed, as a challenge, the effects of religious differences on local pig farming. *"For example, some denominations such as the Seventh Day Adventist don't even touch the flesh from pigs, they are seen as unclean animals (as read in the book of Numbers 11:1-20 and Leviticus 11)"* said one participant. *"Some of the staff will therefore inspect the meat by law and not by faith"*, he added. Muslims living in the areas were said to be against issues related to pig farming. This was said to affect the selling of pork in the market centres, one participant said, *"There is less pork served in the local hotels because Muslims and even some other faithful are not likely to enter hotels where pork is served"*. On the same note, a participant indicated that some people never liked pork because of its fatness. The staff thought the existing local belief on pig rearing negatively impacted on pig rearing as a business.

Additional concerns raised by the staff were that of lack of sufficient space to keep pigs, resulting in youth groups not venturing into pig keeping because their parents failed to give them space.

4.3.5 Farmer training needs

Both farmers and staff groups were asked to describe topics they thought needed to be included in the training package that was to follow the FGDs. With regard to pig feeds, farmers wanted to know the available feed types and the number of times a pig needed to be fed. For diseases, they wanted to be taught the clinical signs to look for in a sick pig, and causes of disease, with one farmer citing a common example of a pig failing to eat. They further wished to know what treatments were available for pigs and where they could get help when their pigs got sick.

Considering the lack of animal health staff in the divisions, the staff said farmers needed to be taught how to perform simple procedures such as deworming on their own. They argued that it was hard to respond to some farmers if they could not afford to pay for the staff's mileage charges. Farmers need to be provided with sample drugs and with demonstrations on how to administer the drugs. Farmers also wanted to be taught about pig housing. Some didn't know if pigs were supposed to be kept indoors or outdoors. In one of the farmer groups, a participant asked if tethering of pigs was okay and if farmers could tether pigs on the neck instead of the legs. The staff thought farmers needed to be taught how to build pig houses using locally available materials. Farmers interested in building pig houses would then be given housing plans by the extension officers.

Knowledge on sow productivity was discussed at length, specifically, farmers wanted to know how to breed sows and what determined how many piglets a sow produced. With regard to the pig breeds, they wanted to be taught how to identify the ones that grew faster and perhaps those that could thrive well under local conditions. Farmers further wanted to know the financial sources available to local smallholder pig farmers. The staff thought this was possible but said pig farmers needed to be encouraged to form small groups that could enable them to apply for loans and also have easy access to market outlets. These would help farmers market many pigs at once, which is possible if farmers came together and did group marketing. *"Such groups can apply for credits from the government offices"*, said one of the participants. They further observed that farmers needed to be taught how to make proper use of pig by-products at slaughter wastage that occurs at slaughter.

At the community level, farmers need to be reminded about the importance of co-existing together peacefully and how to reduce neighbour to neighbour conflicts brought about by poor pig husbandry practices. One staff member said, *"Train the society on how to live together, ie the importance of a neighbour"*. Concerning the existence of cultural beliefs about pig rearing, pig farmers needed to be taught about the potential effects this has on the industry. *"Farmers need to move from the existing cultural beliefs and take pig keeping positively"* was a comment from one staff member. The staff reported rural villages where pigs were slaughtered illegally at homes and pork was reportedly consumed without being inspected. Such practices were thought to be potential health risks that must be addressed during the training.

4.4 Discussion

Pig farming plays an important role in the livelihood of many families in rural villages of Western Kenya. A number of factors may explain the continued popularity of local pig farming in the districts of Western Kenya; first, keeping free range pigs requires minimum amount of inputs, and secondly the financial risk involved is small, will little time and money being invested (Dirk and Geert, 2004). There is a good local demand for pork and most of the pork produced is consumed locally. Focus group discussions were used to gather data on farmer perceptions; this was an initial part of a longitudinal study investigating pig farming in selected sub-locations of

Western Kenya. The use of focus groups is common in social and health research (Morgan, 1997; Kruger and Gericke, 2002). A key feature of these groups is to actively encourage group interaction among the participants (Krueger, 1994; Webb and Kevern, 2001). Pig farmers and the extension staff in the study had the opportunity and come together and discuss issues pertaining to pig farming in their villages (for the farmers) and divisions of work (extension staff).

The local sector faces many challenges that will need to be addressed before reasonable gains are realised. The staff thought that pig farmers needed to organize themselves into groups and combine efforts to secure marketing contracts for their pigs if they were to get better returns for their pigs. Improved marketing through formation of farmer groups, access to credit and equipping the farmers with basic knowledge on pig farming present opportunities to profitable pig production in the district. The belief that pigs are dirty and can eat anything is not true and needs to be discouraged. Pigs are indeed are very clean animals but can be messy if maintained in an unclean environment. Pigs can eat anything if left without food.

Women in this study appeared to take the lead in the management of the family pig; men are rarely at home and cannot therefore be entrusted with pig farming. This is not surprising since, according to Dirk and Geert (2004), pigs are traditionally owned by women. Women play crucial roles in the domestic and economic life of the society (Damisa and Yohanna, 2007), promoting pig farming in the villages is therefore equivalent to promoting the life of the whole society. Typically, a farmer will raise one pig at a time, the pig will be sold out after reaching a typical market age of 9 to 12 months, usually weighing 30 (±11.4) kg. Pig buyers, usually butchers, will walk from homestead to homestead sourcing for pigs to buy, a reason why farmers said pig marketing is better compared to other livestock species. Part of the money received is used to buy a piglet (usually at a cost of Ksh 777±174), this is in turn be raised to maturity. Interestingly, men were the ones who sold the family pig(s), and likely dictated on how the family used the money. Although this is perhaps in line with the cultural expectation that men are the decision makers in most rural families, it may signify the minimal involvement of women in family decision making. Involving women in decision making will not only act as an incentive for them to engage more in agriculture but will also contribute to overall goal of increased productivity and poverty alleviation. Pig investments in the study areas should therefore involve women considering the role they play in the society.

Although agricultural extension is a powerful tool with a rich potential to empower and support rural livelihoods (Anon, 1999; Rola *et al.*, 2002), the current extension system in Kenya is ineffective and not able to meet the needs of the local farmer (Muyanga and Jayne, 2006). Observations by the researchers indicated that extension networks in the study villages, particularly those addressing the needs of the pig farmer, were weak. Farmers did not know if pig veterinarians existed, this further point to poor farmer- extension worker interactions. The training topics highlighted by the different groups were an indication of knowledge gaps in pig management in these villages. Such topics will need to be considered in future planning and strengthening of extension networks, particularly in designing field training manuals.

The focus groups generated concepts about rural pig keeping that would not have been captured in a pre-structured questionnaire conducted as one-to-one interviews. The belief that a pig could be used as charm for protection against the evil people in society, the fate of the pigs that had been possessed by demons and the discrepancy about which spouse is responsible and allowed to sell the pig presents good examples for these. These beliefs might however have a negative effect on pig farming. If farmers view pigs as an escape from poverty, then they need to be educated on potential consequences of holding on to those views. One advantage of focus groups is that they allow for active discussions of taboo topics and encourage open discussions on embarrassing topics during participant interactions (Kitzinger, 1995; Stevens, 1996; Webb and Kevern, 2001).

It was important to compare the perceptions of the staff with those provided by the farmers, and to observe the similarities and differences in opinions between the two. There is the obvious expected difference in knowledge between the staff and the farmers. Issues that were mentioned across the farmers groups and repeated by the staff were considered crucial and gave an indication that participants had similar opinions about pig farming. The participating staff worked with the pig farmers in the delivery of various services, it was therefore not surprising that they highlighted points that had already been discussed by the farmers. The staff addressed issues on success and sustainability of pig farming in Western Kenya. For example, poor infrastructure is key to delivery of animal health services and necessary for disease surveillance. Its effects can be felt even more if there are limited veterinary service providers. Staff observed that informal slaughter of pigs was common in the interior villages. In such areas, the farmers do not only go against the regulations of consumption of meat without meat inspection but also may cause a health hazard for consumers.

Key areas where farmers had limited knowledge on pig farming were identified during the discussions, for example, when farmers suggested pigs should be left free arguing that tethering prevented pigs from getting enough exercise. The staff on the other hand advised that pigs left free were more likely to be poisoned by neighbours and were the potential causes of neighbourhood to neighbour conflicts. These conflicts were either as a result of the pig farmer's failure to tether her pig or using weak tethers allowing the pigs to break loose and destroy neighbour crops. Farmers will need to be adequately trained on better pig husbandry practices and on the control of potential public health risks, of importance is *Taenia solium*, an important zoonotic disease transmissible between pigs and humans.

Humans are the definitive host for *T. solium*, and harbour the adult tapeworm after consumption of infected under-cooked pork. Ingested cysticerci develop into adult tapeworms in the human gut. Pigs acquire the infection after ingesting *T. solium* eggs that are passed in human faeces. Allowing pigs on free-range pigs is a risk factor for the infection. Neurocysticercosis in humans occurs after one has consumed food contaminated with *Taenia* eggs, cysts develop in the brain tissue.

Considering the limitations of focus groups as a data collection tool (Stevens, 1996; Morgan, 1997), these findings cannot be generalised to the entire pig population in Kenya. The results may however provide some indication on farmers' perceptions about small-holder pig keeping in other areas of East Africa where pigs are raised under similar settings. Selection bias may have occurred in recruiting the participants because this was done through the help of village elders. They may have proposed names of participants who were close friends and may have excluded some successful pig farmers. Separate discussion fora for women and men may have provided more open discussion however, with the genders together the discrepancies between the role of men and women in pig rearing and selling were highlighted. Consultations between the moderator and village elders led to the conclusion that the focus groups would be more acceptable in the communities if both genders were combined.

4.5 Conclusions

Pig farming is an enterprise with rich potential that has not been fully exploited in the district. This study generated concepts about pig keeping in Western Kenya that would not have been captured in one-to-one interviews. Examples of this were the beliefs that pigs are used as a charm for protection against the evil people in society and the discrepancy about which spouse is responsible and allowed to sell the pig. Improved marketing, access to credit and equipping the farmers with basic knowledge on pig farming are key to profitable pig production in Western Kenya. The sector likely faces many challenges that will need to be addressed before reasonable gains are realised. The results obtained will facilitate stakeholders such as researchers, authorities and communities, to better address the needs of rural pig farmers in Western Kenya. Future research needs to directly address the issues raised by the farmers and staff to enable the smallholder pig sector to thrive in this region of Kenya. The focus groups likely strengthened the bond between the farmers, researchers and staff. It created an outlook that can now be used in further public engagement while ongoing research studies on appropriate feed, health and improvement of market access are being analysed.

CHAPTER FIVE

5.0 ESTIMATING PIG WEIGHT USING BODY MEASUREMENTS

5.1 Introduction

Weight predictions using body measurements have been used in different species of animals (Enevoldsen and Kristein, 1997; Thiruvenkadan, 2005). A strong correlation between pig weight and girth measurements has been reported (Groesbeck *et al.,* 2003). Backyard farmers in the Philippines used length and girth measurements to estimate weight of their pigs because they could not afford to buy weighing scales (Murillo and Valdez, 2004).

In Western Kenya, farmers keep indigenous (non-descript) pig breeds. These are usually confined by tethering or allowed to roam freely (Mutua *et al.*, 2006). Receiving fair prices for pigs sold has been a major challenge affecting small-holder pig farming in these settings. Pigs are mostly sold from homes to local pig traders, usually pork butcher men, who travel between farms on bicycles looking for pigs to buy. However, rural farmers have no system in place that they could use extensively and accurately to obtain the pigs weight. Obviously, the most accurate method of measuring a pig's weight is by weighing it using a scale. Pig farmers in the Western Kenya cannot afford scales. The only option left for them is guessing the weight of the pigs prior to selling. If farmers underestimate the weight of their pigs, they may settle for a price that is below market value and subsequently loose money. Prediction of pig's body weight using the girth and length measurements has not been studied in rural villages of Western Kenya or in other similar settings in East Africa. The purpose of this study was therefore to determine and validate models that farmers can use to predict live body weights of pigs using these body measurements.

5.2 Materials and Methods

5.2.1 The study locations

As described in section 3.2.

5.2.2 Selection of study farms

As described in 3.3, farms within each village were randomly selected proportional to the number of farms to include between 65 % and 75 % of all farms in each village. Only three farms withdrew after the first visit in Busia because these farmers did not want to participate in follow-up visits. All the randomly selected farms accepted to participate during the initial farm visits in Busia and Kakamega.

5.2.3 Data collection: Body weight and measurements

Most pigs present on the farms were weighed and body measurements were taken at each visit. Only nursing pigs that the farmer wished to sell and pregnant sows were exempted from being weighed or measured. The farmer was asked to estimate the age and the weight of the pig. Each pig was then restrained by a member of the research team. Small pigs were held in the restrainer's arms while larger pigs, those too large to hold, were restrained using a hog snare. A uniquely numbered ear tag was inserted in the pig's ear. A measuring tape was then used to determine the body length in centimetres from the midpoint between the ears to the point where the tail joined the body.

The girth was measured in centimetres around the pig's body, just behind the forelegs. For pigs weighing less than 10 kg, a small spring scale that measured up to a maximum of 15 kg was used. Larger pigs were weighed with a circular spring scale that weighed up to a maximum of 100 kg. Small pigs were placed in a basketball net with one end tied together and the net was then suspended from the scale. Larger pigs were suspended with a horse girth that was fitted just in front of the hind legs and behind the forelegs. The scale was suspended from a tree branch and the horse girth was attached to the bottom of the scale using a hook. During the follow-up visits, all pigs that were still on the farm were weighed and their length and girth measurements taken. New pigs were ear tagged, measured, weighed and included in the study. Details for all the pig measurements are illustrated in Figure 3 – 5.

Figure 3. Weighing young pigs (of ≤25 kg) using spring scales

Figure 4. Measuring body length (cm) of the pigs using a typical tape measure

Figure 5. Weighing heavier pigs (max 100kg) using large weighing scales supported on strong tree branches

5.2.4 Pig age categories

The pigs were put into three age categories representing young pigs before the typical market weight was achieved (up to 5 months old), those in the typical marketing age but prior to the typical breeding age (5.1 to less than 10 months old) and those of mature breeding age (10 months and above) (Figure 6).

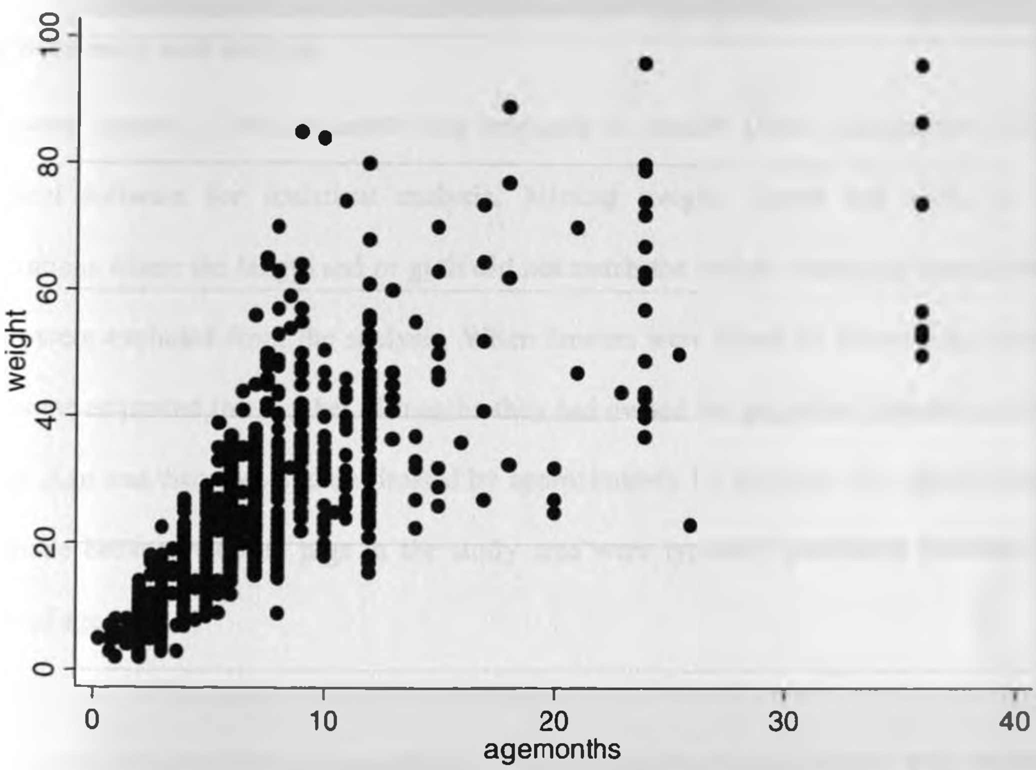


Figure 6: Distribution of pig weight (kg) and age (months) for the 840 pigs weighed and measured in 2006- 2008 in Busia and Kakamega Districts.

This graph was used in classifying pigs into three different age categories (pigs aged ≤5 months, 5.1- 9.9 months and ≥10 months).

In cases where the pig farmer could not estimate the age of the pig, length and girth measurements were used to put the pig in its appropriate age category. Based on the preliminary associations between age, length and weight, pigs with length of less than 56 cm or weight of less than 12 kg were placed in the young age category; pigs with a length of at least 80 cm or a weight of at least 30 kg were placed in the middle age category; while pigs with a length of 92 cm and a weight of at least 42 kg were placed in the breeding age category.

5.2.5 Data entry and analysis

Data were entered in MS Access® and exported to Stata® (Stata Corporation, TX, USA) statistical software for statistical analysis. Missing weight, length and girth, as well as observations where the length and or girth did not match the weight within the normal biological ranges were excluded from the analysis. When farmers were asked to estimate the age of their pigs, some estimated the number of months they had owned the pig rather than the actual age of the pig. Age was therefore underestimated by approximately 1.5 months. This general assumption was made because weaned pigs in the study area were typically purchased between 4 and 8 weeks of age.

Data were divided into two unique data sets. The first data set (model dataset) was composed of a random sample of 75 % of all pigs that were measured once and one randomly selected observation from each pig that was measured more than once. To select these, all pigs that were measured more than once were sorted by the pig identification and the date when the measurements were taken. Each pig measured more than once was thus ordered by the smallest to the largest weight. For pigs measured twice, the first observation of the first pig and the second observation of the second pig were included in the first data set. This systematic process was repeated until all pigs were represented once in the data set. Pigs weighed three times were also ordered by their smallest, middle and largest weights. The observations were selected in a systematic manner to include the largest, smallest and middle weights of the first three pigs and so forth until all pigs were represented once in the dataset. This is the dataset that was used to develop the mathematical weight equation.

The second data set (validation dataset), was composed of the remaining 25% of the observations for pigs weighed once and the remaining observation for pigs weighed twice (Dohoo *et al.*, 2003). One other observation was included for pigs measured three times. The smallest, middle and largest weights were selected for the first three pigs and this pattern was repeated. Each pig was only represented once in this dataset. This is the dataset that was used to validate the weight model that was developed using the first dataset. The third or remaining observation for the pigs weighed three times was neither used in the model nor in the validation data sets and was not used for this study.

Mixed linear model analyses with a random effect of village (stata command: *by sort age category: xtreg weight girth length, re i(village))* were performed by regressing weight on body length and heart girth and gender of the pig for each age category. Fixed effects were retained in the model if they were significantly associated with weight at $p<0.05$. The residuals for the final models for each dataset were examined to determine whether the assumptions of linear regression were met. The predicted weight for each pig in the three validation datasets was determined using the coefficients developed in the model datasets. These were compared to the actual weight measured on each pig and the differences were used for descriptive statistics. The actual weight was compared to the predicted weight using a paired t-test. Finally, the difference between the actual weight and the farmer's estimate of the pig's weight was calculated. The distribution of this calculated difference was compared to the distribution of the difference between the actual pig weight and predicted values from the models. The absolute values of the within-pig differences were compared using a paired t-test at a 95 % level of confidence.

5.3 Results

From a total of 628 pigs, 1,042 pig observations (i.e. records of weight and body measurements) were made but complete length, girth and weight measurements were available for 840 pig observations. Measurements from 202 pig observations were excluded from the analyses due to the following reasons: pregnant sows (n=130); too heavy for the scale (n=16); too difficult to restrain (n=14); or the data for the pig was eliminated during data cleaning (n=42). In total 449 pigs were weighed once, 146 were weighed twice and 33 were weighed thrice.

The numbers of pigs examined over time in Busia varied by the farm visit number, 281 observations were made in the initial visit, 226 in the second visit and 157 in the third visit. During the second visit to Busia district, three farmers chose not to participate in the study; three other farmers were further not interviewed because they no longer had pigs and they were not available to be interviewed. In the third visit, the number of farmers decreased by 29 because they didn't own pigs during the second visit and they still had not acquired pigs by the time this third visit was made.

A total of 88 farmers acquired new pigs in the course of this study: 78 new pigs were recorded during the second visit and 45 during the third farm visit. Most (57 / 88) of these farmers had acquired one pig, two farmers (2%) had acquired four pigs. Out of the 141 pigs that were lost to follow-up, 115 (82 %) had been sold, 20 (14 %) had died while the remaining 6 (4 %) had been stolen.

5.3.1 Age and pig weight

Out of the 840 pig observations, 43 % (363 / 840) were aged 5 months and below, 36 % (305 / 840) were at least 5 months but less than 10 months, and 21 % (172 / 840) were 10 months or older. Pig weight increased with increasing age. On average, these pigs weighed 12 kg (±6.1), 30 kg (±11.4), and 42 kg (±17.0), by age category respectively. Only 27 pig observations had missing age information because farmers owning them could not estimate the age of these pigs. Fifty one percent of the observations were on female pigs. The mean weight of young female pigs, up to 5 months of age was 13 kg (±6.4) versus males of the same age that weighed 12 kg (±5.8); those aged 5.1 to 9.9 months weighed 30 kg (±12.2) with males in the same age category weighing 29 kg (±10.6). The mean weight of adult female pigs was 44 kg (±17.9) whereas males of the same age weighed 35 kg (±12.6). The distribution of body weight in the whole dataset was skewed to the right because there were fewer pigs in the older age category (see Figure 6).

5.3.2 Pig weight and body measurements

Descriptive statistics for the body measurements in the three age categories are summarized in Table 1 and in Appendix 12.3 – 12.6. The 75th percentile of each measurement for the younger pigs overlapped with that of the next older age category. As shown in Table 1 below, the 75th percentile for length, girth and weight for the market-age pigs overlapped with the 25th percentile of measurements for the breeding age pigs.

Table 1. Distribution of length, girth and weight measurements across the three categories of age for pigs in Busia and Kakamega Districts

Age category	Length (cm)	Girth (cm)	Weight (kg)
Up to 5 months			
n=363			
Mean (±)	56 (±11)	51 (±9)	12 (±6)
25^{th} percentile	48	44.0	8
75^{th} percentile	64	57.0	16
5.1 to 9.9 months			
n=305			
Mean	80 (±11)	71 (±10)	30 (±11)
25^{th} percentile	73	64	22
75^{th} percentile	87	77	35
10 months and above			
n=172			
Mean	92 (±14)	81 (±12)	42 (±17)
25^{th} percentile	82	72	30
75^{th} percentile	102	87	50

5.3.3 Regression equations

The model datasets had a total of 509 pig observations; 229 for pigs up to 5 months old, 183 for the 5.1 to 9.9 month old pigs, and 97 for pigs at least 10 months old. The mean weight for pigs in the three age categories in this dataset was 11 (±5.6; 95% CI 10.6-12.1), 30 (±10.9; 95% CI 28.2-31.3), and 44 kg (±18.6; 95% CI 40.6-48.1) for pigs up to 5 months old, pigs between 5.1 and 9.9 months old and pigs at least 10 months old, respectively. Table 2 summarizes the different parameter estimates for the three different age categories of pigs studied.

Length and girth explained 88 % to 91 % of the total variation in weight for the three age categories. Including village as a random effect in the model accounted for 15 %, 2 % and 26 % of the random variation for young, market and breeding age pigs, respectively (Table 2). Sex of the pig did not significantly determine pig weight in any of the age categories ($p>0.05$). Model diagnostics using the residuals did not reveal any problem with the assumptions of the models.

Table 2. Length and heart girth regression coefficients for the 509 pig observations used in the regression analyses

Pig age category	β_0	β_1(Length)	β_2(Girth)	R^2 (%)	Rho (%)
$\leq$ 5 months	-16	0.18	0.36	91	15
5.1 - 9.9 months	-48	0.39	0.64	88	2
$\geq$ 10 months	-74	0.36	1.02	89	26

β_0- The mean pig weight when length and girth measurements take a value of 0 for each of the three age categories

β_1 and β2- The joint regression coefficients of body weight and body length and heart girth respectively

R^2 (%) - The percent variations in weight that is explained by the model

Rho (%)- Percentage representing random effects in the three age categories

The results of regression analysis showed that body weight of young pigs increased by 0.18 kg and 0.36 kg as length and girth increased by 1 cm, respectively. For 5.1 to 9.9 month old pigs, the weight increased by 0.39 kg and 0.64 kg as length and girth increased by 1 cm, respectively. For the breeding age pigs, weight increased by 0.36 kg and 1.02 kg as length and girth increased by 1 cm, respectively.

5.3.4 Model validation

The second dataset, which comprised of 298 observations, was used to validate the model developed in section 5.3.3. A total of 123 were from pigs aged up to 5 months, 109 were in the 5.1 to 9.9 month category while 66 were aged 10 months and above. The mean weight for pigs in the three age categories in the this dataset was 14 (±6.7; 95% CI 12.4 - 14.8), 30 (±11.9; 95% CI 26.7 - 31.2), and 39 kg (±14.4; 95% CI 35.7 - 42.7) for pigs up to 5 months old, pigs between 5.1 and 9.9 months old and pigs at least 10 months old, respectively.

The examination of the residuals indicated that the assumptions for the linear regression model were met. Predicted weight increased with increasing length and girth measurements. Descriptive statistics for the difference between the actual body weight and the predicted weight are summarized in Table 3. Similarly, the descriptive statistics for the difference between farmer's estimated pig weight and the actual weight are set out in Table 3 and in Appendix 12.7 (a and b). The weight predicted by the model was a closer approximation to the pig's actual weight than the farmer's estimate of the weight.

The models used in the prediction underestimated the actual weight of the pigs less than 10 months old by 0.08 – 1.1 kg, and overestimated the weight of pigs older than 10 months by 0.04 kg. Farmers underestimated the weight of pigs by on average 2.4 (7.0), 3.0 (24.0) and 83.4 (20.0) kg for young, market age and older pig categories, respectively (Table 3). The farmer's estimate of the weight was lower ($p<0.05$) than the observed actual weight of the pig for the three pig-age categories. There was no difference ($p>0.05$) between actual weight and the weight predicted by the model. The overall absolute difference between the farmer's estimate and the actual weight (4.18 kg) was significantly greater than the overall difference between the actual pig weight and the weight predicted by the model (0.41 kg) ($p<0.05$).

Table 3. Differences between actual pig weight and either predicted body weight or farmer's estimate of the pig's weight for 298 pigs

	Observed weight minus the weight predicted by the model			Observed weight minus the weight estimated by the farmer		
Parameter	≤ 5 months	5.1-9.9 months	≥ 10 months	≤ 5 months	5.1-9.9 months	≥ 10 months
Mean difference	0.08	1.06	-0.04	3.2	2.96	8.01
SD of the difference	2.43	3.25	4.84	7.9	24.8	23.4
Median difference	-0.24	1.30	-0.59	3.5	7.0	6.5
10^{th} percentile of the difference	-2.08	-2.90	-5.20	-5	-13	-15
25^{th} percentile of the difference	-1.30	-0.86	-2.70	0.5	-2	0
75^{th} percentile of the difference	0.66	2.63	2.60	7.0	14	21
90^{th} percentile of the difference	3.20	4.63	5.60	11	24	34
Mean (±SD) of the actual weight of the pigs	14 (7)	29 (11)	39 (14)	14 (14)	29 (11)	39(14)

5.3.5 Development of the pig weight estimation tool

Farmers had a difficult time using the initial weight prediction models (data not shown). This led to the development of the three weight estimation tools representing the three different pig age categories (Table 4 – 6). Demonstrations on how the tools would be used to estimate the live weight of the pigs were done during the farmer training sessions. As illustrated on Tables 4 below, length, distance from the middle of the ears to the point where the tail attaches the body, is presented on the x-axis while girth, taken behind the fore leg of the pig, is presented on the y-axis. As an example, a pig that is ≤ 5 months old, with a girth measurement of 68cm and a length measurement of 74 cm will weigh, on average 22 (±2.3) kg.

Table 4. Pig Weight estimation tool for Young Pigs (≤ 5) months old

		Girth (cm)																			
		32	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**	**52**	**54**	**56**	**58**	**60**	**62**	**64**	**66**	**68**	**70**
Length (cm)	**36**	2	3	3	4	5	6	6	7	8	8	9	10	11	11	12	13	14	14	15	16
	38	2	3	4	5	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16
	40	3	3	4	5	6	6	7	8	8	9	10	11	11	12	13	14	14	15	16	16
	42	3	4	5	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17
	44	3	4	5	6	6	7	8	8	9	10	11	11	12	13	14	14	15	16	16	17
	46	4	5	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	17
	48	4	5	6	6	7	8	8	9	10	11	11	12	13	14	14	15	16	16	17	18
	50	5	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	17	18
	52	5	6	6	7	8	8	9	10	11	11	12	13	14	14	15	16	16	17	18	19
	54	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19
	56	6	6	7	8	8	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19
	58	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20
	60	6	7	8	8	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20
	62	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20
	64	7	8	8	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21
	66	7	8	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20	21
	68	8	8	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	21
	70	8	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20	21	22
	72	8	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	21	22
	74	9	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20	21	***22**	23
	76	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	21	22	23
	78	10	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20	21	22	23	23
	80	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	21	22	23	24
	82	10	11	12	12	13	14	15	15	16	17	17	18	19	20	20	21	22	23	23	24
	84	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	21	22	23	24	24

***22** is the estimated weight for a pig aged ≤ 5 months old with a girth measurement of 68cm and a length measurement of 74cm

Table 5. Pig weight estimation tool for Market Pigs (5.1 – 9.9) months old

		Girth (cm)																
		52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	94
Length (cm)	58	8	9	10	12	13	14	16	17	18	19	21	22	23	25	26	27	28	35
	60	9	10	11	13	14	15	16	18	19	20	21	23	24	25	27	28	29	36
	62	9	11	12	13	15	16	17	18	20	21	22	24	25	26	27	29	30	36
	64	10	12	13	14	15	17	18	19	20	22	23	24	26	27	28	29	31	37
	66	11	12	14	15	16	17	19	20	21	23	24	25	26	28	29	30	32	38
	68	12	13	14	16	17	18	19	21	22	23	25	26	27	28	30	31	32	39
	70	13	14	15	16	18	19	20	22	23	24	25	27	28	29	31	32	33	39
	72	13	15	16	17	18	20	21	22	24	25	26	27	29	30	31	33	34	40
	74	14	15	17	18	19	21	22	23	24	26	27	28	30	31	32	33	35	41
	76	15	16	17	19	20	21	23	24	25	26	28	29	30	32	33	34	35	42
	78	16	17	18	20	21	22	23	25	26	27	29	30	31	32	34	35	36	43
	80	16	18	19	20	22	23	24	25	27	28	29	31	32	33	34	36	37	43
	82	17	19	20	21	22	24	25	26	28	29	30	31	33	34	35	36	38	44
	84	18	19	21	22	23	24	26	27	28	30	31	32	33	35	36	37	39	45
	86	19	20	21	23	24	25	27	28	29	30	32	33	34	35	37	38	39	46
	88	20	21	22	23	25	26	27	29	30	31	32	34	35	36	38	39	40	46
	90	20	22	23	24	26	27	28	29	31	32	33	34	36	37	38	40	41	47
	92	21	22	24	25	26	28	29	30	31	33	34	35	37	38	39	40	42	48
	94	22	23	25	26	27	28	30	31	32	33	35	36	37	39	40	41	42	49
	96	23	24	25	27	28	29	30	32	33	34	36	37	38	39	41	42	43	50
	98	24	25	26	27	29	30	31	32	34	35	36	38	39	40	41	43	44	50
	100	24	26	27	28	29	31	32	33	35	36	37	38	40	41	42	43	45	51
	102	25	26	28	29	30	31	33	34	35	37	38	39	40	42	43	44	46	52
	104	26	27	28	30	31	32	34	35	36	37	39	40	41	42	44	45	46	53
	106	27	28	29	30	32	33	34	36	37	38	39	41	42	43	45	46	47	54
	108	27	29	30	31	33	34	35	36	38	39	40	41	43	44	45	47	48	54
	110	28	29	31	32	33	35	36	37	38	40	41	42	44	45	46	47	49	55
	112	29	30	32	33	34	35	37	38	39	40	42	43	44	46	47	48	49	56

Table 6. Pig weight estimation tool for Adult Pigs (≥ 10) months old

ngth m)	Girth (cm)																		
	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
70	14	16	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51
72	15	17	19	21	23	25	27	29	31	34	36	38	40	42	44	46	48	50	52
74	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	49	51	53
76	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53
78	17	19	21	23	25	28	30	32	34	36	38	40	42	44	46	48	50	52	54
80	18	20	22	24	26	28	30	32	34	36	38	40	43	45	47	49	51	53	55
82	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55
84	19	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56
86	20	22	24	26	28	30	32	34	37	39	41	43	45	47	49	51	53	55	57
88	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	52	54	56	[illegible]
90	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	[illegible]
92	22	24	26	28	31	33	35	37	39	41	43	45	47	49	51	53	55	57	[illegible]
94	23	25	27	29	31	33	35	37	39	41	43	46	48	50	52	54	56	58	[illegible]
96	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	61
98	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61
100	25	27	29	31	33	35	37	40	42	44	46	48	50	52	54	56	58	60	62
102	26	28	30	32	34	36	38	40	42	44	46	48	50	52	55	57	59	61	63
104	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63
106	27	29	31	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64
108	28	30	32	34	36	38	40	42	44	46	49	51	53	55	57	59	61	63	65
110	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	64	66
112	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66
114	30	32	34	36	38	40	43	45	47	49	51	53	55	57	59	61	63	65	[illegible]
116	31	33	35	37	39	41	43	45	47	49	51	53	55	58	60	62	64	66	[illegible]
118	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	[illegible]
120	32	34	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69
122	33	35	37	39	41	43	45	47	49	52	54	56	58	60	62	64	66	68	70
124	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	67	69	71
126	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71
128	35	37	39	41	43	46	48	50	52	54	56	58	60	62	64	66	68	70	72
130	36	38	40	42	44	46	48	50	52	54	56	58	61	63	65	67	69	71	73
132	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73

5.4 Discussion

Pig farming in Western Kenya is very dynamic and pig numbers fluctuate over time and by season. The number of pigs decreased as farms were re-visited in the Busia District. Farmers had to own a pig during the first visit to be included in the study. However, some of these farmers no longer owned a pig during the follow-up visits. The majority of pigs were lost due to marketing of pigs. This may be an indicator of the potential pig keeping has on the livelihood of local people. Pigs in the study area were mostly sold when they were more than 5 months old but less than 10 months old. Hence there was a skewed distribution observed in biological measurements reflecting fewer adult pigs in the population. Some farmers reportedly asked their friends or family to house their pigs. This was due to a seasonal lack of food available for pig feeding. This strategy corresponds to contract farming used in commercial farming where one person owns a pig but hires another person to feed and care for the pig. These pigs were still included in the study because farmers would bring their pigs to their home farm for the follow-up farm visits.

Although the weight of a pig can be determined accurately by weighing it on a spring scale, farmers in Western Kenya cannot afford to buy scales. Commercial weight bands are special tape measures (Murillo and Valdez, 2004) used to estimate the weight of the pigs in North America. These weight bands are not expected to accurately estimate the weight of the pigs because they were developed for use with fast growing, improved European and North American breeds of pigs that are fed a commercially prepared, complete feed ad libitum and typically reach 110 kg body weight at 6 months of age. The pigs in this study were locally available African pigs typically fed a limited diet of household waste, weeds and seasonal fruits. Thus the farmer's only option was to guess the weight of the pig just by looking at it. These estimates are questionable and usually produce unreliable weight estimates as was found in this study. Pig farmers underestimated the weight of their pigs, and therefore likely sold the pigs for less than their true value. Thus the farmers may not have achieved the true economic potential for their pig enterprise. A similar finding of weight underestimation by farmers was reported in cattle by Machila *et al.* (2008).

Several studies have shown that the live body weight of an animal can be estimated using linear body measurements (Enevolden and Kristensen, 1997; Murillo and Valdez, 2004). Thiruvenkadan (2005) used height at withers, chest girth and length to determine body weight of goats in India. In the current study, length and girth were used to estimate the weight of pigs in rural Western Kenya. Pig weight increased with increasing length and girth. The increase in body length is due to skeletal growth while increases in girth are due to muscle development plus accumulation of adipose tissue.

Murillo and Valdez (2004) found that linear measurements such as body length and height are related to bone growth and are closely related to body weight of growing animals. In this study, parameters reflecting weight and length association changed by age category, therefore it was appropriate to use separate models for growing, market age and breeding age animals. Murillo and Valdez (2004) developed weight models for pigs in the Philippines that were up to 5 months of age. Their models could not be adopted for use on pigs in Western Kenya because the pigs and pig management were dissimilar from those in our study. They were three-way crosses from purebred Large White, Landrace, and Duroc breeds, kept in total confinement, fed ad libitum and they attained 49 kg at 5 months of age. The pigs in our study were indigenous breeds, kept outdoors, fed a limited diet and reached an average of 20 kg at 5 months of age. Murillo and Valdez (2004) developed several equations to estimate pig weight for both sexes and in different age categories. In our study sex was not significantly associated with the weight of pigs. Thus previous age-specific models developed elsewhere may not predict the weight of pigs in Africa because of the differences in the breeds of pigs and the husbandry methods in these previous studies.

Mixed model linear regression was used to determine the association between weight, length and girth after controlling for the random effect of village. Using village as a random variable in the mixed model showed that village explained 2 to 26 percent of the total variation in weight after accounting for the fixed effects of length and girth. Including both length and girth in the model explained a large proportion of the variation (88 % to 91 %) in body weight. This finding agrees with that of Murillo and Valdez (2004), who determined that length and girth were the best body measurements to use when predicting body weight.

The prediction equations developed in the current study are age-specific. For pigs in the market age category (5.1 to 9.9 months of age), the model will predict the weight within 1.3 kg for half of the pigs and within 4.6 kg for 90 % of the pigs. These were an improvement over the farmers' estimate of the weight of their pigs, which was within 7 kg for half of the pigs and within 13 kg for 90% of their pigs. The equations may, therefore, increase the opportunity to improve the farmers' bargaining power when they market their pigs. Farmers were taught on how to use these refined age-specific weight equations to predict pig weight. Estimating live weight of pigs is expected to assist these farmers in determining the appropriate market price for their pigs. Conducting market surveys to evaluate whether those farmers calculating the weight of their pigs during sale receive better prices will be important in monitoring the impact of the study at the farmer level. It will also be important to monitor the effect on the pig buyer if farmers use the pig weight estimations to negotiate the price of the pigs. A separate economic analysis is currently being done to evaluate the potential effects this tool has on pig farmer-pig trader bargaining and the effects on the pricing. An understanding of this is important in the sustainability of the pig business in the study area.

The purpose of the current study was not to develop a weight estimation model to be used by all pig farmers in the country; the interest was on small-holder farms keeping an average 1-2 local pigs. These results cannot therefore be generalised in the wider Kenyan pig population given the nature of the sampling methodology used, and differences in breed and management. However, the results can be extrapolated and applied in areas where pigs are managed under similar settings as in the target population. Pig weighing by farmers and butchers is of greater concern in rural areas; otherwise in the more intensive (commercial) systems, the weight of the pig is determined at the slaughter plant where the company weighs the dressed carcass and pays the farmer based on this weight.

5.5 Conclusion

From the results and the limitations of this study, it was concluded that:

1. Pig farmers visually underestimated the weight of their pigs, and therefore likely sold their pigs for less than their true value. Thus estimating live weight of pigs using body measurements is a suitable alternative to weighing pigs on scales.
2. A mixed joint prediction regression comprising of body length and heart girth accounted for 88 to 91 % of the total variation in actual body weight.
3. Use of an appropriate tape for linear measurements could be used reliably to gauge weights of pigs at farm-gate sales.

4. An economic analysis needs to be done to evaluate the effects of the weight estimation tool on the pig butcher business. An impact assessment (currently underway) will aid in determining the proportions of farmers using the tool and in identifying opportunities to further improve the estimation method.
5. A number of problems may occur when measuring pigs largely because pigs move around and have a tendency to lift their head. This obviously leads to variations in the body measurements thereby impacting on the accuracy of the predictions. It would therefore be advisable for farmers to at least take two measurements and get an average value for the length and girth measurement for every pig examined. Again, pigs should be measured when calm, preferably when confined or being fed. During the rainy season, and where possible, mud should be avoided to facilitate the measurements.

CHAPTER SIX

6.0 REPRODUCTIVE PERFORMANCE OF SOWS IN WESTERN KENYA

6.1 Introduction

On small-holder pig farms, farmers raise only a few pigs, using mostly family labour and local feedstuffs (More *et al.*, 1999). In Busia and Kakamega Districts, the animals are raised to supplement household income. The farmers, particularly the women, are able to pay for basic items such as food, medicine, school fees, and clothing, from the income generated from pig sales. There are few studies on the reproductive performance of sows in the small-holder farms (Lanada *et al.*, 1999). Wabacha *et al.* (2004) studied the reproductive performance of commercial sows in a peri-urban area of Nairobi, Kenya. However, these pigs were crossbreeds of Large White or Landrace, and were intensively managed. Therefore, these hybrid pigs are expected to differ from the indigenous pigs raised in small-holder farms in Western Kenya.

With the pig's short-breeding cycle, small-holder pig keeping is seen by many farmers as the only livestock equivalent of "cash crop", and which has the potential to improve rural livelihoods. To the author's knowledge, there exists no data on the reproductive performance of native sows in rural districts of Western Kenya. Factors such as poor feeding, poor management, and trouble with marketing of pigs have previously been described (Mutua *et al.*, 2007). However, the effects of these factors on sow performance have not been studied. This information is necessary considering the crucial role sows play in enhancing the local pig sector. It is assumed that several opportunities exist in the rural districts of Busia and Kakamega, and these could be used to improve sow performance and subsequent farm productivity. This chapter describes the reproductive performance of sows in the two study districts; data on the pig's productive performance and survival are also described.

6.2 Methodology

6.2.1 Study sites

Detailed description of the study sites and the sampling methodology used is as described in chapter 3. For the purposes of this study, a small-scale pig farmer was defined as a farmer owning on average 1 to 2 pigs. The pigs are of local breeds, non-descript, are mostly black in colour, sometimes black or brown with white patches and/or spots. A sow was defined as any female pig that had farrowed or had previously been mated or bred when the farm visit was made.

6.2.2 Data collection

Data used for this study was part of a longitudinal study investigating opportunities for improved pig farming in Busia and Kakamega districts. Briefly, a total of three farm visits were made to each of the farms, 3 - 6 months apart between June 2006 and February 2007 for Busia, and July 2007 and October 2008 for Kakamega. Face to face interviews were conducted using pre-designed questionnaires. During these interviews, data on the reproductive performance of breeding pigs were gathered from farmers currently owning a breeding pig and those who owned one within the previous year. Additional data on sow productivity was obtained for all sows that farrowed on one of these farms during the study period, even if the sow had been sold before the researcher visited the farm during the second and third farm visits. Details on the income from the sows sold, who bought the sows, and reasons for their sale were obtained from the farms that had sold the sows.

6.2.3 Analysis of the data

Data relating to pig breeding was extracted from the larger dataset and screened for potential data entry errors. These were based on biologically feasible parameters such as age of sow at first farrowing being greater than 8 months, litter size at greater than 1 and less than 20, and number of times a sow was bred in one estrus ranging from 1 to 4. All data from the three farm visits were combined and analyses were performed using Stata® (StataCorp LP, College Station, Texas). Sample means and standard deviations were reported for the normally distributed data such as age at farrowing and litter size, while 50th percentile was reported for the non-normal distributions such as the number of times a sow was bred. On the farms where several sows farrowed, an average value was calculated and that value was used in the subsequent analyses. Data across the two districts were compared, using student t-tests for the continuous variables such as litter size and piglet price, and Chi square tests for categorical variables such as the weaning age categories. Level of significance was set at 5 % for all analyses. Spearman's rho statistics were used to test if the correlation between the variables were significantly greater than zero.

The following putative risk factors were assessed for their association with the number of pigs weaned per litter: sows' age at first farrowing, ownership of boar, weaning age, pre-weaning mortality, number of times the sows were mated, and farrowing-to-breeding interval. Each variable was assessed for its correlation and association with the number of pigs weaned. This was done as a univariate analysis where *p* values of $\leq$0.10 were considered significant. Lowess smoother curves (available in Stata 9th edition) were used to evaluate linear relationships.

The sow production was described using the reproductive parameters: number of live born pigs per litter (NLB), number of pigs weaned per litter, pre-weaning piglet mortality (PWM), age at weaning (weeks), age of sow when bred (SBA), age of sow when she first farrowed, weaning-to-breeding interval (WBI) and farrowing-to-breeding interval (FBI). Inter-farrowing interval was not calculated since most of the farmers did not keep their sows for more than one farrowing. Additionally, farmers did not keep records on the ages at which they weaned their pigs, thus average weaning age was derived by asking farmers to state the age at which they sold the piglets after farrowing. This was likely equivalent to the weaning age, as the researcher found piglets were left to roam freely and, therefore, were allowed to suckle from the sow until they were sold. Weaning age typically fell into one of three categories; ≤4 weeks, >4 - 8 weeks and >8 weeks.

Mortality was calculated as the percent difference in the number of pigs born alive and the number of pigs that were weaned per litter. Farmers were asked to estimate farrowing-to-breeding interval (FBI) in months. The weaning-to-breeding interval was calculated by subtracting the FBI from the average weaning age for the study, which was 5 weeks. The age of the gilt when she was bred and when she conceived (Sow breeding age; SBA) was calculated as the difference between sow's age at her first farrowing minus the assumed gestation period (GP) of four months.

6.3 Results

6.3.1 A description of the sows on the farms

A total of 288 pig farms in Busia and Kakamega districts were visited three times in the course of the study. The total number of completed questionnaires resulting from the three farm visits was 748. Sixty-eight percent (510 / 748) of farmers owned sows at the time of the visit or within the previous one year of the visits. Farmers were asked to state the number of sows owned currently.

Interestingly, no sow was present in most of the study visits (55 %; 280 / 510). These farmers claimed to have had previously owned sows. Thirty-four percent of the farmers (34 %; 177 / 510) had owned one sow. The mean number of sows owned per farm per visit was 1.3 (±0.62) on farms where at least one sow was present when the farm visit was made. There was no difference (p=0.91) between the number of sows owned in Busia (1.3±0.05) and that in Kakamega (1.3±0.06). Approximately 58 % (74 / 124) and 54 % (89 / 164) of the total farms had at least one sow present in the course of the study period in Busia and Kakamega respectively. Below (Figure 7) is a recently farrowed sow that was observed on a study farm in Kakamega District.

Figure 7. A recently farrowed sow on a study farm in Kakamega District.

The sow (Figure 7) was in very poor body condition, an indication of inadequate feeding. Twelve percent (12 %; 63 / 510) of farmers said they fed their sows the same amounts of feed as they fed their growing pigs. The correct way to feed a pregnant sow is to match her feed allocation to her requirements for maintenance, body growth and growth of the developing foetus. If underfed during pregnancy, sows will be too thin at farrowing. Lactational feed intake is also critical for piglet performance and for the subsequent farrowing performance. Consuming inadequate quantities of carbohydrates and protein will lead the sow to a catabolic state, causing her to lose both body fat and muscle mass if she is producing milk. It is therefore important to include a training component of sow feeding when designing programmes to promote small-holder pig farming in rural villages of Western Kenya.

Farmers were asked to specify the sources for the sows they owned. They were asked to state if the sows had been bought as piglets, bought as growing pigs, bred on the farms, provided as gifts, or given freely by the government or non-governmental organizations. The most frequently reported source was female piglets purchased at weaning, which were subsequently reared for breeding (45 %; 229 / 510). Additional sources include sows acquired as growing pigs (6 %; 29 / 510), sows given as gifts (1 %; 6 / 510), sows given freely by non-governmental organizations (1%; 6/510), sows purchased as adults (2 %; 8 / 510), and sows bred on the farms and retained specifically for breeding (7%; 36 / 510). The average prices for sows purchased as piglets (≤ 4 weeks), as growing pigs (4 - 8 weeks), and as adults were Ksh 619±178, Ksh 813±457, and Ksh 3060±684 respectively. Piglets were cheaper in Busia (Ksh 509±57) than they were in Kakamega (Ksh 777±174) ($p < 0.05$). In the majority of the visits (87 %; 447 / 510), sows were fed equal amounts of feed as that provided to other pigs, particularly on the farms where the sow farmer had multiple pigs.

6.3.2 Sow breeding

Data on the age at which sows farrowed for the first time was gathered in 53 % (272 / 510) of the visits (Table 7). The majority of sows farrowed for the first time at 10 months of age (62 %; 167 / 272), while the others (17 %; 47 / 272) farrowed after the age of 12 months. The mean age at which these sows farrowed for the first time was 12.35 (±5.4) months, indicating that the mean age for sows at first breeding was 8.25 (±4.8) months. The mean number of litters for the sows owned by farmers in the current study was 1.04 ±0.21); over 50 % (56 %; 33 / 59) of the farmers sold their sows immediately after their first litter.

Overall, 107 farms had complete data on sows that were sold either during the research period or within the previous one year. Each reason that was provided by the farmer was classified as a "yes" or a "no," depending on whether the farmer had identified it as a reason for the sow sale or not. Reasons for sale included raising money to buy food (40 %; 43 /107), pay fees for the children's schooling (63 %; 67 / 107), pay medical bills (18 %; 19 /107), and cater for Christmas expenses (14 %; 14 / 107). Other reasons (63 %; 67 / 107) included raising money to build their own houses, buying grazing cattle, buying farm inputs, or cover costs related to feeding the pigs.

The mean price reported by the farmers was Ksh 2286±934, Ksh 2603 ±996 and Ksh 2830 ±1114 for the lowest, highest, and expected price for the sows sold, respectively. Most of the sows (91%; 74 / 81) were sold to pork butcher men while the rest (9 %; 7 / 81) were sold to neighbours for breeding.

The mean farrowing-to-breeding interval (FBI) was 2.7±1.7 months. There was no difference between the observed FBI in Busia (2.98±0.18) and that for Kakamega (2.62±0.19) ($p>0.05$). Although the majority (46 %; 69 /151) of farmers rebred their sows 1 to 2 months after weaning, a few (27 %; 42 / 151) had rebred the sows barely a month after weaning. The mean weaning to breeding interval was 1.9±1.6 months. Over half of the sow farmers (57 %; 105 / 185) set one day, typically from 08:00am to 18:00, for breeding. However, this duration could vary from a few hours to a complete day. The mean number of breeding days was 1.55±0.96 while the mean number of times boars were allowed to mate the sows was 2.18±1.08; with a mean of 1.85±0.15 for Busia and 1.79±0.13 for Kakamega. The mean number of breeding times was numerically higher on farms that owned a boar (2.17±1.30) than on farms that relied on borrowed boars (1.90 ±1.31). This difference was not significant ($p>0.05$). For farmers that did not have any boars, the sows were walked to neighbouring farms that owned breeding boars.

Only 15 % (19 / 124) and 17 % (29 / 164) of the farmers in Kakamega and Busia Districts, respectively, owned boars. Sources of breeding boars included: boars that were borrowed from a neighbour (77 %; 339 / 439), owned personally (14 %; 60 / 439), group-owned (0.4 %; 2 / 439) or boars that were free-roaming (2 %; 9 / 439). Artificial Insemination (AI) was not practised in the farms studied.

6.3.3 Weaning age of piglets

Three age categories at which pigs were weaned were generated: ≤4 weeks, >4 - 8 weeks and >8 weeks. More than half (56 %; 182 / 324) of the farmers weaned their pigs at ≤ 4 weeks, 36 % (117 / 324) at >4 – 8 weeks, while 8 % (25 / 324) weaned pigs when they were over 8 weeks of age. The mean age (in weeks) at which piglets were weaned was 3.3 (±0.9) for pigs weaned at the age of one month and below, 7.2 (±0.45) for those weaned at the age of two months, and 13 weeks for those that took at least two months to wean. Farmers in Kakamega were more likely to wean pigs at ≤4 weeks (68 %; 77 / 112) than farmers in Busia (49 %; 105 / 212) ($p<0.05$). Overall, pigs were weaned at the age of 5.4 ±3.3 weeks of age. Pigs were not all weaned on one day, but depended on when the piglets were sold. Some sow farmers retained a pig from the sow and these pigs were not forced to be weaned.

6.3.4 Number of pigs born alive and weaned

Overall, the mean number of piglets born alive in the two study sites was 7.85 ±2.55 with a mean of 7.65±2.55 in Busia and 8.12±2.62 in Kakamega ($p>0.05$). Only two farmers reported seeing stillborn pigs on their farms. The mean numbers of piglets weaned per sow per litter was 6.69 ±3.62 in Busia and 6.90 ±2.75 in Kakamega ($p>0.05$). Litter size and sow's age at first farrowing were correlated; a one month increase in age at first farrowing increased litter size by 0.06 of a piglet ($p<0.01$).

Piglet mortality was calculated as the difference of the average number of pigs born alive and the average number weaned divided by the total number of piglets born alive. Sixty four percent (64 %; 205 / 320) of the farms did not experience any case of piglet mortality. Mortality was 100 % in 3 % (12/320) of the farms. The mean percent mortality was 13 % (±26 %) when all the farms were included in the analyses. On farms where at least one pig died, the mean percent mortality was 38 % (±31 %). Farms were further categorized into low, medium and high mortality, based on the observed pre-weaning mortality of <10 %, 10 – 20 %, and > 20 %. Mean (%) mortality was 0.7 (±2.0), 15 (±3.2) and 60 (±27) for the low, medium and high mortality farms, respectively. The mean number of pigs born alive per litter was 8 (±2.5), 8.1 (±2.1) and 7.8 (±2.4) for farms with the low, medium, and high mortality rates, respectively ($p>0.05$) (Figure 8).

The mean number of pigs weaned per litter was 8 (±2.5), 7 (±1.7) and 3 (±2.5) for the low, medium and high mortality pig farms, respectively. The average number weaned was significantly higher in the low and medium mortality farms than on farms with high mortalities (>20 %; $p=0.000$).

Average litter size was positively correlated with the average number weaned per litter ($r^2=71\%$). Piglet mortality was not correlated with average litter size ($r^2=0.06$), but was inversely correlated with the average number weaned ($r^2= -0.49$). Figures 8 and 9 below summarize the observed relationships between the numbers of pigs weaned per litter, as the dependent variable, and litter size and percent piglet mortality, as the independent variables, in univariate analyses.

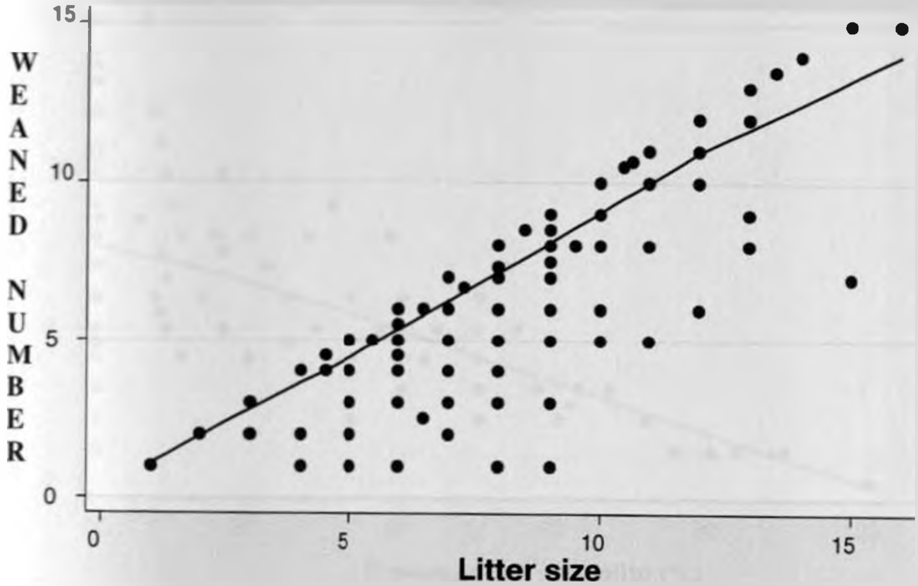


Figure 8. Using Lowess smoother plots to assess the relationship between number of pigs born alive (*litter size*) and the numbers of pigs weaned per litter (*Weaned Number*)

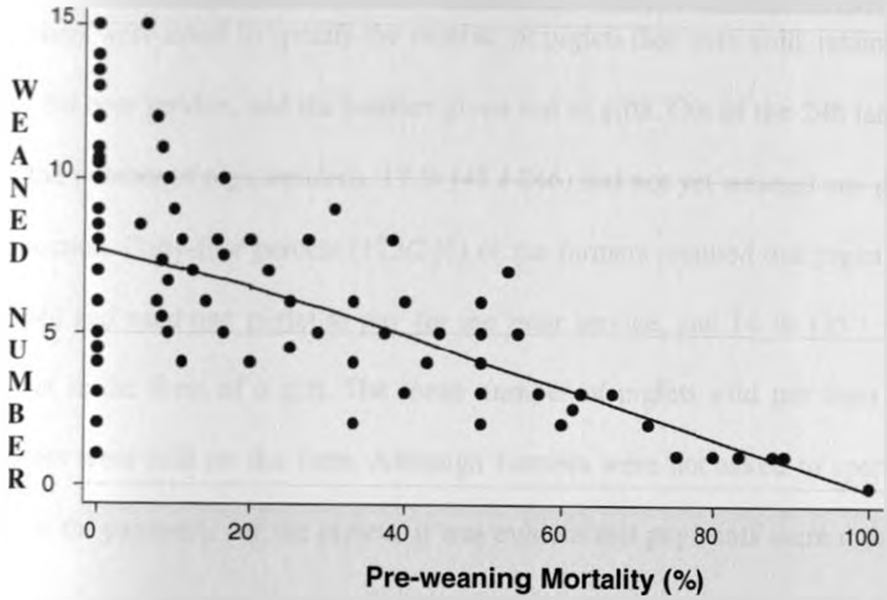


Figure 9. Using a Lowess smoother plot to assess the relationship between the percent of piglets that died prior to weaning (*Pre-weaning Mortality (%)*) and the numbers of pigs weaned per litter (*Weaned number*)

6.3.5 What happened to the weaned pigs

Farmers were asked to specify the number of piglets that were sold, retained for breeding, used to pay for boar service, and the number given out as gifts. Out of the 246 farms (with complete data on the number of pigs weaned), 17 % (41 / 246) had not yet weaned any piglet at the time of data collection. Forty-five percent (113/246) of the farmers retained one piglet for breeding, 17 % (41 / 246) had used one piglet to pay for the boar service, and 14 % (35 / 246) had given out one piglet in the form of a gift. The mean number of piglets sold per farm was 5.3±3.5 and these piglets were sold on the farm. Although farmers were not asked to specify the exact time they made the payments for the piglets, it was evident that payments were mostly made soon after the piglets were born, but the actual piglet transfer was done at a later date. Figure 10 shows piglets on a farm awaiting collection by farmers who had reserved them for rearing on their farms.

Figure 10. Piglets observed in one of the research farms in Butula Division in Busia District. Usually, a pig farmer will reserve one of the piglets on the farm where the sow has farrowed, and come back at a later date to transfer the piglet to her farm where she will raise it to an adult or growing pig.

6.3.6 Determinants of the number of piglets weaned

Results of the univariate analyses indicated that mortality was associated with the average number of pigs weaned per sow per litter ($p<0.05$). A 1% increase in mortality reduced the number of pigs weaned per litter by 0.08 of a piglet. None of the other explanatory variables (sow age, parity, weaning age, breeding method) considered in the study were associated with the number of pigs weaned per litter.

Table 7. Reproductive performance of sows reared by small-holder pig farmers in Busia and Kakamega Districts, Western Kenya

	Reproduction parameter						
Production parameter	Age sows at first farrowing (months)	Age of sows at first breeding (months)	Number of pig born alive per litter	Number of pigs weaned per litter	Farrow to breed interval (months)	Pre-weaning mortality (%)	Weaning age (weeks)
n[1]	272	272	320	320	151	320	324
Percentiles							
25th	10	6	6	5	1.5	0	4
50th	10	6	8	7	2	0	4
75th	12	8	10	9	4	14	8
Mean (SD)	12.35 (5.3)	8.25 (4.8)	7.85(2.5 5)	6.61 (3.25)	2.7 (1.7)	13 (26.0)	5.4 (3.3)

n[1] is the number of observations included in the analyses

6.4 Discussion

The small number of breeding pigs reported in the current study is comparable to what has been reported elsewhere within the tropics (Lanada *et al.,* 2005; Lemke *et al.*, 2005). Breeding pigs constitute a small but an essential part of small-holder pig populations in many low income countries. Previous studies have shown that the reproductive performance of pigs effectively determines the total population size, and influences the number of pigs available for sale (Lanada *et al.*, 2005). A large number of sow farmers had no sow present on the farm when they were visited, perhaps these farmers only kept sows at specific times of the year when they had feed available for the pigs. Pigs play an important role in the livelihood of many local farmers. Farmers could easily sell the pigs at any time of the year, irrespective of whether the pigs were piglets, growing pigs, or breeding pigs, to cater for immediate family needs.

Causes of sow disposal include: increased age at first farrowing, small litter size, and long weaning-to-breeding interval (Lemke *et al.*, 2006: Engblom *et al.,* 2007). Pig farmers in the current study disposed their sows after the sow's first litter. Most of the sows were sold to local pork butcher men for immediate slaughter and sale at the nearby market centres. This meant putting to an end to the productive life of the sows before they had reached their most productive parities (Aherne *et al.,* 1999). The breeding lives of many sows and boars ended prematurely when these were sold to generate cash for the family and / or to meet immediate household needs (Lanada *et al.*, 2005). This has serious implications in the sustainability of the pig sector in the villages. Sows play an important role in producing piglets, which are in turn sold to other farmers in the neighbourhood. Thus, the sows ensure a continuous supply of pigs in the villages and therefore sustain the sector. It is obviously more economical to keep a sow for multiple farrowings than to dispose it after the initial farrowing, since the farmer will incur more costs in purchasing a weaned female pig and managing it to maturity. If the farmer needs to sell the sow to meet an emergency need in the family, it is advisable to sell the sow to another pig farmer who will keep it and benefit from its reproductive potential.

Pigs in the study area were sourced locally within the villages. The main source of sows was piglets purchased at weaning and subsequently reared for breeding. Farmers also preferred keeping native pigs. It may have been difficult for these farmers to get pigs elsewhere outside the villages given the poor rural infrastructure, and perhaps fear of lack of market for new breeds of pigs. This is similar to the findings of Lemke *et al.* (2005), who observed that gilts in Vietnam were mostly acquired from other farmers within the villages. Although local sourcing of pigs in the villages, as observed in the current study, is important, it might be difficult for the farmers to carefully select ideal pigs for breeding since they are not the ones owning the sows and know little about the sow characteristics. Piglets were sold shortly after birth. Sometimes the farmers had to pay for the piglets right away, and other times markings were put on the reserved piglets in fear of the piglets being sold to another willing farmer. The high local demand for weaned pigs presents an opportunity for the local farmers to boost their income through increased piglet production. This advantage can only be realized if these farmers adopt better pig management practices, particularly by improving feeding and breeding, and management of the piglets after birth. These factors would play a positive role of increasing farm performance and productivity.

Breeding pigs were sourced locally, purchased as piglets from within the villages. More *et al.* (1999) reported that home raised pigs are more productive and thrive better than those purchased from commercial piggeries. Although the performance of local breeds is obviously lower than that of the exotic breeds (More *et al.*, 1999), Lemke *et al.* (2005) has warned against the use of exotic breeds in cross breeding. The exclusive or extensive use of exotic breeds as boar and sow lines could potentially cause a severe decrease in indigenous pig population (Lemke *et al.*, 2005). Pig farmers in the current study thought local pigs were easy to manage and their input requirements were low. Such low input-output smallholder herds provide an important source of household income for many needy families (More *et al.*, 2005). It is important to note that exotic pig breeds are rare in the study area, and if farmers were to start keeping these breeds, they will need to be prepared to incur additional costs associated with their management, particularly on the feeding.

The role of boars in sow herds cannot be underestimated; boar contact has been shown to induce ovarian activity and advance estrus by stimulating estrous behaviour in sows (Langendijk *et al.*, 2002). There were few farmers keeping breeding boars in the current study. A number of problems are known to discourage farmers from keeping breeding boars in the past, even in the commercial settings. The high cost associated with the raising boars is perhaps the biggest reason for the decrease in the number of boars owned in the current study. In the study by Wabacha *et al.* (2004), boar keeping was considered uneconomical in Central Kenya and farmers opted to use hired boars instead of raising own boars. In Nepal, farmers are reluctant to keep breeding boars because of the associated costs (Lanada *et al.*, 2005). The usual price for boar service is a weaned piglet, which is usually paid for every successful mating. This observation is similar to what Lanada *et al* (2005) reported in the Philippines. In North Vietnam, matings are charged in cash (Lemke *et al.*, 2005). Sows need to be mated a number of times to enhance productivity; the role of multiple matings has been described in the paper by Dewey *et al.* (1995) and Vickie *et al.* (1998).

The use of local boars and the purchase of piglets from the government farm are the only options for farmers to improve the genetic potential of their pigs. Typically, the sow is walked to the farm where the boar is residing for breeding. The sow stays with the boar for a few hours before she is walked back. Experiences in the field has shown that there are few numbers of boars, and the boar owners limit the duration of time the sow stays with the boar, citing problems of overuse and feeding. The owners of the boar do not wish to accept the responsibility for feeding the sow. The observed number of days and the number of times the boars mated the sows were low in the current study. The use of borrowed boars is risky and creates an opportunity for inbreeding. If boars are scarce and sow owners have to travel long distances to have their sows bred, disease transmission between villages may occur. This is quite possible particularly on farms where sows were reportedly mated by roaming boars. Similar problems have been reported elsewhere. For example, in Nepal, problems of inbreeding and lack of boars for service are common among the small-holder farms (Lanada *et al.*, 2005). Boars with genetic defects are known to affect fertility and should not be used for breeding. Inbreeding has negative effects on litter size (Toro *et al.*, 1988). Although none of the study farms practiced artificial insemination, studies by Dewey *et al.* (1995) showed that natural matings resulted in one more pig per litter than artificial insemination. In commercial herds, boars are often culled because of old age, reproductive or locomotor problems (D'Allaire and Drolet, 1999).

The decision on when to breed pigs for the first time is crucial and is influenced by the genetic background of the gilt and by various other environmental factors (Rozeboom *et al.*, 1996; Tummaruk *et al.*, 2001). The expected age at first breeding falls in the range of 6 - 9 months (Schukken *et al.*, 1994; Payne and Wilson, 1999; Tummaruk *et al.*, 2001). Age at first breeding observed in this study is higher than what was reported elsewhere (~12 months); this can be attributed to a number of management factors, including breeding patterns. It is important to state that a gilt needs to have reached a certain age, weight, and size to reach puberty, to be reproductively sound, and to increase productivity. So, if the gilt is well fed, it may reach puberty earlier than if the gilt's feed is restricted. Gilts will ovulate more at the 2nd and 3rd oestrus than at the 1st oestrus, and if breeding is delayed to the 2nd and 3rd oestrus, litter size and farrowing rate will increase. Age at first mating depends on age at puberty. Sterling *et al* (1998) showed that gilts that reached puberty early (mean age of 185 days) had a higher percentage of return to estrus within 10 days after weaning as primiparous sows, compared to gilts reaching puberty later (mean of 226 days). Previous studies have shown that an older age at first farrowing is unfavourable for sow longevity (Koketsu *et al.*, 1999; Yazdi *et al.*, 2000). Vickie *et al.* (1998) further showed increases in the average number of pigs weaned as average parity of the sows increased.

The average number of pigs born alive obtained in the current study (7.85) compares with what was reported for the indigenous breeds in Zimbabwe (7.9), South Africa (7.2), Nigeria (6.5) and Ghana (6.3) (Dzame *et al.*, 1995). In South East Asia, Kunavongkrit *et al.* (2001) reported a mean of 8.96 and 8.94 piglets born alive per litter for Landrace and Large White breeds, respectively. Litter size observed in the current study is slightly lower than what has been reported elsewhere in Kenya. The average number of piglets per litter in commercial farms in Kenya was reported as 9 (KARI, 1996). Wabacha *et al.* (2004) reported a median of 9 while the current study reported a median of 8. The low litter size could be attributed to the use of indigenous breeds, low levels of feed provided to the sows, inbreeding, and breeding the sows only for one day when they are in estrus. Litter size is reduced by feeding very low energy levels in early pregnancy and in sows with poor body condition (Tokach *et al*, 1999). Reductions in the live born piglets per litter results in reductions of the number of pigs weaned per sow per year, and therefore reduction in herd profitability (Friendship, 1987). The litter size increases with parity (D'Allaire and Drolet, 1999), plateaus around the 7th or 8th, and drops for the subsequent parities (Dewey *et al.*, 1994; Hughes, 1998). Litter size may be reduced by feeding low energy diets during early pregnancy, and if the sows were in poor body condition (Tokach *et al.*, 1999). Further, the average number of piglets born alive and the number weaned per litter increases with the increase in the gilts age at first farrowing (Cozler *et al.*, 1998). The role of genetics in influencing litter size has been described (Johnson *et al.*, 1999).

Piglet mortality is an important constraint in small-holder pig farms and approximates 20 % in many countries (More *et al.*, 2005). The pre-weaning mortality observed in the current study approximates what has been reported in commercial herds elsewhere in the world. The median mortality reported in this study is lower than that of 12 % observed by Wabacha *et al.* (2004), a difference that could be attributed to differences in weaning ages. Piglet mortality is a major cause of wastage in pig production and typically occurs in the first 4 weeks of life (Lanada *et al.*, 1999). The average number of weaned pigs per litter is an important component of sow productivity and is directly influenced by the average number born alive and pre-weaning mortality (Wilson *et al.*, 1986). The early weaning observed in the current study may have biased the estimation of the true mortality.

Details on the causes of observed mortalities were beyond the scope of this study. However, obvious signs of piglet and sow negligence, particularly with regard to feeding and housing, were observed (Mutua, 2008, *personal observation).* Enteritis and overlay are among the most common causes of piglet death (Aherne *et al.*, 1999). Sows in the current study were not vaccinated against *E. coli*, the most common cause of pre-weaning diarrhoea. Additional complaints by the farmers included piglets being born in the rain, getting chilled, and eventually dying. Pig management practices are reportedly low in tropical small-holder farms (Lanada *et al.*, 1999). One concept of importance is feeding sows sufficiently so enough milk could be produced to feed the piglets (Aherne *et al.*, 1999). Piglets require a place where they can stay warm and dry until they are at least 3 days old, when they can maintain their own body temperatures. Confining the breeding sows is one strategy that could be used to ensure piglet survival..

A wide variation in the length of the piglet suckling period has previously been reported (Kunavongkrit *et al.*, 2002). Early weaning has been shown to reduce litter sizes in subsequent farrowing (Wilson *et al.*, 1986), reduce growth rate and increase mortality of the pigs (Main *et al.*, 2004). Similarly, long lactations over 28 days are also associated with lower subsequent reproductive productivity. Usually, uterine involution takes place in 14 - 21 days post farrowing and so sows weaned before day 21 may experience a reduction in litter size in the subsequent farrowings (Friendship, 1987; Koketsu and Dial, 1996; Koketsu and Dial, 1998). Although a sow can do well reproductively if weaned at 3 weeks, piglets weaned at 3 weeks will require very expensive, highly specialized, easy-to-digest commercial feeds.

Another potential loss occurs when the farrowing to breeding interval is delayed. Breeding pigs close to 5 months after farrowing, as observed in some farms in the current study, is not economical and needs to be discouraged. Weaning-to-breeding interval reported here is shorter than that of the 3.1 months observed by Wabacha *et al.* (2004). This might be attributed to the obvious difference in farm management. Usually, a sow will come in heat 10 days after piglets have been weaned and it can be bred. Prolonged weaning-to-conception interval is a management factor related to feed inadequacies and short lactation lengths (Koketsu *et al.*, 1996; Cozier *et al.*, 1997). Long weaning-to-breeding intervals can impact overall sow performance in a herd. Wilson and Dewey (1993) and Dewey *et al* (1995) showed that litter size, farrowing rate, and pigs produced per mated female were decreased for sows mated 7 – 10 days post weaning, compared to sows mated ≤6 days post weaning. High weight loss in lactating sows prolongs the weaning-to-service intervals (Tentasuparuk *et al.*, 2001).

Farmers did not keep any records, particularly during the initial farm visit, and the research project relied on what farmers could remember. There was a potential for recall bias since not all the farmers could remember the reproductive details for the sows they previously owned (Dohoo *et al.*, 2003). Deen *et al.* (1995) argued that farmer's memory, opinion, personality, and the nature of the information being asked affected the accuracy of the information collected. Questionnaires for this study were developed in English but translated to the local Swahili and vernacular languages during the interviews. Further, enumerators used in data collection were taken through all the questions in the questionnaires before the farm visits began. However, on average, the results were within the expected limits and the fact that many of the farmers only had one farrowed sow minimizes the recall bias. Due to the problem of poor record keeping, and the low number of breeding pigs kept, it was not possible to estimate additional production parameters such as the inter-farrowing rate. Pre-weaning mortality was the only variable associated with the number of pigs weaned per litter in this study. There may be other important factors associated with the number of pigs weaned that are not known or that were perhaps not captured in the current study.

6.5 Conclusion

The reproductive performance of sows in rural Western Kenya is sub-optimal and does not reflect the sows' true potential. The wide variation in most of the parameters studied displays the unexploited richness of the sector that, if properly addressed, could directly contribute to rural poverty alleviation. Owners of sows need to be encouraged to keep sows for more than one litter to maximize the opportunity for reproduction performance. This will include increasing litter size, decreasing pre-weaning mortality, and increasing the number weaned per litter. This study provided baseline data on sow productivity which was previously lacking. Breeding boars are important in sustaining the pig sector in the villages. Further research is required to fully understand the reproductive performance of sows in rural Western Kenya.

This study has provided good data on sow productivity that was currently lacking in small-holder settings of East Africa. Although such data are rare, they are obviously needed to improve pig production and to generally consider the sustainability of the pig sector in rural development.

CHAPTER SEVEN

7.0 FEEDING PIGS IN WESTERN KENYA

7.1 Introduction

Although pigs play an important role in the livelihood of many rural households, the contribution of important farm management factors to the sector has not been evaluated. This is essential to ensure steady household incomes. Small-scale farmers in Western Kenya keep indigenous pig breeds, an average 2 per household, which are mostly tethered or allowed to scavenge on their own for food (Githigia *et al.*, 2005; Mutua *et al.*, 2007). These are adapted to harsh conditions and poor quality feed (Nwakpu and Onu, 2007). Considering that indigenous pig breeds will not disappear given their good qualities and farmer preferences, research efforts should focus on their management, particularly the feeding and feed supply, and explore opportunities to improve the small-scale pig production sector. Improved feed resources and feeding practices are key interventions that could increase the competitiveness of the rural pig farmer given current soaring food prices.

A pig's diet should contain adequate amounts of carbohydrates, proteins, minerals and vitamins (Goodman, 1994; Aherne *et al.*, 1999); incomplete diets may potentially limit nutrient balance and subsequently affect the pig's growth potential (Paul *et al.*, 2007). Growth rate in pigs is driven by feed intake (Aherne *et al.*, 1999; Magowan *et al.*, 2007). Commercial feeds are available in the rural districts of Western Kenya, they are thought to be too expensive and unaffordable to many of the rural farmers. Pigs, as mono-gastric animals, can only utilize grass in a very limited way. Considering the high costs of feed ingredients, in this study, it was important to explore alternative feedstuffs for local breeds. These feedstuffs need to be offered in a manner that balances the pig's nutrient requirement.

Understanding the availability and utilization of local feedstuffs was essential before farmers are empowered to provide more balanced feed to their pigs. This chapter is the first phase of this whole process by providing baseline data on the utilization of local feedstuffs for pig. The chapter explores the available local feedstuffs for pigs and describes the pig's growth performance in the two rural districts of Western Kenya.

7.2 Methodology

7.2.1 General sampling methodology

Data used in this study were part of a multidisciplinary study investigating rural pig farming in Busia and Kakamega districts. A detailed description of the sampling methodology used is described in Chapter Three. For the purposes of this study, pig feed was defined as any feedstuff provided to the pig by the farmer, and these included both the local and commercial feed types.

7.2.2 Data collection

Three farm visits were made to each study farm 3 - 6 months apart, for the period of June, 2006 to October 2008. Face to face interviews were performed using questionnaires. Data collected included the types of feeds used, the amounts fed, and the feeding frequencies followed. Live weight of pigs, in kilogram, was taken using spring scales. All pigs found on the farms during each visit were weighed unless it was either a pregnant sow or a nursing pig less than 6 weeks of age. Data on the feed costs was gathered at the local market centres. Sample feeds were purchased and subsequently weighed to obtain the actual weight of the feed in kilogram. A description of the conversion method used is illustrated in Appendix 12.8. The food was weighed on a digital (Salter RTM) scale.

7.3.3 Data analyses

Data processing and analyses were performed using Stata® (StataCorp LP, College Station, Texas). Average daily weight gain (ADG) was measured in grams per day. ADG was calculated as the difference between the weights of the pigs in two visits divided by the total number of days between the visits. This was calculated for individual pigs that were weighed during both the 1st and 2nd visit, and / or the 1st and 3rd visit, and/or the 2nd and 3rd farm visits.

Average Daily Gain

= (final weight – initial weight) ÷ (days between initial and final visit)

Daily feed amounts were calculated by multiplying the amounts given per meal with the feeding frequencies stated by the farmer. Since farmers provided different feed units for the same feed type, efforts were made to convert the various units to a standard measurable unit for analyses. A G*orogoro* is a tin can that is commonly used in the market place to sell 2kg of maize. However, the same size of tin is traditionally used to sell many food products in the market place. A 'Gorogoro' of each of the following foods were purchased and weighed for use in this study; blood, beans, whole maize, ground maize, posho mill waste, and rumen contents (Appendix 12.8).

Feeds were classified into three categories; proteins, vitamins, and carbohydrates. The classification was based on literature information on the nutritive composition of the feeds (Goodman, 1994; FAO, 1997; NRC, 1999; Aherne *et al*., 1999). Local feed names were used for weeds, brewers waste *(machicha)*, and fish (*omena*). *Machicha* is fermented maize residue that is typically prepared through fermentation of maize in water, and the sour composition is dried in the sun on iron sheets. Then millet and water are added, and the liquid is squeezed out using a sac. The expelled liquid is what is used locally as brew, while the residue is what is utilized as local pig feed. Omena (*Rastrineobola argentea),* is a fresh water, fast swimming, small fish found in open waters. It is dried prior to sale. A "posho mill" is the grist mill mostly used to grind maize, cassava, and millet. The "posho mill" waste is the collection of dust that is on the floor of the mill after the grain has been ground.

Sample means and standard deviations were calculated for the average daily gain data. Frequency tables were generated for different feeds provided. A chi-square test was used to determine associations among farm visit and specific feeds given to the pigs. A p value of ≤ 0.05 was considered significant. Individual feed frequency calculations were based on the total number of completed questions from the three farms visits. Calculations for the fruit types were based on the total number of feed observations since farmers had an option of providing more than one fruit type at each visit. The overall proportion of farms reporting each feed type was based on the number of farms that had fed a particular feed type at least once in the course of the study period. Analysis of variance (ANOVA) was used to compare the mean daily weight gains among the three pig-age categories. Pigs were classified based on their ages; young ($\leq$5 months), market (5.1-9.9) months, and breeding ($\geq$10 months) pigs, average daily gain (ADG) was described for each category. The percentile values for the ADG were subsequently used to put pigs in to three different ADG categories, namely, low ADG ($\leq 25^{th}$ percentile), medium ($\leq 50^{th}$ percentile), and high ($\leq 75^{th}$ percentile).

7.4 Results

7.4.1 Pig feeding in Busia District

A total of 164 farms were visited in Busia and these represented a total of 455 completed farmer questionnaires during the 1^{st}, 2^{nd} and 3^{rd} farm visit. Typically, a pig farmer tethered her pig under a tree, usually within the farm compound. Then the pig was expected to feed on grass most of the day with little supplementation.

The feeds that were fed to pigs at least once during the study period included: Omena (98 %; 161 / 164); cassava (79 %; 130 / 164), *machicha* (66 %; 109 / 164), sweet potato vines (96 %; 158 / 164), *ugali* (99.4 %; 163 / 164), waste from *posho* mill (68 %; 113 / 164), and fruit (89 %; 147 / 164).

There were a total of 4902 observations on the different pig feeds in this study of which 12 % (631 / 4902) were for farms that fed fruit to their pigs. The fruits fed included bananas (9 %; 58 / 631), jack fruit (1 %; 5 / 631), guava (1 %; 8 / 631), avocado (24 %; 150 / 631), mango (11 %; 69 / 631), oranges (0.01 %; 1 / 631), and paw paw (23 %; 147 / 631). Farmers used the fruits that were spoilt or over-ripe and obviously not appetizing to humans. Peels from bananas, avocados and mangoes were also fed to the pigs. There were 4 observations of farmers tethering pigs under fruit trees. This strategy was used as it enabled the pigs to easily pick spoilt fruits falling on the ground. The frequency of farms feeding fruits to pigs was more in the months of October and November (26 %) than in the months of June and July (7 %) or February (12 %) ($p<0.05$).

The frequency of different pig feeds was based on the 455 completed farmer questionnaires resulting from the 1^{st}, 2^{nd} and 3^{rd} farm visits. The most frequently fed foodstuff was cooked ground maize (*Ugali*) (88 %; 404 / 455), kitchen left overs (83 %; 382 / 455), dried fish (*omena*) (78 %; 357 / 455), sweet potatoes (75 %; 343 / 455), sweet potato vines (65 %; 298 / 455), cassava (57 %; 262 / 455), brewers waste, which was the mash left from home made beer (locally termed as *machicha*) (48 %; 220 / 455), maize (33 %; 151 / 455) and innards from fish (30 %; 138 / 455). Figure 11 and Appendix 12.9 below gives a summary of the feeds that were commonly given to pigs in the District.

Vegetables, including kale, spoilt tomatoes and other local vegetables, were rarely fed to pigs (9 %; 43 / 455). Green leaves (1 %; 5 / 455) fed to pigs included: bananas leaves, cassava leaves, yam leaves, and leaves from local weeds. Weeds included black jack (*Cannabis indica*) and wandering Jew (*Setcreasea purpurea*). The weeds were uprooted from the farms and directly fed to pigs. Sugarcane stems were chopped into pieces and fed to pigs in 25 % (117 / 455) of the farm visits.

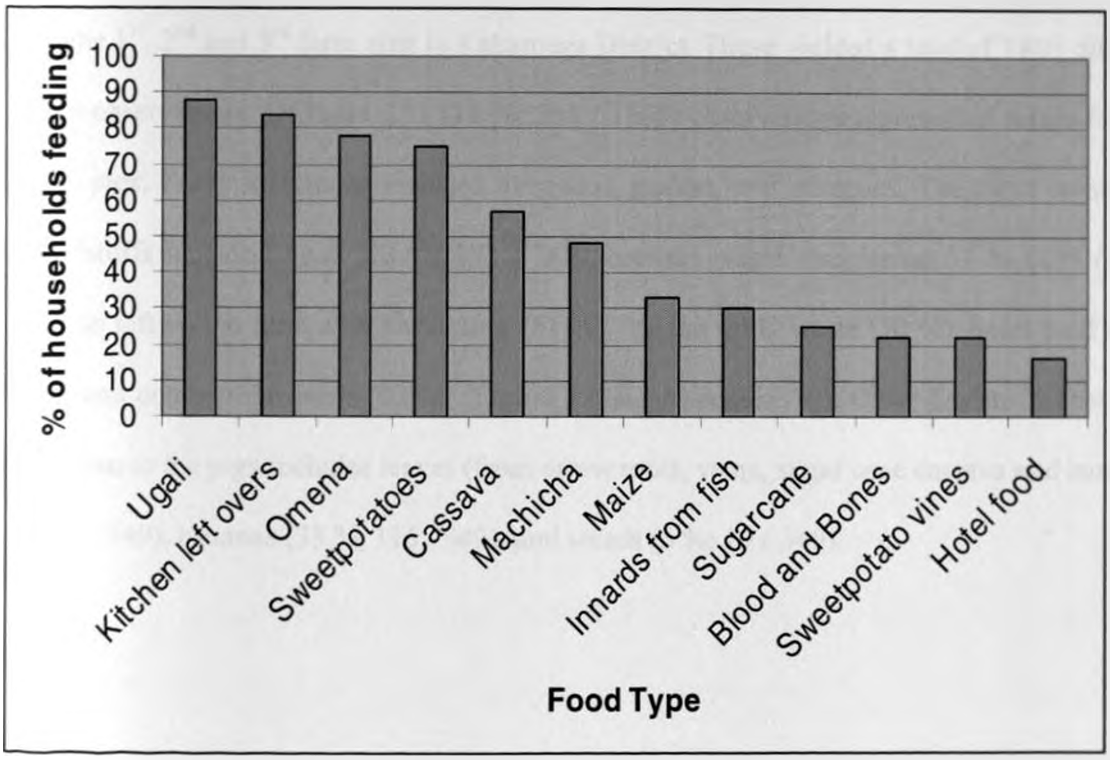


Figure 11. Types of pig feeds given to pigs in rural villages of Busia District, Western Kenya

Ugali: cooked grounded maize flour mixed with water

Machicha: local name for the brewers mash

Omena: small-dried fish

Blood and Bones: Includes fresh blood from the slaughter slabs

Examples of food waste materials that was utilized as pig feeds included kitchen food remains (84 %; 382 / 455) and remains from celebrations such as village parties and funerals (2 %; 8 / 455). Kitchen food remains were mixed with unclean kitchen water before being fed to the pigs. Commercial feeds were rarely fed to pigs (7 %; 34 / 455).

7.4.2 Pig feeding in Kakamega District

A total of 124 farms were visited and these represented 349 completed farmer questionnaires during the 1st, 2nd and 3rd farm visit in Kakamega District. These yielded a total of 1801 different pig feed observations. Of these, 251 (14 %; 251 / 1801) observations represented farms feeding fruits to pigs. Fruits mentioned included avocados, guavas, and mangoes. The most commonly fed foodstuffs included *ugali* (72 %; 252 / 349), brewers waste *(machicha)* 57 % (199 / 349), vegetation left on the farm after harvesting (51 %), "posho mill" waste (50 %), hotel food waste (40 %), and commercial feeds (40 %) (Figure 12 and Appendix 10). Other feedstuffs that were rarely given to the pigs included leaves (from arrow roots, yams, sugar cane cassava and bananas) (3 %; 10 / 349), bananas (33 %; 116 / 349), and weeds (5 %; 19 / 349).

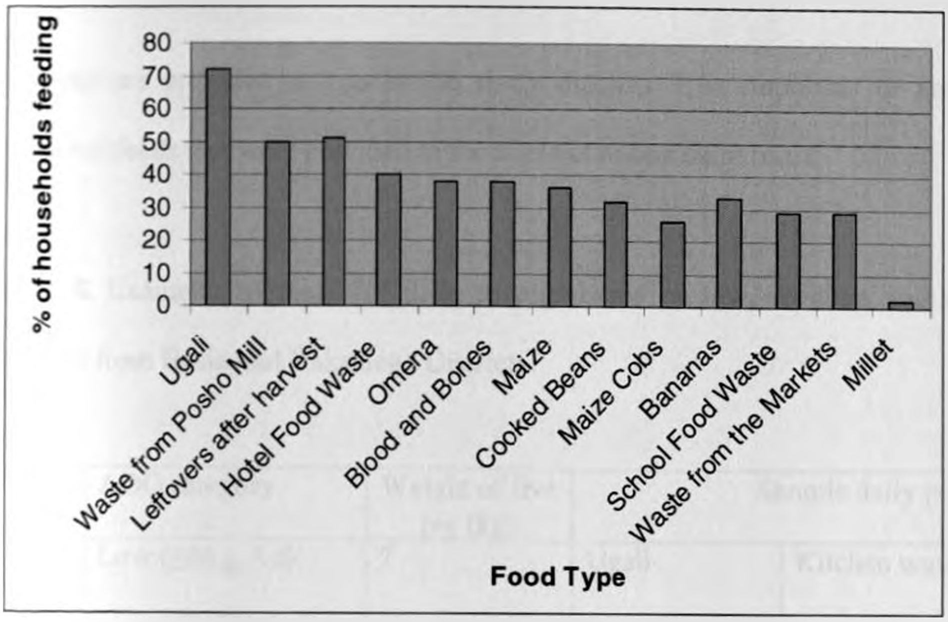


Figure 12. Types of feeds given to pigs in rural villages of Kakamega District, Western Kenya

Ugali: cooked grounded maize flour mixed with water

Omena: small-dried fish

Blood and Bones: Includes fresh blood from the slaughter slabs

7.4.3 Description of the feeds nutrient composition

The following feeds were available in the study area and could be considered as potential sources of protein for the pigs: *omena*, blood, rumen contents, sweet potato vines, and beans. The feeds that could provide energy or carbohydrates included *ugali*, sweet potato tubers, bananas, waste from *posho* mill, and cassava. Food waste (from hotel and kitchen) was considered to be balanced in nutrient composition. Feeding pigs with vegetables and fruit provided them with vitamins. The minerals required by the pig were most likely found in the following local foods: green vegetables, bones, fish (innards and *omena*), food wastes, soil (rooting), and wastes from the markets. As illustrated on the Pig Farmer Training manual (Appendix 12.11), pigs were fed different combinations of feed each day. Table 8 below highlights of some of the feed combinations provided to pigs in the study districts. It is important to note that there were additional feeds that were provided to the pigs but not on daily basis.

Table 8. Examples of feeds fed daily to pigs based on low, medium and high ADG by age category from Busia and Kakamega Districts

Pig Age Category	ADG category	Weight of live pig (kg)	Sample daily pig feeds		
≤ 5 months	Low (≤66 g / d)	7	Ugali	Kitchen waste	Grass
	Median (≤91 g / d)	15	*Ugali*	Kitchen Waste	Grass
	High (≤125 g / d)	25	*Ugali*	Kitchen Waste	Sweet potato vines
5.1 – <10 months	Low (≤81 g / d)	16	Kitchen Waste	Ugali	Grass
	Median (≤125 g / d)	25	Kitchen Waste	Ugali	Grass
	High (≤158 g / d)	32	Omena	Posho mill Waste	Kitchen Waste
≥ 10 months	Low (≤51 g / d)	47	*Ugali*	Kitchen Waste	*Posho* Mill Waste
	Median(≤83 g / d)	58	*Ugali*	*Posho Mill waste*	*Omena*
	High (≤150 g / d)	83	Sweet potato vines	Kitchen food	*Ugali*

Ugali: cooked grounded maize flour mixed with water

Omena: small-dried fish

Blood and Bones: Includes fresh blood from the slaughter slabs

7.4.4 Feeding frequencies

Frequency of feeding pigs was compared between farmers in Busia and Kakamega Districts (Figure 13). The percentage of farmers feeding their pigs three times a day was more (33 %; 38 / 116) in Kakamega than in Busia (9 %; 13 / 144) ($p<0.05$).

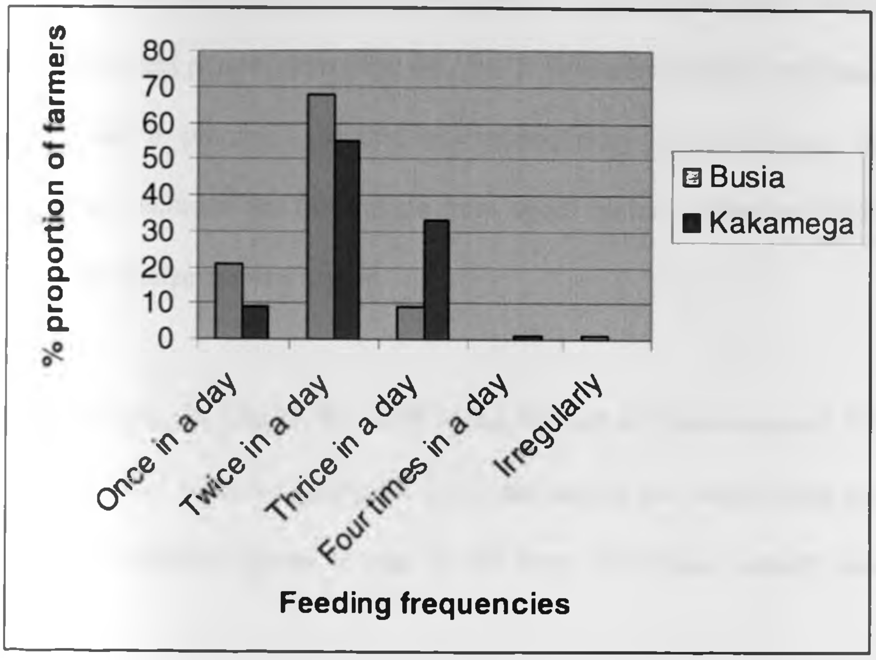


Figure 13. Summary description of the daily pig feeding frequencies in Busia and Kakamega Districts

feed types offered to pigs three times a day, u*gali* was the most frequent feed pigs (58 %; 21 / 36). Dried cassava (4 %; 10 / 223), kitchen left overs (21 %; 47 / %; 105 / 223) and waste from *posho mill* (10 %; 23 / 223) were among the feeds to pigs two times each day. Feeds occasionally fed to pigs included fruits (46 %; ize (9%; 84 / 942), remains left on the farms after the harvest season (6 %; 61 / potato vines (4%; 40 / 942). Waste from *posho* mill was given to pigs either raw prepare u*gali* that was subsequently fed to the pigs. Additional sources for the uded the flour made from spoilt maize, particularly that which remained on the ze harvest season.

ent (30 %; 46 / 124) of the farmers in Kakamega and 40 % (65 / 164) of those in water to their pigs. This was mainly the waste water resulting from kitchen use. cally given to pigs at the time of feeding, usually mixed with the feed being

whether farmers were satisfied with what their pigs ate was asked during the in Busia. Forty four percent (44 %; 73 / 164) of the farmers were not satisfied igs ate. Commercial feeds (44 %; 32 / 73) and *omena* (19 %; 14 / 73) were some farmers desired to feed to the pigs.

performance

in (ADG) analyses was based on 164, 24 and 81 pigs weighed at visits 1 and 2, 1 3, respectively. Overall, pigs in the study area gained 109 (±69) g / day; the ght gain for pigs in Busia District (110±70) did not differ significantly from that nega District (105±75) ($p>0.05$). The median, 25th percentile and 75th percentile for ADG were 104 g / d, 66 g / d, and 150 g / d respectively. The ADG for pigs up to 5 months of age, 5.1 to <10 months of age, and ≥10 months of age averaged 93 (±52) g, 125 (±58) g, and 101 (±80) g, respectively. These means were significantly different from each other (p=0.000).

7.4.6 Daily feeding amounts and estimated costs

Pig farmers reported different feed units when asked to specify the feed amounts given to pigs in single meal. To reduce the potential bias that could arise from this, the number of feed observations included in the estimation of the daily feeding amounts was limited to feeds that were recorded as "*Gorogoro*" and those recorded as "Kg" (Table 9) and Appendix 12.8. These included *machicha*, rumen contents, waste from *posho* mill, slaughter blood, *omena*, maize, cassava, and beans. Overall, the mean amounts of beans given to pigs were 0.77 (±0.44) kg / day, costing the farmer Ksh 50.20 (±28.80). A mean of 1.25 (±1.0) kg of cassava was fed to pigs, costing the farmer an average of Ksh 36.2 (±29.00) per kilogram. The median daily amount and cost of *omena* was 0.5 kg and Ksh 85.00, respectively. The median daily amount and cost of maize was 0.5 kg and Ksh 27.50 respectively (Table 9). The mean and median daily amount of ugali was 1 and 1.65 (±1.57) Kg, respectively.

Table 9. Daily amounts of feed offered to pigs and their estimated costs in Busia and Kakamega Districts, Western Kenya

Food Type		Amount (KG) Given			Cost / KG		
	N	25th percentile	Median	75th percentile	25th percentile	Median	75th percentile
Machicha[a]	169	0.2	0.9	2	8.5	34.3	74
Rumen Contents[b]	3	0.25	0.5	2	13.04	26.1	104.3
Waste from *Posho* mill[c]	175	1	2	2.5	6.8	13.4	17.2
Slaughter Blood (fresh)	23	0.25	0.5	1	20.12	40.3	80.5
Omena[d]	235	0.25	0.5	1	42.5	85	170
Beans	63	0.5	1	1	32.3	64.6	64.6
Cassava	151	0.5	1	2	14.4	28.9	57.7
Maize	25	0.25	0.5	1	13.70	27.50	55.0

[a] *Machicha*, local name for brewers mash

[b] at times, the rumen contents were mixed with fresh blood from the slaughter slabs

[c] Waste from *Posho* Mill, a waste from maize milling

[d] *Omena*, *Rastrineobola argentea*, a small dried fish

7.5 Discussion

Pig feeding constitutes the greatest cost in raising pigs, and is a potential threat to the pig's performance and the sector's sustainability. Small-scale farmers in the current study could not afford to buy commercial feeds for their pigs and so used local feedstuff as an alternative for pig feeding. Pigs are able to thrive well on a variety of different feedstuffs, many of which result from surplus production or are wastes not nutritious or non-appetizing to humans (Goodman, 1994). In addition to pig farming, these farmers also grow food crops. This presents an opportunity for them to utilize the surplus produce or by-products from the crops grown, that would otherwise go to waste if not fed to animals. Feeding pigs different feed rations is advisable since no single feedstuff can meet all the nutrient demands of the pig.

Pigs in this study were allowed to eat grass with farmers opting to supplement the local diets with alternative feeds. It is worth noting that grass does not provide the pigs with adequate nutrients for optimal performance. Pigs are less able to use crude fibre when compared to ruminants (Kumaseran *et al.*, 2007). The high fibre content in grass therefore reduces the efficiency of energy utilization and subsequently impairs the utilization of other essential nutrients (Edward, 2003). However, foliage does provide the pig with some important nutrients and enables them to fully express their natural foraging and rooting behaviours (Goodman, 1994; Lekule and Kyvsgaard, 2003, Magdalena, 2008). Fruit such as mangoes, avocados, and paw paws are common in the study area and could be utilized in pig feeding. The challenge is determining how to establish a sustainable feeding strategy that would utilize these fruits as feeds, taking into consideration the observed seasonality effects. Alternatively, several combinations of feedstuffs could be determined to utilize fruit when it is in season. Farmers could then choose to use a different feed ration when the fruits are not available. Although there are very few fruits that are grown specifically for livestock feeding, culled fruits, vegetables and by-products from processing industries are often available to farmers and could be used as pig feeds (Gohl, 1981).

Subsistence agriculture is common in the study area and farmers combine pig keeping with crop farming. This offers an opportunity for these farmers to utilize the surplus produce or by-products from the crops grown as possible pig feeds. These would otherwise go to waste if not fed to animals. According to Preston (2006), growing alternative feedstuffs for animals needs to be given priority considering the role animals play in sustaining the lives of the poor rural communities. The use of such alternative feedstuffs ought to be documented and further analysis should be done to quantify their nutrient composition (Kumaseran *et al.*, 2007). The use of feeds such as cereal residues, cassava, and potatoes has previously been cited as main sources of feedstuffs for pigs (Lekule and Kvsgaard, 2003). Pigs fed inadequate and unbalanced diets will have low weight gains. Small pigs are worth less to the pig buyer, resulting in low profits for the pig farmer. Low profits in pig enterprise results from low quality feeds coupled with insufficient knowledge on the nutritional requirements of pig (Adesehinwa *et al.*, 2003).

Although farmers in this study told of neighbours using salt to poison free range pigs in the villages, it is important to note that salt poisoning can be caused by feeding salty feeds or restricting pig's access to water. The relationship between salt and water intake has previously been described (Taylor, 1995; Cahn and Line, 2005). High salt levels reduce feed intake and increase the incidence of piglet scours (Laura, 2009). Pigs must consume sufficient amounts of water on daily basis for them to balance the amount of water lost (NRS, 1998). According to Cahn and Line (2005) and Taylor (1995), growing pigs require 2-3kg of water for every kg of dry feed. Lactating sows may require up to 40 kg of water per day to account for water required for milk production and the sow's maintenance. Sows need to be provided with adequate amounts of water for maximum milk production (Goodman, 1994; Laura, 2009).

Many of the farmers fed their pigs only one or two times per day and most feeds offered to pigs often included energy feeds such as *ugali*, *posho* mill waste, and cassava. Also, most farmers fed their sows the same amounts of feed as what was provided to the growing pigs. Energy, amino acids, minerals, vitamins, and water are needed by pigs for maintenance, growth, reproduction and lactation (NRS, 1998). Pigs will not show their full potential if fed limited amounts of amino acids (Aherne *et al*, 1999). It is possible that the sows in the study were underfed, a practice that is likely to reduce the sow's reproductive productivity (Laura, 2009). Sows should be fed as much as they will consume during lactation in order to maximise the growth of the nursing piglet and to ensure the sow does not lose too much weight during lactation. Sows that become catabolic during lactation will have a delayed weaning to breeding interval and will also have lower reproductive performance in subsequent litters. Pregnant sows should gain 18 – 34 kg between breeding to farrowing (Goodman, 1994).

Blood, beans, sweet potato leaves and vines, brewers waste, *omena,* and rumen contents are some of the potential protein rich diets identified in the current study. Blood meal contains up to 80 % protein and is a good source of easily digestible protein for pigs (Mcglone and Pond, 2003). Small dry fish (*omena*) and its dust (fish scraps), is the most common, readily available source of protein for pigs in the study area. As suggested by Goodman (1994) and by Mcglone and Pond (2003), fish and fish scraps are appetizing to pigs and can provide 50 - 70 % of protein. Rural farmers have a tendency to feed only a handful of the *omena* or the *omena* dust to pigs a few times in a week; such a feeding regime is likely not adequate to meet the daily protein demand of the pig. Brewers yeast stimulates growth when used as an additive for pigs fed a diet of cassava (Akinfala and Tewe, 2004). The use of rumen content, the waste obtained from the rumen of slaughtered cattle, as an animal feed has previously been described. Its usefulness as an animal feed depends on the feed composition provided to the animal before slaughter. Rumen content has a relatively good crude protein composition (Salina-Chavira *et al.*, 2007; Adeniji, 2008).

Energy sources identified in this study included maize, sweet potato roots, sugarcane, green vegetables, *posho* mill waste (ground maize, cassava, millet and bean waste), waste from the market, spoilt fruit, kitchen waste, selected garbage feeding, and cassava.

Maize (*Zea mays*) is widely grown in Western Kenya and most of the farmers interviewed used the flour in preparing pig meal *(ugali)*. Maize is a major supplier of energy in mono-gastrics (Salami and Odunsi, 2003). Maize however has low protein content and in particular results in a diet that is deficient in lysine, the first limiting amino acid in pigs (Mcglone and Pond, 2003). There is need for supplementation of maize-rich diets (Cahn and Line, 2005). The high cost of maize owing to decreased production and increased demand limits its use as pig feed. The use of rotten or mouldy maize as feed ingredient (as observed in the current study) can impact on the health and growth potential of the pig (Lemke *et al.*, 2006). Fusarium, a mycotoxin producing zearalenone, is known to create estrogenic-like effects in animals when consumed. The toxin causes a number of manifestations, including cystic ovaries, swollen vulvas, delayed reproductive maturity, and prolapsed rectum or vagina (Ketterer *et al.*, 1982; Laura, 2009). Another toxin is vomitoxin, known to reduce the pig's immune status. Although farmers may mix the good and the bad grains, diluting contaminated maize only reduces the magnitude of exposure to the toxin but does not eliminate the associated negative health effects (Osweiler, 1999).

Although cassava is a common staple food in Busia District, its potential use as an animal feed in the country has not been fully exploited (Karuri *et al.*, 2001). The worlds' demand for cereals for human food continues to increase, thus finding alternative feed sources such as this (cassava) is essential. The presence of cyanogenetic glycosides in cassava limits the use of the crop both as human food and animal feeds. Peeling, chopping, drying and ensiling the cassava may reduce the toxin levels (Tewe and Lyayi, 1989). Both the leaves and the roots could be utilized on the farm for livestock feeding; cassava roots are used as sources of energy for ruminants while the leaves serve as good sources of protein (Wanapat, 2008). The leaves have a great potential for feeding animals (Phuc, 2000). Mixing the cassava with other feeds could provide a better amino acid balance than when fed singly.

Sweet potato roots and vines were frequently fed to pigs in this study. This is an agreement with a previous report that approximated 43% of the world's annual sweet potato production to be used in animal feeding (CIP, 1998). The challenge has been limited knowledge about the use of the crop, particularly among the poor small-holder farmers (Peters, 2008). According to a recent report by Peters (2008), the vines, if used appropriately, can provide a year-round source of feed for pigs in pig farming communities. The sweet potato root is rich in carbohydrates, vitamins and minerals, and thus offers a good opportunity for the pigs to convert the crop into a high-value commodity – pork. There is also an additional opportunity for pig farmers to establish a local sustainable human-sweet potato-pig system. One of the ways in which sweet potatoes could be promoted as a potential pig feed is through planting dual purpose varieties (Peters, 2008). This provides an opportunity for the pig farmer to utilize the tuber as family food, and use the vines and leaves as potential feeds for the pigs. The roots do not store well, ensiling the roots offer an alternative solution to the constraint (CIRAD, 2009).

The role of pigs in recycling and adding value to food by-products, and human food wastes has previously been described (Westendorf *et al.*, 1998: Payne and Wilson, 1999; Austin and Lee. 2000). Feeding food leftovers to pigs is common in the study areas; such wastes are perhaps more balanced since they contain many of the essential nutrients required for a healthy balanced diet. The nutritive value of food wastes is adequate with respect to protein and energy. However, such foods are low in dry matter content and have been shown to affect growth in younger animals (FAO, 1997; Westendorf and Myer, 1998). Food leftovers should therefore be supplemented with feeds such as maize if desirable weight gains are to be achieved (Westendorf and Myer, 1998). More *et al.* (1999) observed that pigs fed household waste are more often supplemented with limited amounts of other available feed stuffs such as carbohydrates, leafy green materials, and protein. Institutional food waste is superior to household or kitchen waste (Goodman, 1994). Hotel waste is able to replace 15 % of the concentrate mixture in swine feeds (Gupta *et al.*, 2005).

Feeding of kitchen leftovers, wastes from celebrations, hotel wastes, school wastes, and waste from the market centres, as observed in the current study, pose great risks: first, due to disease transmission to pigs and second, the public health risks to people. Although food waste ought to be cooked before being fed to pigs (Westendorf and Myer, 1998), none of the pig farmers in the current study reportedly cooked waste food before feeding it to the pigs. Important zoonotic diseases and diseases causing morbidity and mortality in pigs could arise from feeding uncooked swill. These include African swine fever, foot and mouth disease, salmonellosis, campylobacteriosis, trichinellosis and toxoplasmosis (Cahn and Line, 2005). The feeding of market and garbage waste to pigs could expose them to infections such as salmonellosis and trichinellosis. As stated by Corwin and Stewart (1999), the eating habits of non-confined pigs expose them to infections with disease agents and parasites such as *Clostridiun botulinum* and *Taenia solium*.

The average growth performance of 110 g /day (±69) and the median of 108 g /d observed in the current study are below what has previously been reported even among other local pig populations. A growth rate of 130 g / day was reported in local Nigerian pigs by Essien and Fetuga (1989). A median growth rate of 130 g / day was reported on commercial farms exotic breeds in Kenya (Wabacha *et al.*, 2004). Growth rate in pigs is largely driven by feed intake with variations in growth rate reflecting variations in the feed amounts consumed, as well as piglet and sow factors (Lemke *et al.*, 2006; Magowan *et al.*, 2007). Feeding inadequacies, use of unbalanced feed rations resulting in nutrient deficiencies, and differences in breeds could contribute to the observed low weight gains. Genetic factors can contribute to variable weight gains even on pigs of the same litter (Lemke *et al.*, 2006; Magowan *et al.*, 2007). Pigs on free range expend more energy in their scavenging activities and exhibit poorer growth rates than pigs that are confined (Rienke, 2004).

Fruit such as mangoes, avocados, and paw paws are available and could be utilized in pig feeding as potential sources of vitamins. The challenge is determining how to establish a sustainable feeding strategy that would utilize these as feeds, taking into consideration the observed seasonality variations. Alternatively, several combinations of feedstuffs could be determined to utilize the fruits when they are in season. Feed shortages are known to occur on months before successive harvest periods (Lemke *et al.*, 2006). Farmers could then choose to use a different feed ration when fruits are not available. There are very few fruits that are grown specifically for livestock feeding. However, culled fruits and vegetables, and by-products from processing industries are often available to farmers and could be used as pig feeds (Gohl, 1981).

Studies on how the available feedstuffs can be combined to achieve a cheap and balanced pig ration are needed. Analyses (such as proximate analyses) need to be performed to correctly identify deficient nutrients in these feeds prior to balancing. Cassava and sweet potato roots are available and could supplement the use of maize as an energy source in pig diets. Sugarcane farming and local brewing are also common. Their by-products (molasses and brewers waste, respectively) could be incorporated in pig diets as additional energy sources. Slaughter waste by-products including blood, rumen contents, fish innards, *omena* dust, and processing wastes are potential protein sources. The numerous fruits could be utilized to offer source of vitamins, particularly when the fruits are in season. There is also a need to explore additional sources of proteins, energy, and vitamins that could be available but are not used by the farmers. We conclude that pig farming in Western Kenya is an economically viable enterprise with a rich potential to alleviate poverty and increase the pig farmer's competitiveness. There is a need to address the challenge of pig feeding in an effort to improve rural pig farming.

Conclusions

Smallholder pig farming is as an economically viable enterprise with the potential to increase pig farmer's competitiveness particularly now when the price of basic commodities continue to rise. The current study has highlighted a number of local feeds that are available and can be utilized by farmers to feed their pigs and reduce feeding costs. The study has further highlighted the various feed types that could be utilized in formulation of cheap and balanced feed rations. The variations in the feed types offered across farms and villages indicated differences in feed availability and perhaps knowledge on their utilizations. Maize, cassava and sweet potato roots are the main local energy sources for pigs. Sugarcane farming and local brewing are common, and their by-products molasses and brewers waste, respectively, could be incorporated as additional energy sources. Slaughter waste such as blood, rumen contents, fish innards, *omena* dust, and processing wastes constitute important potential sources of proteins. The numerous fruits could be utilized to offer source of vitamins, particularly when the fruits are in season. There is a need to develop new processing technologies that would yield longer shelf-life feeds and provide a long-term solution to the feed problem experienced by the farmers. The study recommends additional research to be conducted on nutrient composition and dietary requirements for the pigs. Further, there is need for extension works to be carried out to promote the use of the feeds.

CHAPTER EIGHT

8.0 DESCRIPTIVE ANALYSIS OF RURAL PIG MANAGEMENT

8.1 Introduction

Pigs are important sources of livelihood for many households in low-income countries; these animals are raised for sale, household consumption, festivals and for financial security (More *et al* 1999; Lee *et al.* 2005). The poor performance of pigs in the tropics can be attributed to inadequate feeding, poor genetics, high mortality rates, poor housing and low reproductive performance (Wilkins and Martinez, 1983; More *et al.*, 1999; Lekule and Kyvsgaard, 2003; Wabacha *et al.*, 2004). These pigs are fed protein deficient diets and are often supplied with inadequate amounts of water (More *et al.*, 1999).

Intensive pig farming is known to be stagnant in many developing countries (Lekule and Kyvsgaard, 2003). In Kenya, indigenous pig population constitutes a small percentage (13 %) of the overall pig population. These pigs are mainly raised under the traditional methods of tethering and free ranging, and are quite popular in the Western districts of the country (Mutua *et al.*, 2007; Githigia *et al.*, 2005). Farms own an average 1 to 2 pigs. There is little documented information regarding the management of these pigs in the country; data on the sectors constraints and potential opportunities for improvement is also lacking. Such information is necessary to gain a better understanding of the sector and in the design of strategies for improvements in the pig industry. Indigenous breeds are hardy and are known to possess a number of advantages, among them their good adaptation to prevailing conditions (Rodriguez and Preston, 1997; Lekule and Kyvsgaard, 2003; Nwakpu and Onu, 2007). These traits present an opportunity that can be utilised in promoting rural pig farming in rural communities.

This chapter provides baseline data on rural small-holder pig production, it discusses cysticercosis caused by *Taenia solium* and explores opportunities for improved pig farming in the two districts of Western Kenya.

8.2 Methodology

8.2.1 Sampling methodology

As described in section 2.1 - 2.2

8.2.2 Data collection

Three farm visits were made to each of the study farms 3-6 months apart for the period of June 2006 to October 2008. Data on pig management practices were gathered during face to face interviews with the farmers. Information about livestock ownership, farming challenge and routine practices was obtained during these interviews. Farmers were asked to classify 'challenges' as either 0 (not a challenge), 5 (a moderate challenge) and 10 (greatest challenge). Their knowledge on *T. solium* cycle, transmissions and risks was ascertained during the farm visits. Questions asked included data on if the farmer had heard of the infection in humans and in pigs and the perceived sources of the parasite. Pigs were examined for the lingual cysts of *C. cellulosae* using a combination of both visual and tongue palpation methods.

8.2.3 Data analyses

Data from multiple farm visits were merged and analysed using Stata® (StataCorp LP, College Station, Texas). Not all questions were repeatedly asked during each interview and some farmers failed to answer some questions. Therefore, the denominator used for the analyses changed by question. During the interview, farmers were whether they considered specific factors a moderate or great challenge to their pig keeping enterprise or not a challenge at all. These categorical variables were recoded as a dichotomous variable by merging the moderate and great challenge into one response. Farmers were also asked about the percentages of time during the day that pigs were housed, or tethered or left to range freely. These responses were regrouped into two categories, namely; percentages of 0 %- 50 % or >50 %- 100 %. Frequency tables were to describe the categorical variables in the dataset. Data among the three farm visits and between the districts were compared; using chi square statistics for the categorical variables where a *p* value of <0.05 was considered significant. Continuous variables such as the cost of a weaned pig were compared using a Student's t-test. The pig-level prevalence for cysticercosis was calculated from the total number of pigs testing positive divided by the total number examined during the study period. Farm-level prevalence was also determined. A farm was considered positive if any one pig examined on the farm was found to be positive.

8.3 Results

8.3.1 Respondents details

Female respondents formed the majority (69 %; 512 / 735) of those interviewed in the study. The proportion of female farmers did not differ between Kakamega (71 %; 201 / 281) and Busia (68 %; 311 / 454). Three age categories were generated for the respondents, <30 years, 30-50 years, and >50 years. The age distribution of the responding farmers was 34 % (250 / 735) <30 years, 44 % (327 / 735) 30 – 50 years and 23 % (158/ 735) >50 years. Education levels of the respondents are set out in Figure 14. Although many (56 %; 397 / 735) of the respondents had attained some primary education, they may (90 %; 361 / 397) or may not (10 %; 36 / 397) have completed this education. The percentage that had attained primary education was higher in Kakamega (60 %; 171 / 281) than in Busia (49 %; 226 / 454) (P=0.003). Informal education was more common in Busia (26 %; 122 / 454) than in Kakamega (18 %; 50 / 281) (p=0.005). Only 2 % (12 / 735) of the respondents had completed college education (Figure 14).

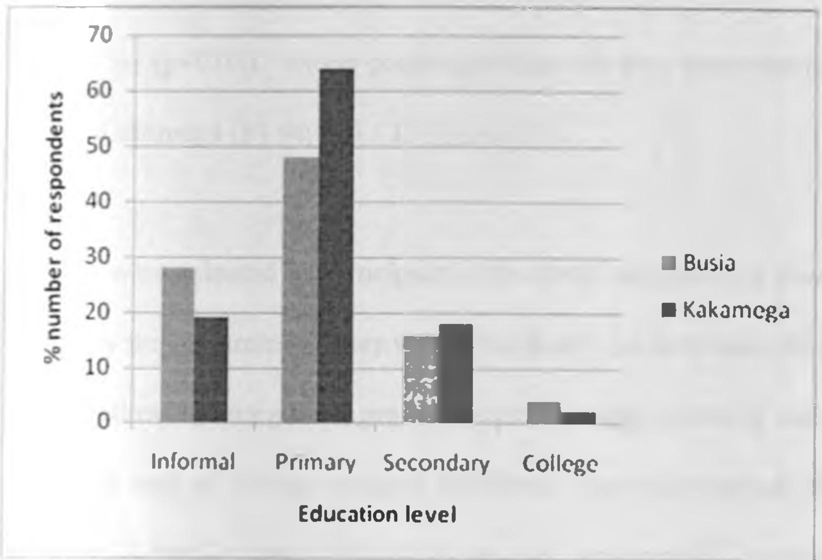


Figure 14. Education levels for the farmers interviewed in Busia and Kakamega Districts, Western Kenya.

Informal: never gone to school

Primary: Includes those that had attended primary schools, completed and not completed

Secondary: Had some level of secondary education

College: Had post secondary qualifications

Most respondents were Catholics (56 %), none was a Muslim respondent. The median and mean land size per farm was 2 and 2.33 (±2.01) acres, respectively. Farm size ranged from 0.125- 10 acres.

During the initial farm visit, farmers were asked to state all the food crops that grew on their farms. The major crops reported were maize (99 %; 286 / 288), beans (97 %; 278 / 288), millet (66 %; 192 / 288), sweet potatoes (89 %; 260 / 288) and sorghum (56 %; 161 / 288). Cassava growing was more common in Busia District (98 %; 161 / 164) than in Kakamega District (68 /

124; 55 %) ($p<0.05$). Sweet potato growing was also more common in Busia (97 %; 159 /164) than in Kakamega (81 %; 101 / 124) ($p<0.05$).

Farmers were selected to participate in the study because they owned a pig when they were first visited by the researchers. They were specifically asked to state the number of pigs owned in each of the following categories; pre-weaned or nursing, growing and adult (breeding) pig. Not all farms had each of the age category described. The mean number of pigs owned per farm was 5.0 (±3.4), 1.8 (±1.2) and 1.5 (±0.9) for the pre-weaned, growing and adult pig categories respectively. Pig farmers in Busia had been keeping pigs for fewer years (6.3±5.6) than the farmers in Kakamega (11.4±8.7) ($P<0.05$). Species mix and livestock numbers on the farms are presented in Table 10.

Table 10. Estimates of the number of animals owned by the 288 pig farmers visited during the 783 farm visits in Kakamega and Busia Districts

			Percentiles				
Livestock Species	% of farms [b]	N[a]	25th	50th	75th	Mean (SD)	Range
Pigs Adult	51	291	1	1	2	1.5 (0.9)	1 – 7
Growing	67	428	1	1	2	1.8 (1.2)	1 - 9
Nursing	14	97	2	5	8	5.0 (3.4)	1 - 15
Cattle	68	452	2	3	5	3.7 (2.8)	1 - 20
Poultry	84	571	5	8	15	11.5 (10.9)	1 - 69
Goats	33	264	2	3	5	3.9 (2.9)	1 - 20
Sheep	24	141	1	2	4	3.2 (2.9)	1 - 15

[a] Number of observations (analyses were based on farms that had at least one in that category of animals present at the time of the 783 farm visits)

[b] Percentage of the 288 farms owning each livestock species category during the initial farm visit

8.3.2 Pork consumption pattern

Most families (74 %; 212 / 288) consumed pork, differences in the consumption patterns were observed. Some families ate pork at least once a week (40 %; 85 / 212), others pork at least once a month (40 %; 85 / 212), and others, 20 % (42 / 212) ate pork irregularly or at frequencies of less than once a month. The latter included families that consumed pork either once in a year, twice in a year or only when it was available. A higher percentage (56 %; 53 / 95) of farmers in Kakamega consumed pork more often (at least once in a week) than those in Busia (27 %; 32 / 117) ($P<0.05$). During the second farm visit (Busia District) and first farm visit (Kakamega District), farmers were asked to rank pork, beef, chicken, goat and mutton, in order of their preference for consumption. A rank of 1 meant the meat was always preferred while a rank of 4 meant the meat was rarely or never chosen (Figure 15). Beef (51 %; 143 / 278) and pork (32 %; 91 / 278) were more frequently ranked as the meat that was "always preferred" than other meats.

Pork was more preferred in Kakamega (39 %; 49 / 124) than it was in Busia (27 %; 42 / 154) (p=0.003). These same farmers 'rarely' consumed either goat meat (88 %; 246 / 278) or mutton (88 %; 245 / 278).

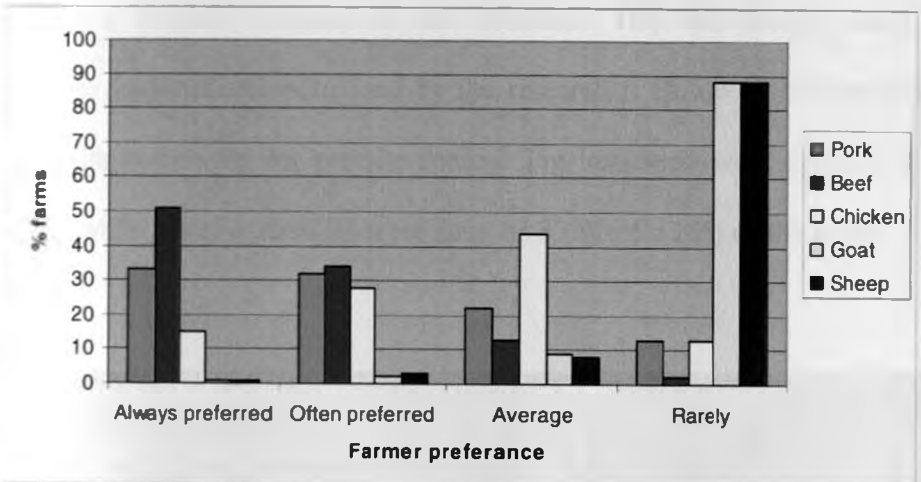


Figure 15. Farmers preference for consumption of different types of meat in Busia and Kakamega Districts

8.3.3 Pig breeds preferred

Most (97 %; 160 / 164) of the farmers owned local (non-descript) pig breeds. Majority (88 %; 141 / 160) of farmers preferred those pigs because they were cheap, available and easy to maintain.

8.3.4 Routine practices

Spraying (29 %; 128 / 438), dipping (24 %; 101 / 438) and deworming (26 %; 116 / 438) were the most frequently observed practices in Busia District. There were four farmers who walked their pigs to nearby rivers for mud bathing (Figure 16). These farmers stated that mud bathing would eradicate ectoparasites, particularly lice and tick infestations, on their farms. According to these farmers, such a practice could substitute for the known formal methods of parasite control such as spraying and dusting. Only 3 % (14 / 438) practiced tooth clipping as a routine practice. Though not captured, observations by the researcher indicated that farmers were not aware of the difference between vaccinations and treatment. This was evident when farmers implied the previous vaccinations were done by the researcher. However, the researchers had injected the pigs with ivermectin for parasite control. Pig treatments were done on 9 % (39 / 438) of the farms, while piglet castrations were done on 37 % (69 / 188) of the farms.

Figure 16. Pig bathing in the mud in a nearby river as the farmer (standing) waits for it to finish the mud bathing exercise. This practice is risky for it can lead to disease outbreaks in the villages, of importance is introduction of African Swine Fever.

8.3.5 Constraints to improved rural pig farming

There were a total of 736 questionnaires with complete data on farm challenges; the most frequently (65 %; 479 / 736) reported challenge was inadequate pig feeding. This constraint was particularly a challenge during the dry seasons either on farms that had a recently farrowed sow or where the herd sizes were large. Other constraints included diseases (46 %; 342 / 736), breeding sows (60 %; 444 / 736), low profits (61 %; 450 / 736) and pigs as causes of conflicts with neighbours (53 %; 395 / 736). Even though poor profit was reported by 61 %, only 25 % (188 / 736) had experienced problems getting buyers for the pigs. Table 11 shows that piglet mortality was a more frequent problem in Kakamega (55 %; 167 / 302) than in Busia District (45 %; 196 / 434) ($p<0.001$). It was also a frequent problem earning profits from pig keeping in Kakamega (68 %; 208 / 302) than in Busia (55 %; 242 / 434) ($p<0.001$). Farmers in Kakamega were less likely to report problems relating to marketing of pigs than their counterparts in Busia District (OR=0.51, CI 0.36-0.73). Pig farmers in Busia were two times more likely to experience disease problems on their farms when compared to farmers in Kakamega District (OR=1.95, CI 1.4 - 2.6).

Piglet mortality and sow breeding were significantly differed among visits by district ($p<0.05$). Cost of the piglets and neighbour conflicts were significantly different across the visits in Busia District ($p<0.05$). There was no difference among the visits in the two districts for the challenges of feeding, diseases and management ($p>0.05$). In Busia, there were more cases of pigs bothering neighbours during the first and third visits (52 %; 86 / 164) and 77 % (90 / 116) than during the second visit (31 % (48 / 154) ($p<0.05$). Piglet mortality was most often a significant limitation during the third farm visit in February (77 %; 72 / 116) for Busia District but a significant limitation during the first visit in June (67 %; 79 / 117) in Kakamega District ($p<0.05$).

Only 31 % (109 / 342) of the farmers who reported disease as a constraint could describe the clinical manifestations they had observed. Of these, 33 % (34 / 109) included mange (*Sarcoptes scabie var Suis*), ticks, salt poisoning and lice (*Haematopinus suis*) infestations (Figure 17). Vomiting, anorexia, reddening of the skin, excessive salivations and tether wounds were additional signs reported by the farmers and those that were indicative of poor health (Figure 18a, b and c).

Management problems (46 %; 339 / 736) that were of concern to farmers included use of weak tethers, breeding sows, pig confinement and lack of time to attend to the pigs. Many of the breeding problems (60 %; 444 / 736) were related to having too few boars in the villages, which forced farmers to walk for long distances looking for boars to service their sows. Causes of piglet deaths included crushing as a result of being stepped on by the sows and hypothermia as a result of the pigs being rained on. Neighbour conflict problems observed was related to farmers using weak tethers to confine their pigs. The loose pigs escaped to neighbouring farms and subsequently destroyed crops.

Poor pig husbandry practices (77 %; 224 / 289), limited space for keeping pigs (28 %; 81 / 289) and cases of salt poisoning (32 %; 91 / 289) were additional challenges reported by farmers in Kakamega District.

Table 11. Classification of farming challenges as either serious or moderately serious based on pig farmers perception in 2006-2008, Busia and Kakamega Districts

	% proportion			
Type of the challenge	Busia (n^1=434)	Kakamega (n^2=302)	Overall %	P value
Cost of the pig	53	49	52	0.25
Pig management	41	53	46	0.00*
Pig diseases	53	36	46	0.00*
Pig feeding	62	68	65	0.10
Getting the sow bred	59	61	60	0.55
High piglet mortality	45	55	49	0.01*
Getting pig buyer	20	31	25	0.00*
Disturbing neighbours	51	56	53	0.18
Making profit from pig sale	55	68	61	0.00*

*Association between district and the type of the challenge was considered significant at the 95 % level of confidence

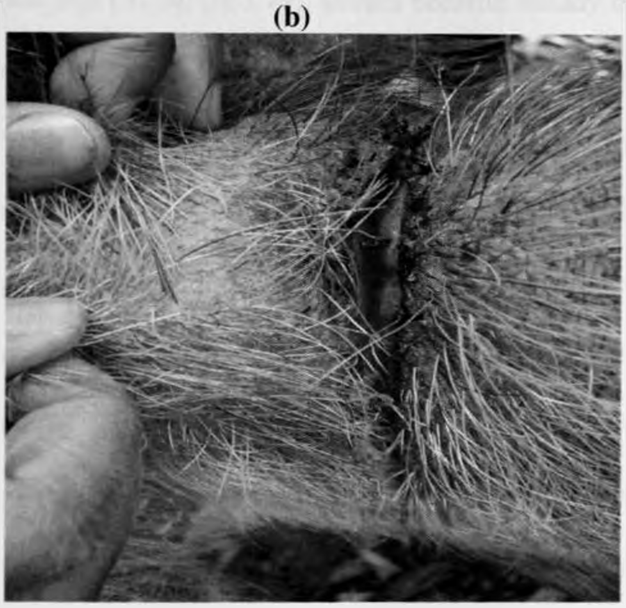
n^1 and n^2 – Number of Observations

Figure 17. Chicken feeding on lice (*Haematopinus suis*) from an heavily infested pig in Kakamega District. Control of ectoparasitism in pigs was rare; it was observed that pigs in the villages were heavily infested with lice and mange.

Figure 18(a). A tethered pig in one of the farms in Kakamega District.

This pig had been tethered on the neck, and a tether wound was beginning to form. The research team changed the tether point from the neck to the pig's leg. It is important for pig farmers to change the tether positions to avoid wounds developing, and better still to do away with tethering altogether and adopt housing system of pig containment.

(b)



(c)

Figure 18 (b and c). Cases of serious tether wounds in the fore limb (b) and neck (c) of pigs examined in Kakamega District.

Tether wounds were quite common and resulted from inability of farmers to make proper knots and disregard for regular change of tethers to alternative sites on the pig's body. Such wounds pave the way for secondary bacterial infections, leading to low productivity. This observation raises a major animal welfare concern. Because of the resultant pain, the wounded pig will not feed well and this further affects the farm output. Placing more weight on one limb could lead to other complications including lameness and hoof deformities.

8.3.6 Pig confinement

Only 27 % (79 / 288) of the farms owned a pig house, this included 13 % (22 / 164) of farms in Busia and 46 % (57 / 124) of farms in Kakamega. Farmers in Kakamega were more likely to construct a pig house than the farmers in Busia District (OR=5.4; CI 3.1-9.7). Pig houses were constructed using locally available material (Figure 19). Interestingly, on farms where a pig house existed, pigs were typically confined during the night and not during the day. Reasons for the non-confinement included; fear of the pigs damaging the houses (47 %; 37 / 79), lack of food to provide for the confined pigs (37 %; 29 / 79), houses became muddy during the rainy season (38 %; 30 / 79) and when farmers lack the time to manage the confined pigs (30 %; 24 / 79). A few farmers (2 %; 2 / 79) thought pigs needed to remain outside to eat grass, exercise and have access to fresh air. Reasons why most farmers (73 %; 209 / 288) had not constructed pig structures included; a pig house was not necessary (8 %; 16 / 209), no time to prepare pig houses (13 %; 28 / 209), such activities needed skills which the farmers lacked (11 %; 23 / 209) and lack of money to buy the required construction materials (45 %; 93 / 209). Additional (15 %; 31 / 209) reasons included farms with young pigs that did not require housing, farmers who demolished the pens because of firewood shortages, pens that had previously been destroyed by rains and growing pigs that frequently destroyed the structures.

Figure 19. A typical pig pen constructed using locally available materials in Busia District

This was one of the best structures observed during the study period, its location within the farm compound was ideal. The shade from the trees ensured the pigs would get adequate cooling effect when the weather was hot. The structure is constructed using locally available materials. The roof is made of iron sheets, while the walls are made of pieces of wood. Some farmers used grass to over lay the roof to reduce the heat in the house. The photo was taken during the day, and was empty, no pig was present. The floor did not offer adequate drainage when it rained, perhaps the reason why the farmers talked of not using the structures during the rainy season. This structure was suitable for young pigs for it was not strong enough for breeding pigs.

Farmers were asked to state the percentages of day time ($\leq$50 % versus >50 %) when pigs were housed, tethered or allowed on free range, during crop planting, growing and harvesting seasons. Tethering of pigs was more frequent (>50 %) during the planting (91 %; 263 / 290), growing (90 %; 263 / 290) and harvesting seasons (78 %; 227 / 290) than either being in a pig house or allowed to be on free range. Pigs were confined in pens (>50 % of the time) by 4 %, 3 %, and 2 % of the farmers during the growing, planting and harvesting seasons, respectively. There was no difference in the percentage time pigs were housed, tethered or allowed on free range among the three farm visits (p>0.05). Figure 20 presents the management options of growing and adult pigs during the three crop seasons in Busia and Kakamega Districts.

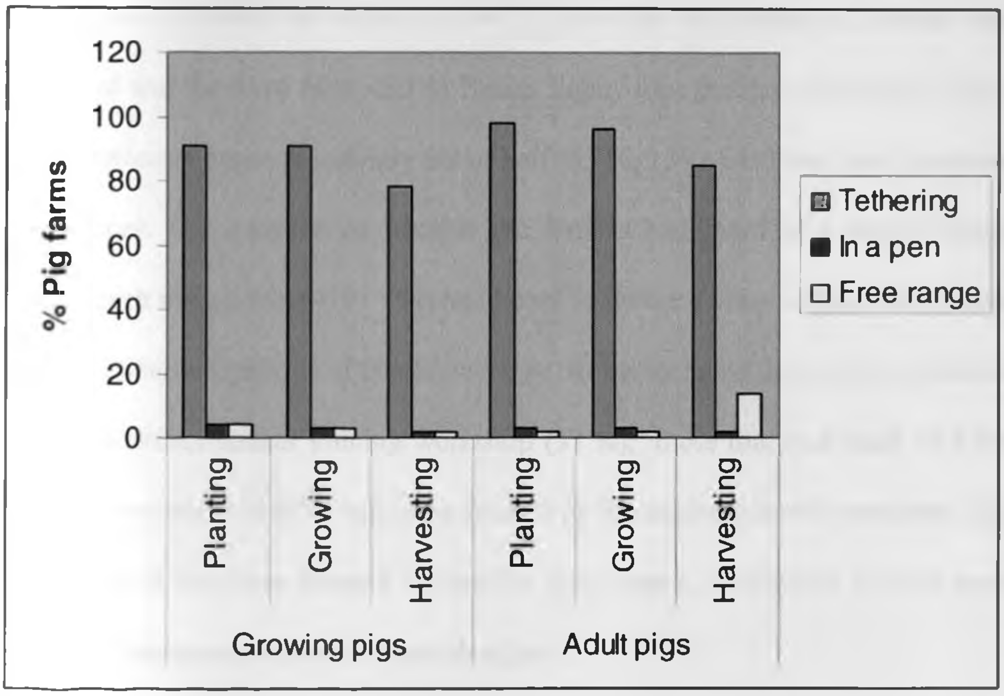


Figure 20. Pig management (free-ranging, penning and tethering) during the crop planting, crop growing and crop harvesting seasons in Kakamega and Busia Districts

8.3.7 Porcine cysticercosis

A total of 1290 pigs, from 288 farms, were examined for the larval cysts of *C. cellulosae* using the lingual palpation method (Table 12 and Figure 21). Household prevalence of porcine cysticercosis was 15 % (43 / 288), while prevalence in pigs was estimated at 4.5 % (58 / 1290). There was no difference between the prevalence observed in Busia (5.1 %, n=758) and in Kakamega (3.5 %, n=532). Fifty eight percent (58 %) of the total number of pigs examined were females. Sex of the pig was not associated with cysticercosis ($p>0.05$). A total of 6 pigs were found positive in two consecutive farm visits of which 5 (83 %) were breeding females.

A question on whether the farmers knew of tapeworm infestations in humans was asked during the second and the third farm visit in Busia. Eighty nine percent (89 %; 249 / 284) had heard of the infestation in humans and only about half (55 %; 139 / 249) had seen tapeworm segments on human feces. The question on whether the farmers had heard of a similar disease in pigs was asked at each visit; 53 % (419 / 784) had heard about the disease in pigs. Sixty nine percent (290 / 419) indicated their source of this knowledge, which included those that had heard of the disease during a previous farmer training workshop (57 %), those that had heard of it from neighbours (19 %), government staff (6 %), close friends (4 %) and from family members who had attended the training (1 %). Two farmers claimed to have seen *C. cellulosae* cysts in pork meat, one of whom had previously operated a pork butchery.

Cooking the meat well (34 %; 55 / 233), throwing infected pork away (17 %; 40 / 233) and manual removal of cysts before cooking (1 %) were some of the measures that farmers would adopt in case they encountered pork infected with larval cysts of *T. solium*. Eight percent (8 %; 18 / 233) said they would boil the pork in water for about 10 minutes before cooking. Only 14 %

(64 / 429) of the farmers said they had their pigs inspected before sale of the live pig. These farmers were referring to inspections involving the general health of the pig, the pig's size and estimated live weights for the pigs. This inspection was done by the pig farmers themselves. The proportion of farmers that reportedly had their pigs inspected was higher in Kakamega (29 %; 42 / 142) than it was in Busia 7 % (22 / 287) (p<0.05).

Table 12. Prevalence of porcine cysticercosis by lingual palpation in Busia and Kakamega Districts

District		Visit 1	Visit 2	Visit 3	Total	Prevalence (%)
Busia	+	16	19	4	39	5.1 (39 / 758)
	n	298	264	196	758	
Kakamega	+	7	4	8	19	3.5 (19 /532)
	n	201	168	163	532	
Total	+	23	23	12	58	4.5 (58 / 1290)
	n	499	432	359	1290	

n- Number of pigs examined

+VE- Number of pigs testing positive

Figure 21. *C. cellulosae* cyst in the tongue of a pig as shown by the arrow. The cyst was detected on the underside of a pigs tongue in Busia District

8.3.8 Perceived costs of pig feeds

Only a small proportion of farmers (13 %; 35 / 260) felt rural pig feeding did not cost them any money, 58 % (153 / 260) felt feeding cost them money but not too much, while 52 % (137 / 260) said feeding cost them more, even more than what they received from selling the pigs. In terms of feed availability, 56 % (148 / 260) of the farmers reported that feeds were not easy to obtain locally. The proportion (%) of farmers citing high feed costs in Busia was higher during the initial farm visit (54%) than it was in the second visit (38 %) ($p<0.05$).

8.4 Discussion

Small-holder pig farming plays an important role in the livelihood of many households in Western Kenya; pigs are sold to earn family income which can in turn be used to buy food, pay for school fees and pay for medical bills. Farmers studied in this study were middle aged (30-50 years), with basic primary education and were more often women. These farmers do not qualify to get well paying jobs, engaging in rural pig farming therefore provides them with an opportunity to better their lives and earn a living. Pig farmers also kept other livestock species in addition to pigs to diversify their incomes. The average land size per farm was small, at only 2.33 (±2.01) acres. Pigs are perhaps the most ideal animals to keep considering their small space requirements and because of the fact that they do not need grazing land. Pork is an affordable and preferred meat in the rural communities of Western Kenya, perhaps an opportunity that can be utilized in the efforts to promote pig farming in the villages.

The local pig industry in Western Kenya faces a number of challenges which might negatively impact on pig's overall performance. The proportion of farmers who identified specific challenges differed by district, study sub-locations in Busia District were considered "rural", further from main town of Busia, while those in Kakamega were considered "peri-urban", near the urban town of Kakamega. This presents an expected difference in the magnitude of the outcomes studied. For instance, diseases was a lesser challenge in Kakamega than it was in Busia, perhaps Kakamega farmers were better positioned to access extension services from the nearby government offices than in the distant rural Busia. Feeding is the most expensive part of pig farming; it is therefore not surprising that the farmers identified it as the most frequently encountered challenge. Inadequate pig feeds had also been mentioned by farmers during a previous focus group study conducted in the area (Mutua *et al* in press). However, utilizing local feedstuffs as alternative feeds for pigs could reduce the costs associated with purchased commercial feeds. The numerous food crops grown in the area presents an opportunity that can be utilized in formulating local feed ingredients for pigs. The seasonality of feeds is however a challenge (More *et al.,* 2005).

Piglet prices were lower in Busia than they were in Kakamega District. This may be because, on average, farmers in Kakamega had been keeping pigs for more years and obviously had more experience in the industry than farmers in Busia. Again, and as suggested by More *et al.* (2005), pig production away from town (like farms in Busia) is less market-oriented and serves as a means of family saving, for socio-cultural and for consumption. Thus the high price of piglets in Kakamega may be driven by the good market access for pigs in the villages near the town.

The poor pig management practices observed in the current study limits the production potential of pigs. Farmers did not use antihelminthic to routinely control for common worm infestations, perhaps due to lack of capital and poor extension services (Wabacha *et al.*, 2004). A similar observation was reported by More *et al.* (2005) who noted that veterinary services such as deworming were less available to farmers particularly those away from towns. The current study did not collect samples to determine specific helminth infections, however, internal parasites such as *Ascaris suum*, *T. suis* and *Oesophagostomum* have been identified on commercial pig farms in Kenya (Nganga *et al.*, 2008). Pigs in the study area are kept outdoors and this complicates the control of common parasitic infections. This can affect growth performance and lead to subsequent economic losses (Stewart *et al.*, 1985; Stewart and Hale, 1988; Nganga *et al.*, 2008). Infestations of mites (*Sarcoptic scabiei* var *suis)* and lice (*Haematopinus suis*) were commonly observed on the pigs in the study districts (data not recorded). A part of the research was to treat all pigs in the study farms with Ivermectin (Ivomec®). *Sarcoptic scabiei* var *suis* is an important ectoparasite of pigs seen mostly where nutrition, management and hygiene are low. The disease can impact growth rate and feed utilization efficiency. *Haematopinus suis* causes severe irritation, pigs scratch and rub against objects leading to skin damage and reduced weights (Cargill and Davies, 1999; Cameron, 1999; Muirhead and Alexander, 2002). It is also responsible for the transmission of diseases between infected pigs (Nsoso *et al.*, 2006). The local belief that letting the pigs bathe in the mud would control for the common ectoparasites is a potential short-term control strategy for ectoparasites infections. The practice may predispose the pigs to acquiring diseases such as African Swine Fever (ASF) if pigs congregate at rivers; ASF can cause serious economic losses on pig farms (Penrith *et al.*, 2007).

Pigs are adversely affected by climatic factors and should be housed to guard them against environmental hazards (Lekule and Kyvsgaard, 2003). Total confinement of pigs was rarely done in the study area and most farmers lack pens to house their pigs. Those that had the structures rarely confined the pigs during the day, a clear indication that pig farmers did not understand the importance of pig confinement, particularly the public health concerns of free-range pigs. This was of particular concern with respect to the maintenance of the lifecycle of *T. solium*. Neighbour conflicts were an important challenge, mostly on farms where pigs were allowed to roam freely. Purchase of strong ropes to tether pigs was a problem in many households, this led to use of weak tethers which were easily broken by the pigs setting them free to roam and further add to neighbour conflict. Tether wounds observed on the neck and leg of the pigs is a welfare concern (Neville and Temple, 2007); such wounds can be attributed to the failure of the farmers to regularly change tether positions potentially leading to secondary bacterial infections. A recent study in Uganda indicated that 33 % of farmers did not have structures to house their pigs (Ampaire and Rothschild, 2010). The same study identified crop rooting by pigs and breaking of tethers as some of the challenges associated with failure to confine pigs.

Local construction materials such as grass and wood are available and can be utilized in preparing simple pig housing structures for rural pigs. Government staff at the Ministry of Livestock can offer assistance to the farmers by designing the recommended pig housing for the farmers to use. Training farmers on better pig husbandry practices can address the observed term control strategy for ectoparasites infections. The practice may predispose the pigs to acquiring diseases such as African Swine Fever (ASF) if pigs congregate at rivers; ASF can cause serious economic losses on pig farms (Penrith *et al.*, 2007).

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Local construction materials such as grass and wood are available and can be utilized in preparing simple pig housing structures for rural pigs. Government staff at the Ministry of Livestock can offer assistance to the farmers by designing the recommended pig housing for the farmers to use. Training farmers on better pig husbandry practices can address the observed problem of non-confinement and other related issues observed in the current study. Allowing pigs to scavenge is against the Kenya government legislation which recommends pig confinement in pig- proof houses (Laws of Kenya: Pig Industry Act, Cap 361, 364). However, as earlier indicated (Dirk and Geerts, 2004), farmers may find it easier to let their pigs loose since the associated financial risk is small and less time is spent looking after the pigs. The free range behaviour of pigs has been associated with increased risks of contacting porcine cysticercosis (Lekule and Kyvsgaard, 2003), an important zoonotic disease, perhaps unknown in many rural households (Wohlegemut *et al.*, 2010). Although most of the farmers were aware of human taeniasis (~90 %), the study did not specify the *Taenia spp* that farmers talked about. *Taenia saginata* and *T. solium* are difficult to differentiate by parasitological examination because their eggs are indistinguishable. Correct identification is important because the consequences of human infection by these two parasites are very different (Mayta *et al.*, 2000).

This study found a pig-level prevalence of 4.5 %, an indication that *T. solium* cysticercosis is still present in the locally raised pigs of Western Kenya. A previous study in Teso District reported a prevalence of up to 6.5 % (Githigia *et al.*, 2005; Mutua *et al.*, 2007). Lingual palpation method has previously been used in estimating cysticercosis prevalence in pigs (Ngowi *et al.*, 2004), the method, though highly specific, has a low sensitivity in detecting *T. solium* infected animals (Gonzalez *et al.*, 1990). The prevalence observed is therefore an underestimate of the true prevalence in the districts of Busia and Kakamega. It is expected that the actual prevalence will double the observed prevalence. Only 6 pigs out of the total that tested positive were still present on the farms when the researcher made the subsequent visits. This obviously indicates that the pigs were sold out for slaughter at the local butcheries for local consumption exposing consumers to greater risks of infection.

8.5 Conclusions

This study has highlighted a number of issues that are of major concern in the sustainability of local pig industry, of importance is feeding, marketing and breeding. Farmers should be encouraged to improve management, husbandry practices and productivity of indigenous pigs. One of the possible ways that could reduce production costs is by farmers using locally available feedstuffs that would balance the nutrient requirements of the pig. Allowing pigs on free range is not only illegal but also presents a public health risk to the poor farming households in Kenya. Tethering pigs was the main method of confining pigs in most of the farms. Though this is a step towards confinement but the tether ropes causes severe injuries to the pigs. This is one good reason that farmers need to be encouraged to totally confine their pigs in pens. Alternatively, in the meantime, an adjustable loose-fitting soft leather cup, tied around the leg or the neck of the pig to reduce the occurrence of tether wounds, and attached to the rope would be a sustainable tethering system. Awareness about *T. solium* taeniosis / cysticercosis complex needs to be increased further in order to safeguard the human population from risks of the disease.

CHAPTER NINE

9.0 ASSESSING THE IMPACT OF VILLAGE FARMER TRAINING WORKSHOPS ON PIG MANAGEMENT

9.1 Introduction

Poor housing, inefficient disease control and poor feeding are some of the challenges affecting the local pig production in Western Kenya (Githigia *et al.*, 2005; Mutua *et al.*, 2007). Poor knowledge on improved pig husbandry practices in the region has also been highlighted (Mutua *et al.* In press). These farmers live in close contact with their animals and are therefore potentially exposed to zoonotic diseases such as *Taenia solium* (Mutua *et al.*, 2007). The main role of agricultural extension, particularly in developing countries, is to disseminate technologies generated by research organizations and help promote benefits of improved farming techniques more widely (Anon, 2009).

The agricultural extension system offered by the Ministry of Livestock (Government of Kenya) is inadequate and does not sufficiently address the needs of small-scale farmers (Muyanga and Jayne, 2006). Most farmers have limited opportunities to attend short-term agricultural training courses offered by local institutions such as universities and non-governmental organizations. This is further complicated by the observed poor rural infrastructure. Village training in the form of workshop provides an opportunity for the farmers to learn and could stimulate improvements in pig management. The objective of this particular study was to assess the impact of farmer workshops conducted by trained government staff followed by individual (one-on-one) training for farmers who missed the training on rural pig management in Busia and Kakamega Districts.

9.2 Methodology

9.2.1 Development of the Training Manual

The preliminary visits and the results of the first farm visits together with the focus group discussion data gave guidance on the topics to be included in the training manual. These were: 1. The cycle of a sustainable pig production, 2. The life cycle of *Taenia solium*, 3. The management of breeding pigs, 4. Care of suckling piglets, 5. Pig feeding, 6. Pig housing, 7. Estimating the weight of pigs and 8. Control of common pig diseases.

9.2.2 Staff training workshops

A total of 40 local government extension staff were trained using the Training of Trainers approach (TOT). Those in Busia were trained at the Divisional headquarters, while those in Kakamega were trained at the District headquarters. Workshop trainees included the local animal-health providers, community-health workers, agriculture staff, public health officers, social workers, adult-education specialists, veterinarians, and livestock production officers. In Busia, the local assistant chief attended the workshops. All the participants attended the training of farmers at the village level. The TOT workshops were conducted in English. Two sets of trainings were done; the first between the first and second farm visit, and the second training was after the third farm visit.

9.2.2 Farmer Training Workshops

Pig farmers (including those that were not part of the study) from 3 - 4 neighbouring villages were invited for the training workshops. They were requested to come together for a one day training workshop. The workshops were typically hosted in one of the pig farmer's compound, although in some villages, this was done in a local church or in a school. Two sets of trainings were conducted: the first one between the first and second farm visit and the second training after the third farm visit, at the end of the research (Table 13). The workshops were organized in collaboration with the Divisional Livestock and Veterinary Offices, publicity was done by the assistant chiefs and village elders.

Table 13. Description of the number of farmers attending pig training workshops in Busia and Kakamega Districts, Western Kenya

Study site		Date of the Training	Number of participants
Busia (Butula)	1st training	June / July 2006	109
	2nd training	June 2008	117
Busia (Funyula)	1st training	June / July 2006	133
	2nd training	June 2008	92
Kakamega (Shinyalu)	1st training	June / July 2007	45
	2nd training	July / August 2009	52
Kakamega (Ikolomani)	1st training	June / July 2007	91
	2nd training	July / August 2009	50
		Total	689

Farmers were surveyed on three occasions, 4 – 6 months apart. The farms were visited and the interviews were conducted in Swahili using pre-designed questionnaires. The first farm visit occurred one month before the first farmer training workshop. Those farmers who were part of the study but were unable to attend the workshops were given individual (one-on-one) training during the follow visit. Each of these farmers was issued with a training package comprising of writing materials, *T. solium* cycle print out, tape measure, and weight recording sheets that outlined how he / she could use the tape measure to estimate the weight of the pigs. To ensure farmers understood what was being taught, all the training were done in Swahili but translated to the local luhya language. The trainings involved using a combination of lecture, handouts and flip charts or posters methods as teaching aids. All farmers, whether or not they attended the training, were given an opportunity to ask questions during the workshops.

A second set of farmer training workshops were conducted 2 years after the initial workshop. During this workshop, farmers were taught about a method to estimate the weight of the pig, the *T. solium* life cycle, feeding, breeding, and housing pigs and summarized information from the research. Those receiving the one-on-one training were asked to state the reasons why they did not participate in the group training. All participating farmers were asked if they implemented any changes in response to the research and education opportunities.

9.3 Data management and analysis

During the second follow up visit, respondents were asked to state if any member of the family had attended any of the farmer training workshops. This question was used to place farms in to two groups, first, those that had a family member who attended the training workshops and secondly, those where no family member attended the workshop but were subsequently provided with the one-on-one training. Based on the farm visit number, data were classified into two categories, "before the training" (1^{st} farm visit) and "after the training" (3^{rd} farm visit).

Analyses were done to evaluate the impact of farmer training workshops on pig management. Main outcomes of interest included type of challenge experienced by the farmers (Yes | No), routine practice done (Yes | No) and pig confinement (as percentage of time) at different seasons

(<50 % and ≥50 %). In the first analyses, Chi-square statistics were used to explore for potential associations between attending the farmer training workshop ("attended training" versus "missed training") and each of the above outcomes variables. The second set of analyses compared the proportion of farms experiencing each outcome before the training (1st visit) and after the training (3rd visit). Descriptive statistics were used to describe farmer's uptake of knowledge during the workshop. Difference between age of the farmers was compared using student's t-test for those who had attended the training and those that did not attend the training. All the analyses were done in Stata®. Graphs were generated in Ms Excel®.

9.4 Results

9.4.1 Training manual

The training manual developed is presented as Appendix 12.11 (some sections of the manual have been omitted to reduce the number of pages). As indicated on Table 13 above, a total of 40 government and 667 pig farmers were trained in the course of the study period.

9.4.2 Farmer training workshops

Sixty five percent (65 %; 188 / 288) of the farmers attending the initial training workshop were part of the study; 74 % (116 / 156) of this was in Busia while 64 % (72 / 113) was in Kakamega (Table 14).

Table 14. Description of study farms represented at the farmer training workshops in Busia and Kakamega Districts, Western Kenya

	District		
Description	Busia	Kakamega	Total
Number (%) of study farms represented at the training Workshop	116 (71 %)	72 (58 %)	188 (65 %)
Number of farms not represented at the training	48	52	100
Total farms in longitudinal study	164	124	288
Number of participants (%) interviewed during 2nd farm visit and who had attended the training workshop	73 (63 %)	45 (62 %)	118 (63 %)

A high percentage (78 %; 147 /188) of the farmers who participated in the workshops were the primary care takers for the pigs. These were the persons responsible for the feeding and management of the family pig. Workshop details including participant information and lessons learnt were obtained during the second farm visit. Sixty three percent (63 %; 118 / 188) of the respondents attended the workshops. The mean age (years) of these farmers was 40.4 (±15.0) and 41.9 (±11.9) for Busia and Kakamega Districts respectively. Over fifty percent (59 %; 67 / 118) of the participants had attained some or all the primary school education. Others included those farmers who had never gone to school (18 %). Those who had attained some or all of secondary education were (17 %) and 1 % who had attained college education.

9.4.3 Knowledge Uptake by the farmers

Of the 188 farmers interviewed during the second farm visit, 63 % (118 / 188) had attended the workshop. To assess their knowledge uptake, the farmers were asked to state what they thought they learned during the first workshop. Ninety six percent (113 / 118) had learnt at least one lesson from the training and 90 % (102 / 113) could specify up to three lessons that they learned.

The most common lesson learned by the participating farmers was pig feeding (52 %; 62 / 118). Specifically, these farmers had learned about the importance of feeding pigs more than a single meal each day and feeding balanced pig rations. Other lessons learnt included the importance of pig housing (47 %; 56 / 118), how to breed a sow (25 %; 30 / 118), marketing their pigs (39 %; 46 / 118), and recognition and treatment of pig diseases (15 %; 18 / 118). Breeding lessons included heat detection, breeding a sow multiple times in one oestrus cycle, basic sow biology such as gestation length and care of nursing piglets. Those that learned about marketing said they used the information about pig weight calculations to estimate the weight for the pigs before selling. This enabled them to make better bargains for pig prices. Other lessons learned were those involved with routine practices conducted when managing pigs and record keeping. Interestingly, those that had learned about record keeping displayed samples of these to the researchers during the follow-up farm visits (Appendix 12.12). Figure 22 below summarizes the key lessons learned by farmers during the farmer training workshops.

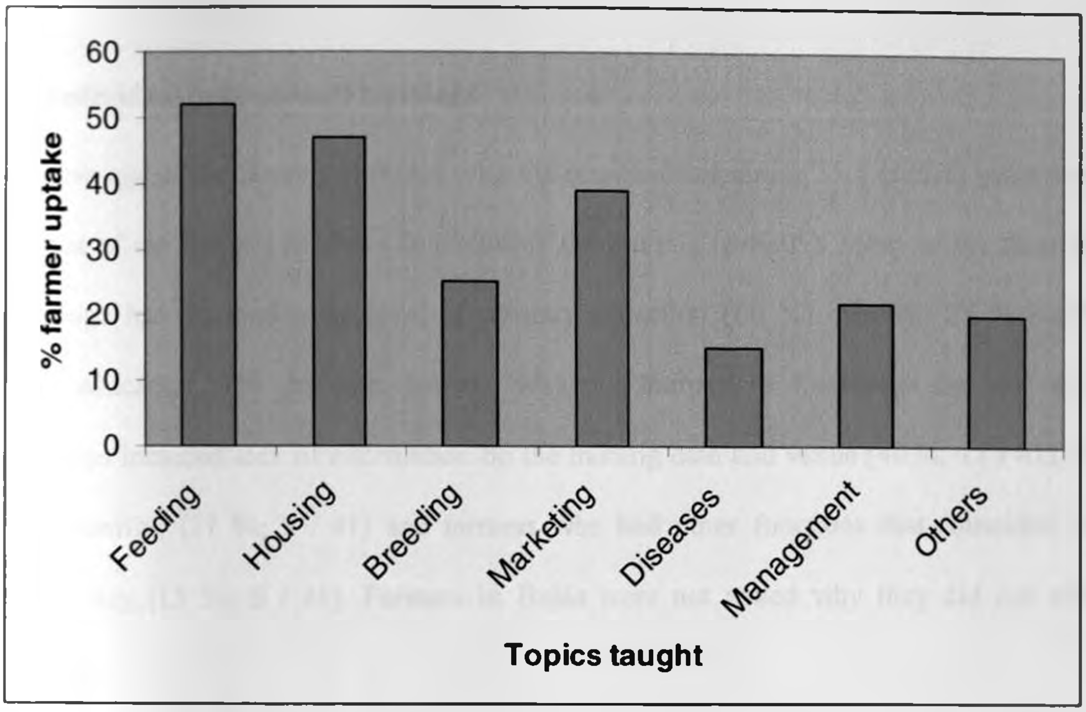

Figure 22. Percent of farmers who identified specific component parts of the training that they used, 4 – 6 months after attending the workshops in Busia and Kakamega Districts, Western Kenya

9.4.3 Daily feeding frequencies

Pig feeding was classified as frequent or infrequent based on the number of meals offered to pigs each day. Frequent feeding included feeding pigs more than one meal a day, any other form of feeding observed was considered as infrequent. Infrequent feeding was more common on farms where no one attended the farmer training (33 %; 27 / 81) than on those that were represented at the training (24 %; 45 / 188) ($p<0.05$).

9.4.4 Individual (one-on-one) trainings

The mean age of the farmers provided with the one-on-one training 35.4 (±12.7) years was lower than that of the farmers (40.3±14.0) attending the training ($p<0.05$). Many of the farmers at the workshops had attained some level of primary education (60 %), whereas 25 % had had no formal education. The common reasons why pig farmers in Kakamega did not attend the workshops included lack of information on the training date and venue (40 %; 17 / 41), sickness in the families (17 %; 7 / 41) and farmers who had other functions that coincided with the training day (15 %; 6 / 41). Farmers in Busia were not asked why they did not attend the workshop.

9.4.5 Training and farming challenges

During the second follow-up visit, the pig farming challenges experienced on farms where someone attended the workshop (n=188) were compared with the challenges experienced on farms from which nobody attended the workshop (n=81). Sow breeding difficulties were experienced by more farms represented at the training (50 %; 95 / 188) than by farms where no one attended the training (35 %; 29 / 81) ($p<0.05$). Similarly, the proportion of farms experiencing problems buying piglets was higher (42 %; 80 / 188) on farms where someone had attended the workshop than on those from where no one attended (25 %; 21 / 81) ($p<0.05$) (Figure 23).

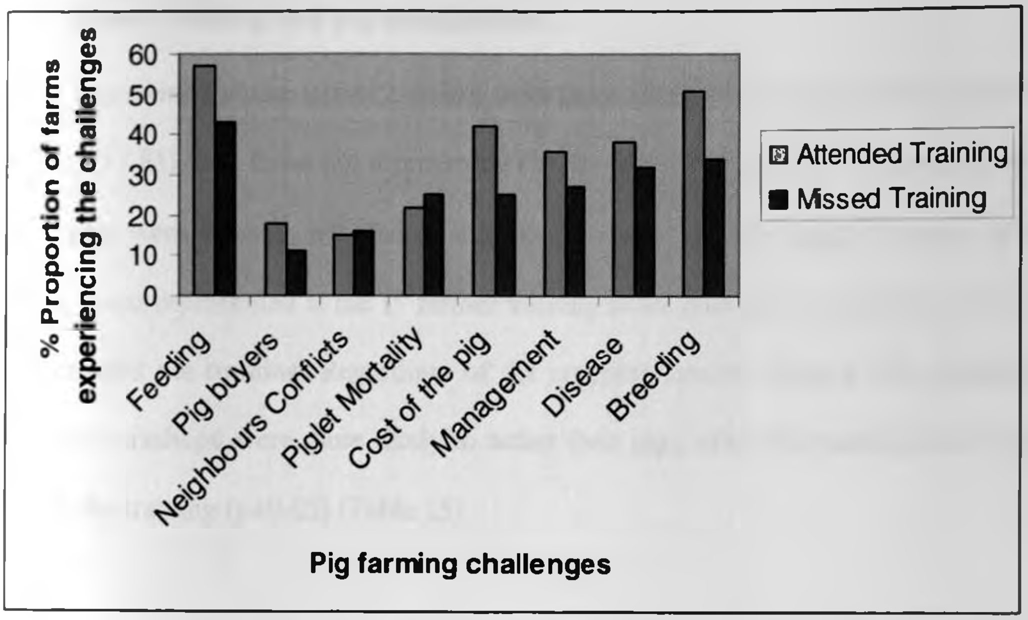

Figure 23. A comparison of small-scale pig farming challenges experienced on farms that were represented at the training and those that were not represented at the Farmer Training Workshops

A higher proportion of farmers were able to describe their challenges to pig keeping after the workshop and the one-on-one training than prior to the educational opportunities. All of the following challenges were significantly less during the first farm visit than during the third farm visit; getting pig buyers for market pigs (12 % versus 23 %), neighbour conflicts (51 % versus 77 %), piglet mortality (25 % versus 57 %), breeding sows (49 % versus 62 %) and low profits (41 % versus 70 %) ($p<0.05$).

9.4.6 Farmer training and pig management

Farms represented at the farmer training were more likely to have pigs fed less than twice a day (33 %; 27 / 81) than those not represented (24 %; 45 / 188) ($p<0.05$). The proportion of the day when pigs were housed, tethered or allowed to roam free by cropping season was compared among farms represented at the 1st farmer training to the proportions reported on farms where no one attended the training. Regardless of the cropping season, farmers who attended the initial training workshops were more likely to tether their pigs, after the training, than those who had missed the training ($p<0.05$) (Table 15).

Table 15. A comparison of the proportion (%) of farms using housing, tethering and allowing pigs to roam freely (≥50 %) of the time for farms that attended the first training session and those that missed the training days in Busia and Kakamega Districts, Western Kenya

Season	Management Method	% Attended training N=188	% Missed the training N=81	P value
Planting	In a pen	2	1	0.69
	Free Range	1	2	0.62
	Tethering	59	45	0.04*
Growing	In a pen	3	1	0.46
	Free Range	2	2	0.86
	Tethering	57	38	0.06
Harvesting	In a pen	3	1	0.46
	Free Range	17	11	0.40
	Tethering	47	34	0.04*

* Significant at 95 % Level of Confidence

The proportion of the day when pigs were housed, tethered or allowed to roam free by cropping season was further compared among farmers before and after the training was provided. Farmers in Busia were more likely to tether their pigs, regardless of the cropping season, after both the training and one-on-one workshops were conducted (3rd farm visit), than before (1st farm visit) the workshops ($p<0.05$) (Table 16).

Table 16. A comparison of the proportions (%) of farms using housing, tethering and allowing pigs to roam freely (≥50 %) of the time before and after the farmer training workshops in Busia District, Western Kenya

Season	Management Method	% at the 1st farm visit	% at the 3rd farm visit	P value
Planting	In a pen	2	7	0.03*
	Free Range	4	3	0.90
	Tethering	46	73	0.00*
Growing	In a pen	1	4	0.10
	Free Range	5	4	0.54
	Tethering	48	72	0.00*
Harvesting	In a pen	1	2	0.73
	Free Range	12	22	0.03*
	Tethering	40	64	0.00*

* Significant at 95 % Level of Confidence

Routine practices of deworming the pigs and iron injection were compared for farms represented at the training and those not represented. There was no difference between the proportion of farms deworming their pigs (36 %) before the training and the proportion deworming pigs (22 %) after the training. Similarly, there was no difference between proportion of farms practising iron injection on their farms before the training (3 %) and the proportion doing it after the training (3 %) ($p>0.05$). Although the percentage that did piglet castration before the training was higher (24 %; 40 / 164) than the percentage that did piglet castration following the training (15 %; 19 / 121), the difference was not significant ($p>0.05$).

9.5 Discussion

Training of Trainers (TOT) approach as used in the current study involved first training the local extension staffs who were, in turn, used to train the pig farmers in the villages. It was based on the premise that effective extension services can improve agricultural productivity if farmers are given information that helps them to optimise the use of limited resources. The current extension system in Kenya is ineffective and hardy meets the needs of the farmer (Muyanga and Jayne, 2006). This might limit the pig farmers' ability to access extension services (Gebremedhin *et al*., 2009). Poor infrastructure was blamed for the weak pig extension services in Kakamega District. Thus, by training the government staff, participants were able to use the information to educate farmers in the target villages and also in other villages as they interacted with them over time.

Farmers were trained using posters, flip charts, lectures and demonstrations. Each farmer was provided with information sheets for the *T solium* life cycle, images of feeds that pigs can digest, weight recording sheets and illustrations of how to measure a pig to estimate its weight. Most of the trained staff spoke local Luhya language and this made them the most suitable persons to deliver the farmer training packages. The simplicity and the flexibility of the training methodology used allowed the participants to get information that were relevant to rural pig rearing. The multiple village trainings presented the farmers with an additional opportunity to participate in the trainings for those farmers who had missed the training session offered close to their villages. An additional opportunity for the farmers to learn was provided during the individual one-on-one trainings done on the farms. Farmers who participate in training activities have higher knowledge test scores relative to non-participants (Rola *et al.*, 2002). In this study, farmers who failed to attend the planned trainings were younger (35.4±14.0) compared to those who attended the training (40.8±14.0). The absence of the young pig farmers could be attributed to their involvement in work-related activities. Age has been shown to influence adoption of technologies (Mutuc *et al.*, 2007), and as suggested by SWAC (2005), young producers may find it difficult to adopt agricultural innovation in a community. Approximately 30% of the farmers missed the workshops. Extension cannot reach every farmer (Madhur, 1999) and some farmers will rely on their neighbors for information and advice (Trip *et al.*, 2005).

The proportion of farms experiencing high costs for piglets and problems relating to sow breeding was higher for farms that had attended the training than on those that missed the training. A possible explanation might be that those who came for the training owned a sow and had, therefore, invested more in keeping the pig longer, breeding the sow and raising the piglets. This higher level of investment may have led them to attend the workshops hence the bias. Perhaps those who attended the workshop became more observant the way the pigs were managed and therefore could easily single out these challenges after the training. The proportion of farmers using iron injection on their farms did not differ for farms that attended and those that did not. However, the overall small percentage of farms practicing this indicates that the method was rarely done on the farms studied. Furugouri (1972) showed that piglet's iron absorption from the soil is not high enough to meet its iron requirement of the piglet. Piglets are born with minimal reserves of iron and the sow milk contains insufficient iron to satisfy their demands. The effects of this on rural piglets might be minimal since the pigs are raised outdoor and have access to soil and thus have access to iron.

No difference was observed when the type of challenge was compared between farms attending the training and those that chose not to attend the training for piglet mortality, feeding, diseases, pig management or neighbour conflicts. This could be attributed to the short duration between the time when the first training workshops were done and the second follow up farm visit. This could be attributed to the fact that farmers had limited time to adopt the lessons learned. Adopting new management changes in livestock farming takes time for implementation to happen and for the effects to show. Thus assessing impact immediately after participation likely captures short-term knowledge acquisition that may or may not last for long (Godtland *et al.*, 2003).

The frequency of pig feeding was higher on farms that had attended the training than on those that had not. The fact the feeding was the lesson many farmers learnt during the training workshop might explain why these farmers fed their pigs more often after the training than before the training. However, emphasis should be on both the frequency, the amounts fed and the type of feedstuff farmers provide to their pigs since all these is important in influencing the overall performance.

In this study, the proportion of farmers experiencing the different challenges was higher during the third farm visit than during the initial farm visit. One can argue that the third farm visit in Busia was done in the month of February, a time when farmers were experiencing problems sourcing their own food. The farmers were, therefore, more likely to report problems relating to feeding pigs during this visit than during the initial farm visit. However, the other challenges were not expected to be higher in February than in other times of the year. It may be that by highlighting the best management practices for pig rearing in the training, the farmers were more able to set high goals for their pig farming enterprise. This may have then helped them to identify the challenges they had in reaching each of these goals.

The training had an impact on how farmers managed their pigs during all of the cropping seasons of the year, planting, growing and harvesting. This could be attributed to the knowledge acquired by the farmers during the workshops and on the one-on-one training. The reasons farmers restricted their pig's movement after the training may have been motivated by one or all of the following reasons: the law states pigs must be confined (GOK, 1972), confining pigs will stop the life cycle of the *T. solium* parasite (Phiri *et al.*, 2003; Ngowi *et al.*, 2004), knowledge about pig feeding would enable a farmer to provide food for the pig rather than letting the pig scavenge on their own and raising awareness of the fact that roaming pigs bother the neighbours. It is possible that farmers who remembered learning about pig feeding, housing, management and breeding, might have translated to improvements in pig management. Pigs are destructive on farms when left to roam freely, and as observed in the current study, farmers might opt to tether them during the critical crop (planting and growing) seasons, and perhaps let them free after the crops have been harvested.

The specific reason for the development of the training manual was to come up with a training tool that could be modified and used to enhance the extension service in Busia, Kakamega and other districts of Kenya where pig farming is practised. In this way, it would offer sustainable pig health that would lead to reductions in disease incidence, improvement in management and sustainable increases in pig productivity and profit.

9.6 Conclusion

Strengthening the link between extension and research allows for improvement in information flow from the farmers to the researchers and vice versa. Spielman *et al.* (2009) showed that research and extension can contribute substantially in strengthening household livelihoods. The farmer training conducted using the Training of the Trainers model spanned a two year period during which time two separate sets of training workshops and two opportunities for one-on-one (on-farm) training occurred. Although the one-on-one farmer training method required a significant outlay of financial resources and expert time, it was seemingly very effective. This method enabled farmers who were unable to attend the workshops to receive the education provided at the training workshop, a study in Punjab ranked farm and home visits at the top of other extension media (Khalid *et al.*, 2006). Farmers appreciated learning information about pig management. They explained that the training had positive impact in their pig management practices, including tethering, weight estimation prior to selling the pigs, frequency of feeding pigs and use of a wider variety of feeds, breeding sows and treatment of ectoparasites. These changes are expected to contribute towards sustaining the pig sector in the in the two districts of Western Kenya. One of the recommendations drawn here is formation of stronger links between the partners, including the central and local authorities, universities and non-governmental organizations, together with the concerned communities. Since farmers, particularly those in the developing countries are in constant need of knowledge, researchers should design and test interventions based on their priority needs and own assessments.

CHAPTER TEN

10.0 GENERAL DISCUSSIONS AND CONCLUSIONS

Small-holder pig keeping remains an important source of livelihood in farming communities in Busia and Kakamega districts. Pigs can be sold any time whenever a family need arises. It is no wonder farmers equated it to operating a village bank during the focus group discussions. Pork meat is quite popular and offers an affordable local source of protein to many of the families. Poor marketing, feeding and breeding are some of the challenges highlighted in the current study and greatly impact on the returns from the sector. It is advisable for farmers to organize themselves into groups such as cooperatives, through these; farmers can combine efforts to secure sustainable marketing arrangements. Pig farmers in the current study had limited access to credit facilities to expand their businesses, and according to FAO (2008), this might limit their access to inputs thereby impacting on farm productivity.

The current study showed that pigs are easier to manage relative to other livestock species, an advantage that can be utilized in the efforts to enhance rural productivity. The challenge might be inadequacies in feed availability; as stated by Radostits (1985) feeding is the single most costly item in pig farming accounting for 70-75 % of the costs. Pigs can, however, thrive well on a variety of feedstuffs, many of which result from human foods. Since farmers in the study sites cannot afford to buy commercial feed rations for their pigs, utilizing local feedstuffs as potential feeds presents an opportunity for them to reduce feeding costs and thereby boost their returns from pig farming. It is important to emphasize that no single feedstuff that can supply all the nutrients required for normal body functions. A number of protein, vitamin and carbohydrate-rich foods were identified in the current study but pig farmers need to be taught on how to combine different feed rations to provide a complete ration for the pigs. Studies on the nutrient composition of feeds, including proximate analyses, are necessary to identify specific nutrient deficiencies in the local diets provided to pigs in the study areas.

One of the reasons why farmers kept pigs was their growth rates compared to other species. On the contrary, the weight analysis showed that growth rate in these pigs were low, particularly when compared to what has previously been reported in the literature. This can be attributed by the feeding of inadequate diets of poor quality. Growth rate in pigs is driven by feed intake and reflects variations in the amounts of feed taken (Magowan *et al.*, 2007). Kumasereran *et al.* (2007) observed that feeding pigs with low quality diets could lead to reduced weight gains and subsequent poor performance. Although farmers believed pigs needed to eat grass as part of their diets they also wished they could get commercial feeds for the pigs. This might imply that grass alone was not enough to satisfy the nutrient requirements of the pigs. Teaching farmers on the importance of both quality and quantity of pig feeds is important to enhance rural pig productivity.

By visual estimation, farmers underestimated the weight of their pigs and so likely sold the pigs for a value less than the actual weights. The prediction equations developed from the mathematical models were a closer approximation to the actual weight of the pigs than the weight estimated by the farmers. As earlier indicated, pig weight could be calculated more accurately by using scales. However, these were not readily affordable for farmers. In particular, as feed prices increase, these weight prediction equations present an opportunity for small-scale farmers to improve their bargaining power for better prices. Previous age and breed-specific models (Murillo and Valdez, 2004) developed elsewhere may not accurately predict the weight of pigs in

Africa since differences in breeds, feeding and housing methods exist. Pigs in the current study were local non-descript breeds, kept outdoors, fed poor quality diets and reached an average of 30 kg at 6 - 10 months of age. Improving these breeds is one way of increasing performance; however, for farmers to take advantage of this, they will need to improve the overall management practices, particularly breeding, feeding and disease control. One of the ways in which farmers could keep tract of the weight performance of the pigs is by keeping records of the monthly estimated weights. This may also encourage the farmers to feed their pigs more than what was previously done.

Pig farmers in Busia and Kakamega districts were not aware of the health risks associated with poor pig husbandry practices. The belief that pigs had no enemies and could, therefore, walk freely in the villages, was disastrous and needed to be discouraged. One of the pig farmers concern for free range pigs was that of destroying neighbour crops. Additionally, and perhaps more important, allowing pigs to scavenge for food predisposed them to infections with *C. cellulosae* parasite which presented a very serious public health threat. Farmer education coupled with well-formulated law re-enforcement strategies are the most sustainable options which can be utilized to ensure total confinement of the pigs.

The high local demand for piglets observed in this study presented an opportunity for sow owners to sell piglets and earn an extra income. The proportion of farmers owning sows was low and so was the number of sows owned per farm per visit. Essentially, farmers should keep a small number of productive breeding pigs in order to maintain an appropriate herd size. It was likely that large herd size for pigs was limited by the scarcity of feed and the role of the pig as a source of family income. As described by Lanada *et al.* (2005), reproductive performance of sows determines total population size and further influences the number of pigs available for sale. Pig farmers in the study area were not happy paying a single piglet after the sows were successively bred. The effects of these could be felt more on farms where litter size per sow per farrowing was small and still the farmer had to pay one piglet for boar service. Improving sow management through proper feeding and breeding practices could obviously increase sow performance and consequently result in high litter size and healthier piglets.

Many farmers were completely unaware of the basic sow physiology and so had limited knowledge on sow breeding. The effects of age at first breeding, age at farrowing and parity on the performance of sows have already been described (Schukken *et al.*, 1994; Payne and Wilson, 1999; Tummaruk *et al.*, 2001). There is an urgent call for the farmers to be trained on issues of sow management, including feeding and breeding. High costs of feeding are known to discourage farmers from keeping breeding animals (Wabacha *et al.*, 2004: Lanada *et al.*, 2005). This problem can be solved through the promotion of available local feedstuffs as potential pig feeds. Group owned boars could solve the problem of the few boars in the village and thus farmers will not have to walk for long distances looking for boars to serve their pigs. It is important to emphasize that timely access of a sow / gilt that is on heat translates to timely breeding and maximises litter size. Boar owners and the farmers need to understand the positive relationship between multiple mating and litter size and therefore allow enough time for the sow to stay with the boar. A common fear by the boar farmer is the increased cost of feeding the sow during the days she spends with the breeding boar. A possible solution to this is to request the sow owners to contribute towards the sow feeding costs while she is with the boar. Alternatively, the boar owner can feed the sow and request the sow owner to cover the extra charges. If the farmer has an option, he or she should be encouraged to sell only growing pigs or old sows instead of selling a 1st or 2nd parity sows because litter size and therefore the number of piglets weaned increases with increasing parity up to about the 6th parity. On the other hand, butchers, when they have an option, should be encouraged not to buy young breeding sows for slaughter as this ends the sow's productive life pre-maturely. Both the farmer and the butcher need to be taught on the positive relationship between sow parity and farm productivity, particularly the number of pigs weaned/ sow/ year.

Litter size influences the number of pigs weaned hence the number available for sale. The average number of pigs weaned per litter is an important component of sow productivity (Wilson *et al.*, 1986). Early weaning reduces litter size (Wilson *et al.*, 1986), growth rate and increases mortality (Main *et al.*, 2004) and subsequently impacts on productivity. Further research will need to be conducted to study the common diseases affecting pigs. It has been noted that African swine fever is an important viral infection in the study area. Reasons why pigs were lost to follow up include pigs that were sold, those that had died and pigs that had been stolen. Most farmers did not house their pigs; this might have contributed to cases of theft observed in the current study.

Some of the challenges experienced in this study included the lack of strong tree branches to weigh the pigs in some of the farms, restraining pigs particularly those on complete free range and the post election violence that affected the follow-up visits. Farmers rarely kept records and this might have introduced bias in the accuracy of quantitative parameters investigated (Dohoo *et al.*, 2003).

In conclusion therefore, future research needs to directly address the issues raised during this study in order to offer long term solutions to issues relating to rural pig farming. The results obtained will facilitate stakeholders such as researchers, authorities and communities, to better address the needs of rural pig farmers in Western Kenya. The FGD brought pig farmers together to discuss opportunities for improved pig production. Similarly, the groups brought together staff from the Ministries of Agriculture, Livestock, Health and community Development for discussions on rural pig rearing. The trainer's workshops and the subsequent farmer training workshops provided the farmers with knowledge on better pig management practices and the control of zoonotic *T. solium*, transmissible between pigs and humans. The workshops strengthened the link between the extension staff and research. This is necessary for information flow from the farmers to the researchers and vice versa. The study provided baseline data on pig management and feeding which can now be used in future research. The weight prediction tools developed for the three pig-age categories empowered the farmers to better estimate the weight of pigs, have better bargaining powers on the prices and get better prices for the pigs. Although the weight estimation tool is expected to improve rural livelihoods, the results cannot however be generalised to the wider Kenyan pig population given the nature of the sampling methodology used and differences in breed and management. The findings can however be applied in other areas in Africa where pigs are kept in similar settings as in Western Kenya.

CHAPTER ELEVEN

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CHAPTER TWELVE

12.0 APPENDICES

Appendix 12.1: Sample questionnaire used in household data collection in Busia and Kakamega Districts

3001. (1.1) **Respondents Details:**

Name	Sex	Age (years)	Education	Religion	Occupation	Relation to household head

[**Sex** Male, Female] [**Education** Informal, Primary (KCPE), Secondary (KCSE), College and above [**Relation:** self, wife, husband, parent, son, daughter]

3002. Are you the household head? Yes |__| No |__|

3003. (1.2) Household Head details *(household head is the name of the person making decisions in the family)*

Name	Sex	Age (years)	Education	Religion	Occupation	Size of Land (Acres)

3004 (1.1) Location information

Division: ____________Village: ___________Date: ____________

GPS : Latitude______________ GPS: Longitude_______________

3005. (3.13) Which of the following does the household own? (Please insert the number of the items owned by that household, 0 for any item the household does not own)

ITEM	How many	ITEM	How many	ITEM	How many
Piped water	|__|	Armchair sets	|__|	Working radio	|__|
Water tank	|__|	Wheelbarrow	|__|	Working TV	|__|
Electricity	|__|	Hand cart	|__|	Working clock	|__|
Generator	|__|	Bicycle	|__|	Tractor	|__|
Telephone	|__|	Motor cycle	|__|	Car	|__|
Glass windows	|__|	Working Latrine	|__|	Pick up truck	|__|

3006. (1.12) How is each house in your compound constructed? Check all that apply.

House	Roof	Walls
1	[iron sheets] __ [Grass] ___ [other: specify] ____________	[mud]__ [bricks]__ [Stone]__ [Wood]__ [other: specify] ____________
2	[iron sheets] __ [Grass] ___ [other: specify] ____________	[mud]__ [bricks]__ [Stone]__ [Wood]__ [other: specify] ____________
3	[iron sheets] __ [Grass] ___ [other: specify] ____________	[mud]__ [bricks]__ [Stone]__ [Wood]__ [other: specify] ____________
4	[iron sheets] __ [Grass] ___ [other: specify] ____________	[mud]__ [bricks]__ [Stone]__ [Wood]__ [other: specify] ____________
5	[iron sheets] __ [Grass] ___ [other: specify] ____________	[mud]__ [bricks]__ [Stone]__ [Wood]__ [other: specify] ____________

Tear off sheets.

3007. (3.15) Do you have a working latrine? [Yes] [No] *(Check if the latrine is there and if it is in use)*

3008. (3.15.1) If yes, how often do you use the latrine? [Always] [Sometimes] [Never]

3009. (3.15.2) How often do the children in your household use the latrine when they have to defecate?

[Always] [Sometimes] [Never]

3010. (3.16) How many people live in this **home**? ___ Adults ___children;

In this **compound**? ____ Adults ___children

3011. (3.17a) How many children are in your compound and are old enough to go to primary school?
_____ children

3012. (b) How many of these children do attend primary school regularly?
_____ children

3013. (c) How many children in your compound are eligible to attend secondary school?
_____ children

3014. (d) How many children are attending secondary school?
_____ children

3015. (1.6.1) Does anyone in your household eat meat? [Yes] [No]

3016. (1.7) How would you rate the following categories of meat in terms of your household preference?

Meat	Always Preferred	Often Preferred	Average	Rarely Chosen	Never Chosen	Don't Know
Beef						
Pork						
Chicken						
Goat						
Sheep						
Duck						

3017. (1.4.1) For each livestock animal please complete the following table

Animal	How many do you currently keep on your compound?	How many do you personally own?	How many did you personally own 1 year ago today?	Approximate cost of feed and housing of 1 animal per month KSH per Month	Amount of hours of labour for 1 animal per month Hours per Month
Cattle					
Sheep					
Poultry					
Goats					
Sows					
Boars					
Growing pigs (pigs older than 8 weeks but not full grown)					
Piglets (piglets less than 8 weeks)					

3018. (1.4.3) If you had extra money, which farm animal would you rather buy and why?

Farm animal:____________________
Reason: ____

3019. If you had extra money, which farm animal would be the 2nd likeliest you would buy and why?

Farm animal:____________________
Reason: ____

3020. If you wished to sell an animal in hurry, even if you don't own one now which animal is the easiest to sell?

Farm animal:______________
Reason? _______________________________________

3021. If you wished to sell an animal in a hurry, even if you don't own one now, which animal is the second easiest to sell?

Farm animal: ___________________
Reason? ____

3022. (1.3) Are you the one who was interviewed about pig keeping the last time we visited your homestead? [Yes, No]

3023. (1.3.2) If yes, are you the primary care taker of the pigs? [Yes] [No]

3024. (1.3.3) If No, who is the primary care taker of the pigs? [Another adult female] [Another adult male] [Female teenager] [Male teenager] [Other (specify)]____________

3025. When was the first time someone in your compound owned a pig?
_________ months | years ago

3026. Is this the first year you have owned a pig? [Yes; No]

3027. Is this the first year you or the primary care taker has cared for a pig? [Yes; No]

3028. Did you **PURCHASE** a livestock animal during the last 12 months? For each animal you purchased, please fill in a row in the two tables below.

Animal number (number to match table below)	Animal Type (See list of types below)	Age when purchased	Weight when purchased	Who you purchased it from [neighbor, friend, breeder, relative] specify if others	Purchase Price KSH	Month Purchased (best guess if unknown)
1					KSH	
2					KSH	
3					KSH	

Table continued: For each animal listed in the table above, please complete the following table

Animal number (number to match table above)	Animal (Type)	Why did you purchase?	Do you still own? [Yes; No]
1			
2			
3			
4			
5			

(Note to enumerator: Please use 1 line for each animal purchased. The same animal should be represented in both tables which we will match by animal number)

Animal Types (Cattle, Sheep, Chickens, Ducks, Goats, Adult Sows, Adult Boars, Growing pigs, piglets, other; please specify)

3029. If you no longer have an animal that you had purchased in the last 12 months (identified in tables above), because the animal was **LOST**, **STOLEN**, **EATEN**, **GIVEN AWAY** or **GIVEN TO FRIENDS FOR CARE**, please complete a row in the following table for each of those animals

Animal Number (number to match tables above)	Animal Type	Name / Pig #	Lost | Stolen | Ate | Gave Away | Gave to Friends	Month when lost, eaten, stolen or gave it away	Was the animal eaten, or given away as a result of the political events in January.
1					
2					
3					
4					
5					

3030. Did you **SELL** any of your livestock animals in the last 12 months? For each animal you **SOLD**, Please complete a row in the following **two** tables: Note, the animal does not have to be listed in the previous tables to qualify for this table. You might have purchased the animal prior to one year ago.

Animal number *(match each entry with table below)*	Type of Animal *(sheep, goat, chicken, pig, cow etc)*	Cost of Animal when you bought it?	How long did you have the animal for? I had the animal for ___months	Who you sold it to or gave it to? *(Neighbor, Family member Butcher, Livestock buyer, other please specify)*	Is this animal listed in the PURCHASED Table (3028) above. If yes, record the animal number from table 3028. If no, record No.
1		KSH	Months		
2		KSH	Months		
3		KSH	Months		
4		KSH	Months		
5		KSH	Months		
6		KSH	Months		
7		KSH	Months		
8		KSH	Months		
9		KSH	Months		
10		KSH	Months		

Table continued: For each animal listed in the table above, please complete the following table

Animal number (will match the table above)	Price Sold KSH	Weight when sold	What month did you sell the animal?	Why did you sell the animal?	Was it a good investment? Yes/No	Did you sell the animal as a result of the political events in January? Yes/No
1	KSH	Kg				
2	KSH	Kg				
3	KSH	Kg				
4	KSH	Kg				
5	KSH	Kg				
6	KSH	Kg				
7	KSH	Kg				
8	KSH	Kg				
9	KSH	Kg				
10	KSH	Kg				

*Animal Types (Cattle, Sheep, Chickens, Ducks, Goats, Adult Boars, Adult Sows, Growing pigs, piglets, other; please specify) *Potential reasons for selling (school fees, medicine, illness, death, food, price offered was high, additional people in compound, others: please specify)*

3031. In your opinion, are the animals listed below easy or difficult to **BUY**?

Livestock	Extremely Easy	Easy	Average	Difficult	Extremely Difficult	Don't Know
Cattle						
Sheep						
Chickens						
Ducks						
Goats						
Adult pigs						
Growing pigs						
Piglets						
Other						

3032. Since the political events in January, which animals are more difficult or more easy to buy?

Animals harder to buy ___________ ___________ ___________
Why ____

Animals easier to buy ___________ ___________ ___________
Why ____

3033. Which the animals are you most likely to buy in the next 12 months?

Livestock	Absolutely	Likely	Possibly	Not Likely	Not Likely	Don't Know
Cattle						
Sheep						
Chickens						
Ducks						
Goats						
Adult pigs						
Growing pigs						
Piglets						
Other						

3034. Are the animals listed below easy or difficult to **SELL**?

Livestock	Extremely Easy	Easy	Average	Difficult	Extremely Difficult	Don't Know
Cattle						
Sheep						
Chickens						
Ducks						
Goats						
Adult pigs						
Growing pigs						
Piglets						
Other						

3035. Since the political events in January which animals are more difficult or more easy to sell?

Animals harder to sell ___________ ___________ ___________
Why ____

Animals easier to sell ___________ ___________ ___________

Why ____

3036. Rank the following livestock/crops for profitability?

Livestock	Very profitable	Somewhat profitable	Sometimes profitable, sometimes not	Rarely profitable	Never profitable	Don't Know
Cattle						
Sheep						
Chickens						
Ducks						
Goats						
Adult pigs						
Growing pigs						
Piglets						
Maize						
Beans						
Cassava						
Sugar Cane						
Potatoes						
Tomatoes						

3037. For each food crop that you sold in the last year (since June 2007), please complete the following table: (example of crops: maize, beans, cassava, millet, sorghum, sugar cane, sweet potatoes, peas)

Crop	Weight when sold	Who you sold it to	Price Sold KSH	Cost of seed and fertilizer to grow crop	How long did grow the crop?	Month sold (before or after January)

PIG MANAGEMENT

3101. (2.1) How do you keep your **growing** pigs? What percent of the time (during the day) are the pigs kept in a pen, tethered or free range? [0% means never and 100% means the pigs are only ever kept one way]

a) During the planting season

i) In a pen	[0%]	[<50%]	[> 50%]	[100%]
ii) Free range	[0%]	[<50%]	[> 50%]	[100%]
iii) Tethering	[0%]	[<50%]	[> 50%]	[100%]

b) During the growing season

i) In a pen	[0%]	[<50%]	[> 50%]	[100%]
ii) Free range	[0%]	[<50%]	[> 50%]	[100%]
iii) Tethering	[0%]	[<50%]	[> 50%]	[100%]

c) During the harvesting season

i) In a pen	[0%]	[<50%]	[> 50%]	[100%]
ii) Free range	[0%]	[<50%]	[> 50%]	[100%]
iii) Tethering	[0%]	[<50%]	[> 50%]	[100%]

3102. (2.2) Do you keep your **Breeding pigs** differently from above? [Yes] [No] ____

3103. (2.2.1) If Yes, what percent of the time (during the day) are the pigs kept in a pen, tethered or free range? [0% = never and 100% = pigs are only ever kept one way]

d) During the planting season

i) In a pen	[0%]	[<50%]	[> 50%]	[100%]
ii) Free range	[0%]	[<50%]	[> 50%]	[100%]
iii) Tethering	[0%]	[<50%]	[> 50%]	[100%]

e) During the growing season

i) In a pen	[0%]	[<50%]	[> 50%]	[100%]
ii) Free range	[0%]	[<50%]	[> 50%]	[100%]
iii) Tethering	[0%]	[<50%]	[> 50%]	[100%]

f) During the harvesting season

i) In a pen	[0%]	[<50%]	[> 50%]	[100%]
ii) Free range	[0%]	[<50%]	[> 50%]	[100%]
iii) Tethering	[0%]	[<50%]	[> 50%]	[100%]

3104. (2.2.2) Briefly describe for growing and for breeding pigs how you keep them in addition to what you have said above?

____

____

3105. (2.3) Do you have a pig house? [Yes] [No] ___________________________

3106. (2.4) If yes, what makes you decide when to move the pigs out of the pig house? *(Please select all that apply)*

i) When it rains, the floor is too muddy

ii) When I do not have food to give the pigs

iii) When I do not have time to feed the pigs in the pig house

iv) When the pigs damage the pig house Other (specify): ____________________

3107. (2.5) If you do not have a pig house, why have you not constructed one? *(Please select all that apply)*

[Do not need one] [Do not have the time to build one] [Do not know how to build one] [Do not have the money to build one] [Other (specify)] ___________________________

3108. (2.6) What do you think is the main challenge of small-scale pig keeping? (Number each challenge as either 0, 5, 10 where 10 is the biggest challenge, 5 is moderate challenge, and 0 is the something that you do not think is a challenge)

Challenge (check all that apply)	**Yes**	**No**		**0**	**5**	**10**
Feeding	|__|	|__|		|__|	|__|	|__|
Diseases (specify)	|__|	|__|		|__|	|__|	|__|
Management (specify)	|__|	|__|		|__|	|__|	|__|
Cost of buying the pig	|__|	|__|		|__|	|__|	|__|
Getting the sow bred	|__|	|__|		|__|	|__|	|__|
Not getting enough money for the pig when it is sold	|__|	|__|		|__|	|__|	|__|
Piglets die	|__|	|__|		|__|	|__|	|__|
Finding someone to buy the pig	|__|	|__|		|__|	|__|	|__|
The pigs bother my neighbours	|__|	|__|		|__|	|__|	|__|
Salt poisoning by neighbour	|__|	|__|		|__|	|__|	|__|
Ropes to tether pigs not available	|__|	|__|		|__|	|__|	|__|
Lack of adequate knowledge about pig keeping	|__|	|__|		|__|	|__|	|__|
Limited space for keeping pigs	|__|	|__|		|__|	|__|	|__|
Making a profit	|__|	|__|		|__|	|__|	|__|
Other: specify: ____________	|__|	|__|		|__|	|__|	|__|

3109. (2.7) Do you feed your pigs? [Yes] [No] If yes, do all your pigs get the same quantities of food each meal? [Yes / No]

3110. (2.7.1) What do your pigs eat?. How much will **one** growing pig get at **one** meal? *(Read through all the options)*
(NB: If the farm only has a sow, complete the feeding information on question 3.2:if same amounts are given for sows and other pigs please indicate on the questionnaire)

Type of food	Quantity*	How often fed**	Food	Quantity*	How often fed**
ma			Maize (cooked / uncooked)		
ma peels			Maize stocks or cobs		
s			Millet		
left over from making beer			Omena (cooked / uncooked)		
va			Pasture/Grass		
va peelings			School food waste		
nercial pig feed			Sweet potato (cooked / uncooked)		
food waste			Sweet potato peels (cooked / uncooked)		
from maize / cassava			Sweet potato vines		
ds from fish			What is left in the field after harvest		
potato			Blood / Bones		
en left overs			Fruits (specify)		
from the market			Sugarcane (specify)		
from the posho mill			Other (specify)		

**examples of quantity are: 2 bananas, or a handful of waste, or Litre, cup, 1 plate ¼ kg, debe, 70kg, bundle, 2 kg (Gorogoro), plate, sufuria, bundle, pieces, stem etc*
*** examples of frequency are: daily, 2 times a day, once a week, twice a month, rarely*

3111. (2.8) How often do you feed your pigs? [Once in a day] [Twice in a day] [Once a week] [Irregularly i.e. If food is available] [Three times a day]

3112. (2.9) Do you water your pigs? [Yes] [No]

3113. (2.9.1) How often do you water your pigs (a) once a day (b) when feeding (c) rarely (d) I don't
3114. (2.10) Has keeping of pigs brought you OR your neighbour any problem in the past? [Yes] [No]
3115. (2.10.1) If yes, what problem/s? ____________________________

3116. (2.11) Thank you for telling me what your pig eats, can you also remember what food your family ate yesterday? [Yes; No]

If yes, what did your family eat for?

i. Breakfast (when you woke up)____________
ii. Lunch (meal during the day)________________
iii. Supper (main meal before you went to bed)_______________

PIG PRODUCTION

Sow and boar information

(This section will only be asked to farmers who have owned sow(s) in the last one year; define a sow as a female pig that has had piglets or has been bred)

(This section explores the various reproduction and production aspects of the locally raised pigs in Western Kenya; A sow is any female pig that has farrowed / or has had piglets)

3201. (3.0 Have you acquired any sow since the last time we visited your home? [Yes] [No]
If YES, how many sows do you have now? _________

3202. (3.1 Where did you get your sows from? What did you pay for the sows? (Check all that apply)

Source	Yes	Price (KSH)
Bought as a piglet	____	_________
Bought as a growing pig	____	_________
Bought as a sow	____	_________
Given as a gift	____	_________
Bred in the farm	____	_________
Given by the government	____	_________
Other (specify) __________	____	_________

3203. Please fill details for the sows you have owned in the table below

Sow #	Sow age (now or when she died/sold)	Was sow ever bred? Y/N	How many litters did she have this year	age at 1st farrowing this year	Litter size		Number of piglets that were weaned		What age did you wean your piglets **
					1st Farrowing	2nd Farrowing	1st litter	2nd litter	
1									
2									
3									
4									
5									

*if you don't have the particular sow, please give reason why the Sow is missing (was sold, died, got lost, gave out to friends)
** [< 4 wks] [4-8 wks] [>8wks] [depends on the time I get potential buyers]
[other age:_______________wks]

3204. How many litters has each sow had in her life?
Sow 1 ___ sow 2___ sow 3 ___

3205. If you sold a sow, what was the price you sold her for?
First sow sold:_____Ksh Second sow:________Ksh Third sow:_____ KSH

3206. How old was the last pig to be weaned?
Sow 1___ wks Sow 2___ wks Sow 3___ wks

3207. How did you breed your sow / gilt? [neighbours boar-free] [neighbours boar-paid piglet] [neighbours boar-paid money ___KSH] [roaming boar] [I own a boar]

3208. If you paid a piglet after your sow was successfully mated, how many piglets did you have to pay?________________ piglets per sow bred.

3209. (If it is more than one piglet, why is it more than one piglet?
____
____

3210. Would you prefer to use cash payments or piglets when your sow has been bred?
[cash] [piglet] [other: specify__________]

3211. If you paid KSH after your sow was successfully mated, how many KSH _____ KSH per sow that was bred?

3212. If you own a boar, on average how many sows does your boar breed in one month?
_________________ sows per month.

3213. How many sows did your boar breed last year? ______ sows.
3214. How many months has your boar been breeding sows? _____months
3215. How many piglets were you paid last year for services from your boar? ______ piglets
3216. How much money were you paid last year for services from your boar? ____ KSH

3217. (3.3) Has any of your sows farrowed since the last time we were in your farm? [Yes] [No]? *If yes, complete the following table*

Sow details	Sow one	Sow two	Sow three
Give the approximate age (*months*) of your sow when she farrowed?			
Was this her first farrowing? [Yes; No]			
How many piglets were born in the recent farrowing			
Have you weaned these piglets			
If yes, at what age did you wean them?			
How many piglets were weaned in this last farrowing?			
How many piglets died before 8 weeks?			
What did you do with your weaned pigs? [Sold] [Retained as breeding stock] [Gave to friends] [Other]	---------- ---------- ---------- ----------	---------- ---------- ---------- ----------	---------- ---------- ---------- ----------
Have you re-bred or mated your sow after her previous farrowings?	Yes / no	Yes / no	Yes / no
How soon after farrowing was the sow rebred? (*Vile nguruwe wako alizaa, ulimpatia ndume baada ya siku / wiki/miezi ngapi?)*			
How many days did she stay with the boar before she could be bred? *(Alikaa na ndume siku ngapi kabla ya kupandwa?)*			
How many times did the boar mate / breed her? (*If the farmer observed) (Alipandwa mara ngapi?)*			
How many days in a row did the boar breed the sow? *(If the farmer observed)*			

Alikaa na ndume siku ngapi?			

3218. (3.2 Do you feed your sows different from other pigs [Yes] [No]?

If yes, how much will a sow get at one meal?

Food	Quantity*	How often fed**	Food	Quantity*	How often fed**
Banana			Maize		
Banana peels			Maize stocks or cobs		
Beans			Millet		
Mash left over from making beer			Omena		
Cassava			Pasture/Grass		
Cassava peelings			School food waste		
Commercial pig feed			Sweet potato		
Hotel food waste			Sweet potato peels		
"Ugali" from maize flour			Sweet potato vines		
Innards from fish			What is left in the field after harvest		
Irish potato			Blood / Rumen contents		
Kitchen left overs			Fruits (specify)		
Waste from the market			Sugarcane		
Vegetables			Other (specify)		
Waste from the posho mill			Other (specify)		

*examples of quantity are: 2 bananas, or a handful of waste, or 250 ml, ¼ kg, debe, 70kg sac, bundle, 2 kg (Gorogoro)

** examples of frequency are: daily, twice a day, once a week, twice a month, rarely; seasonal

Routine Practices

3219. (3.5 What routine practices have you recently done to piglets in your farm? Tooth clipping [Yes] [No] , De-worming piglets [Yes] [No], Iron injection [Yes] [No], Castration of piglets [Yes] [No], Vaccination of pigs [Yes] [No], Take to the river for bathing [Yes] [No

3220. (3.6 What routine practices have you recently done in your farm for growing pigs older than 8 weeks of age? De-worming pigs [Yes] [No], Powder or spraying for parasites [Yes] [No], Castration [Yes] [No], Vaccination of pigs [Yes] [No], Take to the river for bathing [Yes] [No [Other (specify) _________

3221. (3.7 What routine practices have you recently done in your farm for sows and boars used for breeding? De-worming sows / boars [Yes] [No], Powder or spraying [Yes] [No], Vaccination of pigs [Yes] [No], Take to the river for bathing [Yes] [No] Other (specify) _________

3222. (3.8 Have you sold any pig since the last time we visited you? [Yes] [No] _______

3.8.1 If Yes, how much money did you receive when you sold your pigs? Who bought the pig? *(give the lowest and highest price if more than one pig was sold)*

Type of pig	Lowest	Highest	Expected price*	Who bought**	Village/ Mkt sold***
1 Piglet (less than 4 wks of age)	______KSH	______KSH	______KSH		
1 Piglet (4 – 8 wks of age)	______KSH	______KSH	______KSH		
1 Pig (3 – 6 months of age	______KSH	______KSH	______KSH		
1 Pig (7 – 12 months of age	______KSH	______KSH	______KSH		
1 Sow	______KSH	______KSH	______KSH		
1 Boar	______KSH	______KSH	______KSH		
1 Weaner	______KSH	______KSH	______KSH		

* How much would you have wished to sell the pig at
** Who bought (neighbour, butcher men, friend)
*** Specify the village of market or of the trader

3223. (3.10.3) If you sold a sow after we visited you (in June July), how many times had it farrowed before you sold her? ___ times

(Litters is the same as the number of times the sow had farrowed)

3224. (3.11 Have you heard of a disease in pigs where cysts are found in pig's muscles and can be passed from pigs to man? [Yes, No]

If Yes, where did you hear this from? a) Neighbour b) Government staff c) during the pig farmer training d) other, specify__________

3225. If you have a pig with cysts, I s there anything you can do to make the port safe to eat? (Circle one)
Yes, No; Don't Know
If Yes, what?____

3226. (3.11.2 Do you know how pigs get the disease? [Yes, No]
If yes, please describe ____

3227. (3.11.3 Do you boil your drinking water? [Always] [Almost always] [Sometimes] [Never]

POLITICAL IMPACT

3300. Please fill in the table of the prices?

Category	Beef	Pork	Chicken	Goat	Sheep	Duck
Cost per kg **before** January						
Cost per kg **after** January						

3301. What setbacks did you or your family face as a direct result of the political events in January?

How did this impact your family	Extreme impact	Large impact	Moderate impact	Slight impact	No impact	Don't Know	Does not apply
Cost of food became expensive							
Property Damage specify: ____________ ____________							
Cost of farm inputs increased							
Availability of food decreased							
Availability of farm inputs decreased							
Sold livestock at less than expected price							
Sold crops at less than expected price							
I had a harder time selling my crops							
I had a harder time selling livestock							
I was not able to travel outside my village							
I was not able to travel outside my compound							
I was not able to feed my sow							
I was not able to feed my pigs							

3302. What other setbacks did your family face as a direct result of the political events in January

b) Lost a primary income source in the family [Yes; No; Not sure]

If yes, approximately how much income was lost ____________KSH per month?

Was this loss temporary or permanent? ______________

c) Children couldn't go to school [Yes; No; Not sure]

How many children couldn't go to school as a result ___________ children?

i) How many new people came to live in your compound after the conflict? ________

How many children ________ how many adults ________

Were there other impacts on you or your family as a result of the political events in January that we haven't listed? [Yes; No; Not sure]

Please describe these? ____
____
____

3303. (3.12) Are there any household members who are employed in this family? [Yes; No]

3304. (3.12.1) If yes, approximately how much salary does each member earn per month?)

Household member	≤2000 KSH	2001-4000 KSH	4001-10000 KSH	≥ 10,001 KSH
1				
2				
3				

3305. Did any member of the household lose their income as a result of the political events in January ? [Yes; No; Don't know]

3306. Which household members if yes? Circle each household member. [1; 2; 3]

3307. Please explain the reason for the member losing their job? _________
____

Reason for changes might be (lost job, gained job, changes in working hrs, bigger employer expectations)

TRAINING

3400. Did you attend any of the pig-farmer seminars organized by ILRI in 2006? [Yes | No]

3401. If you didn't attend any of the seminars. (Please check all that apply)

a) I didn't have pigs that time although I was a pig farmer
b) This is the first time I am keeping pigs
c) I didn't know the dates for the seminar
d) I didn't have time to attend
e) Someone else from my compound attended
f) Other reason (please explain):____________________________

3402. (1.5.5) If you are the one who attended, list three major things that you learned during the seminar

(a)____
(b)____
(c)____

3403. If you tried something because of the farmer training, or because of the research, what was it?

1. I tried ____
2. I tried ____
3. I tried ____

For each item above that you tried, please rate how successful it was for you?

Number matches the line numbers above	Very Successful	Moderately Successful	Did not make a difference	Not at all Successful	It made things worse	Don't Know
1						
2						
3						

SELLING PIGS

3501. Have you sold a pig in the last year? [Yes; No]
If no, please go to next section.

3502. (3.9.2 How did you determine the price you should get for the pig you sold? (check all that apply)

a) Health of the pig
b) Gender of the pig
c) Age of the pig
d) Breed of the pig
e) Size of the pig
f) Other (describe) ________________
g) The pig buyer offers me a certain price
h) I just guessed
i) It depends on the time of year
j) I measured length and girth and used a formula
k) It depends on how much I need the money at the time

3503. Do you usually estimate the weight of the pig before you sell it? Yes / No

3504. If yes, how do you estimate the weight of the pig? (Check all that apply)

a. I can tell just by looking at the pig what it weighs
b. I use a scale
c. I use a tape measure
d. I just guess the weight
e. Other Specify: ____

3505. When you are selling a pig, do you usually negotiate the price of the pig with the buyer?
Yes / No

3506. If yes, what reason(s) does the buyer usually give so you will lower your price?

____

____

3507. What percent of the time does the women or the man in your family negotiate with the buyer? ____% men ___% women ____% both

3508. Do you have a contract or agreement in place with any of the buyers/butchers?

Yes / No

3509. When you went to sell a market pig, did you ever have to lower your price because other farmers were trying to sell pigs at the same time? [Yes; No; don't know]

3510. For each pig you sold last year, why did you sell it? (Check one item per row for each pig that you sold)

Pig	Buy Food	Pay School Fees	Buy Christmas Gifts	Buy Goods	Other: Specify
1					
2					
3					
4					

3511. (3.10.2) The last time you sold a pig;

a) Do you think you received a good price for the pig(s) you sold? [Yes; No]
If No, why? ______________________________
If Yes, why? ______________________________

b) How long did it take you to sell your pig once you had made the decision to sell?____________(specify if hours/days/ weeks)

c) Were you in a rush to sell your last pig? [Yes; No]

d) Do you think the selling of your pig helped you financially? [Yes; No]

If yes, how did it help you? ______________________________

If No, why didn't it help you? ______________________________

3512. (3.11.2) When you are selling your pigs, is there any inspection done on the pig's
[Yes; No; Don't know]

3513. (3.11.3) If YES, what inspection? ______________________________
3514. Who does the inspection? ______________________________

IMPROVING THE INDUSTRY OF PIGS

3601. If the change mentioned below happened in my village, I think that the pig industry in my village would:

	Definitely improve	Likely improve	Not change	Be somewhat less successful	Be much less successful	Do not know
Each farmer raised more pigs						
More farmers raised pigs						
Better roads to improve trading						
Better feed for pigs						
Healthier pigs						
Better health service for pigs						
Credit available to pig farmers						
Credit available to pig buyers						
Government supplies low cost weaned pigs						
Improved breeds brought to the area						
Coordination of marketing						
Coordination of buying from pig farmers						
Created markets to buy and sell pigs						
Guaranteed price / KG						
Farmer cooperatives						
Other						
Other						

3602. If you think credit to **farmers** would help, why would this help?

____

____

____

3603. If you wanted to expand **your** business, do you have any access to credit? Yes / No

3604. If yes, whom can you get credit from? (check all that apply)

a)Government
b)Non Govermental organizations (Give the name of the NGO)

____

c) Other pig farmers
d)Farmer groups (merry-go-rounds)
e) relatives
f) Others: Please specify________________________

COMMENTS

3701. Do you have additional comments about the pig research team's work that you would like to share?

____

____

____

3702. Do you have other comments about the business of pig farming that you would like to share?

____

____

Notes to the Interviewer

Please ensure that the Questionnaire number, household name, the GPS readings match in both the weight sheet and the questionnaire. Always counter check if all sections of the questionnaire have been filled

1. Ask if the farmer has any questions (the team leader will respond to the questions asked)
2. Thank the farmer for his / her cooperation during the interview and also for his/her time

Appendix 12.2: Sample data sheet used in pig weight data collection exercise in Busia and Kakamega Districts

Date______________________ Time farm visited by team today____________

Household name__________________ Questionnaire Number _____________

GPS N____________________ Checked for completion Yes / No___

E____________________ Camera: _______________

Pig ID		Source	Age	Estimated weight	Breed	Pig description	Photo
Tag colour	Tag number		(wks/mos/yrs)	Farmer (kg)		(Colour)	Number(s)

(b)

Pig ID		Sex*	Estimated weight	Length	Girth	Lingual	Weight	Blood samples	
Tag colour	Tag number		Technician (kg)	(cm)	(cm)	test	(kg)	Serum	

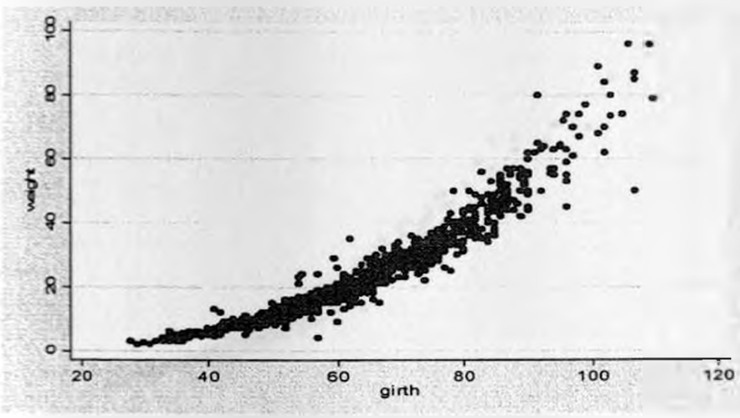
(c)

No of pigs examined/ and Ear-tagged in June/July	No missing	Pig ID (details for pigs missing)	*Reasons for missing	Record (if the farmer used the pig wt sheet issued during the training)	New Wt sheet (if new wt sheets were issued; record # issued)

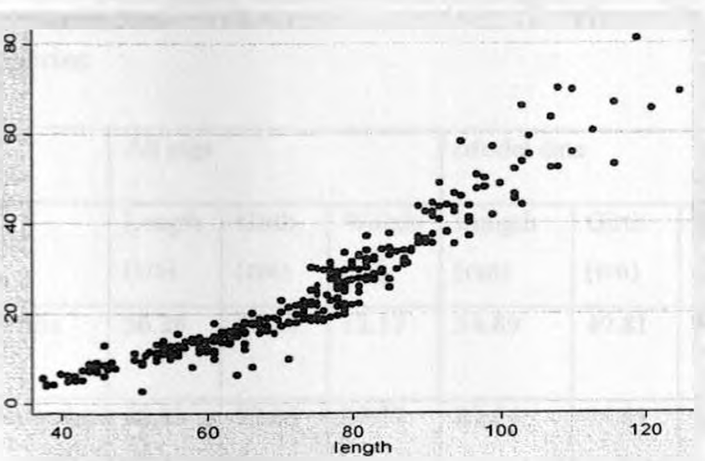
***Reasons- Died, sold, lost, any other reason...... (if sold, what was price obtained for the pig? Did the farmer base the price on the weight of the pig?)**

Ask if the farmer used the pig weight sheets, record the information recorded by the farmer in a separate sheet of paper

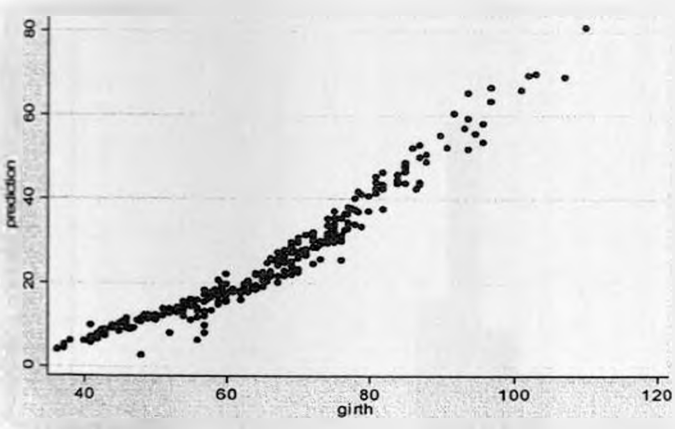
Appendix 12.3: Relationship between the observed pig weight and pig girth for all pigs in the study in 2006 - 2008



Appendix 12.4: Relationship between predicted pig weight and length for pigs in 2006-2008



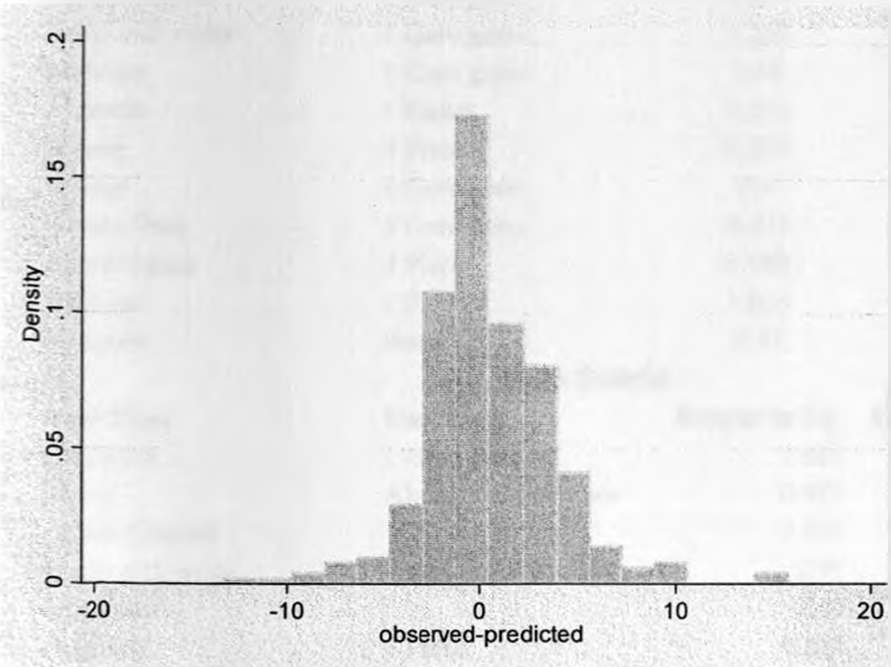
Appendix 12.5: Relationship between the predicted pig weight and girth measurements for pigs



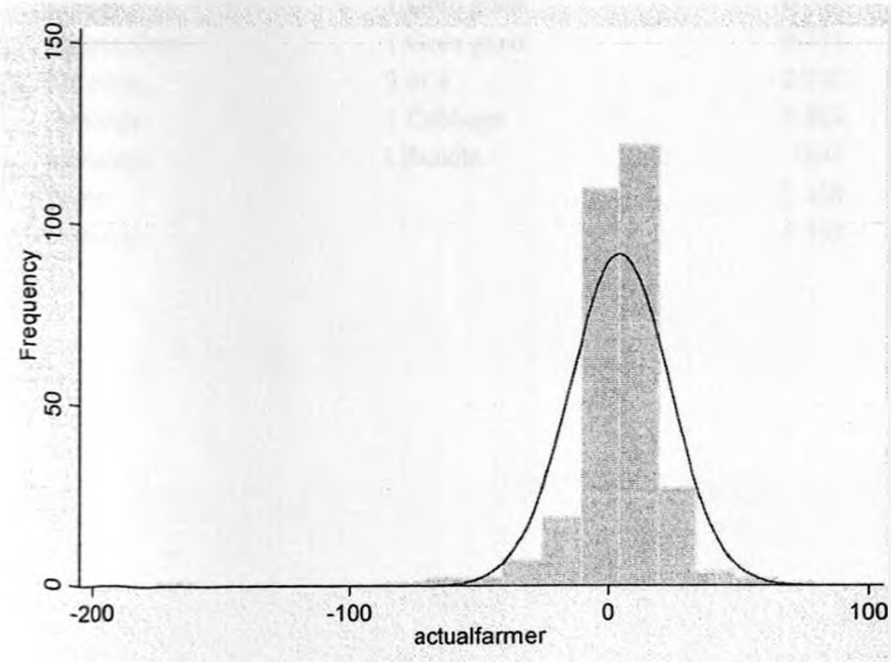
Appendix 12.6: Mean measurements for length, girth and weight for the three age categories

	All pigs			Model data			Validation data		
	Length (cm)	Girth (cm)	Weight (kg)	Length (cm)	Girth (cm)	Weight (kg)	Length (cm)	Girth (cm)	Weight (kg)
≤ 5 months	56.28	50.84	12.17	54.89	49.81	11.39	58.62	52.70	13.6
5.1-9.9 months	80.30	70.05	29.57	80.64	74.41	29.8	79.55	70.18	29.57
≥10 months	92.19	80.45	41.67	94.24	82.12	44.35	90.31	79.18	39.24

Appendix 12.7 (a and b): Distribution of the difference between the observed pig weight and the weight predicted by the model (a) and the difference between the observed and farmer estimate (b) for pigs in Busia and Kakamega District, Western Kenya



a)



b)

Appendix 12.8: Feed costs in Kakamega and Busia Districts

Kakamega District

Feed Type	Unit used	Weight in Kg	Cost / Kg
Machicha	1 Goro goro	1.623	36.96857671
Blood	1 Goro goro	0.932	80.472103
Rumin Content	1 Goro goro	1.725	52.17391304
Posho mill waste	1 Goro goro	1.263	31.67062549
Molasses	1 Goro goro	2.68	18.65671642
Avacodo	1 Pieces	0.542	9.225092251
Banana	4 Pieces	0.295	33.89830508
Omena	1 Goro goro	0.6	250
Omena Dust	1 Goro goro	0.731	109.4391245
Irish Potatoes	4 Piece	0.983	30.51881994
Cabbage	1 Piece	1.826	27.3822563
Mangoes	Bunch	0.41	24.3902439

Busia District

Feed Type	Unit used	Weight in Kg	Cost / Kg
Machicha	1 Goro goro	1.623	
Blood	Almost 1 Goro Goro	0.932	
Rumin Content		1.725	
Posho mill waste	Almost 1 Goro Goro	2.93	6.825938567
Molasses		2.68	
Avacodo	1 Piece	0.408	12.25490196
Banana	3 Bananas	0.388	25.77319588
Omena	1 Goro goro	0.528	170.4545455
Omena Dust	1 Goro goro	0.731	
Potatoes	3 or 4	2.272	17.6056338
Cabbage	1 Cabbage	1.826	
Mangoes	I Bundle	0.41	24.3902439
Beans		2.168	64.57564576
Cassava		1.558	28.88318357

Appendix 12.9: Pig feeding in Busia District, Western Kenya

BUSIA					
Food type	Visit 1	Visit 2	Visit 3	Total	% total (proportion)
	N=164	N=157	N=134	455	
Banana	10	17	31	58	13
Banana peels	16	16	32	64	14
Beans (mainly the soup)	23	30	32	85	19
Bones and blood	1	59	39	99	22
Cassava	87	80	95	262	57
Cassava peelings	0	5	34	39	8
Commercial feeds	9	14	11	34	7
Hotel food waste	20	17	34	71	16
Innards from fish	42	47	49	138	30
Kitchen left overs	145	128	109	382	84
Maize	45	35	71	151	33
Maize cobs/stocks	10	15	30	55	12
Mash from beer	76	73	71	220	48
Omena	137	114	106	357	78
Rumen contents	1	1	3	5	1
School waste	3	4	6	13	2
Sweet potatoes	126	112	105	343	75
Sweet potato vines	92	101	105	298	22
Ugali (maize / cassava)	160	132	112	404	88
Sugarcane	6	55	55	117	25
What is left on the farm after harvest	33	42	46	121	27
Weeds (mainly black jack)	12	7	3	22	4
Vegetables (local, tomatoes)	4	9	1	14	3

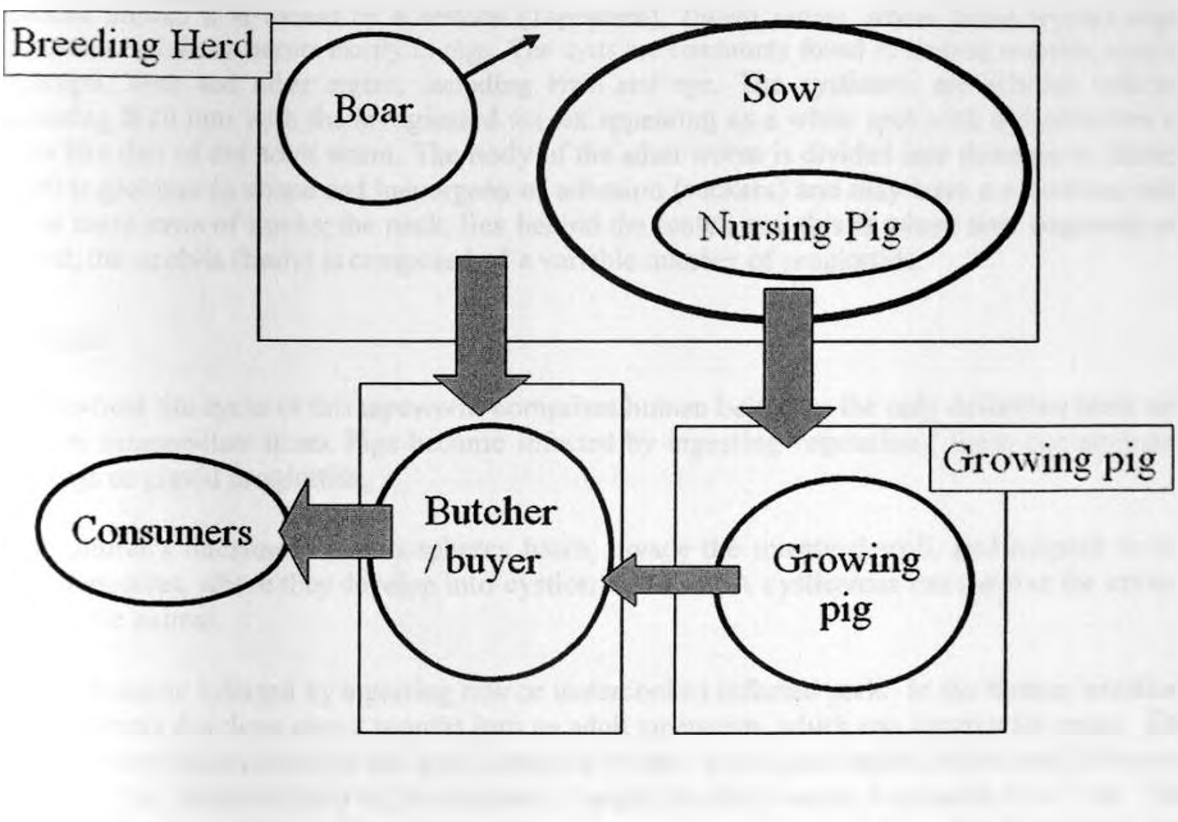
Appendix 12.10: Pig feeding in Kakamega District, Western Kenya

Feed type	1st (n1=124)	2nd (n2=121)	3rd (n3=104)	Number of observations	% of n3+n2+n1
Blood / Bones	58	39	36	133	38
What is left on the farms after harvesting	99	46	32	177	51
Posho mill waste	91	47	38	176	50
Waste from the market	54	29	20	103	29
School food waste	50	28	24	102	29
Cooked beans	69	21	21	111	32
Commercial feeds	67	32	40	139	40
Hotel food waste	63	37	38	138	40
Bananas	70	24	22	116	33
Omena	67	34	31	132	38
Millet	4	2	1	7	2
Maize cobs	59	12	19	90	26
Maize	72	29	24	125	36
Ugali	123	68	61	252	72
Total number of observations	**946**	**448**	**401**	**1801**	

Appendix 12.11

TRAINING MANUAL FOR PIG FARMERS IN WESTERN KENYA

Cycle of a Sustainable Pig Industry



Consumers:

To ensure a sustainable pig industry it is vital to ensure consumers are confident that we are producing safe and wholesome pork. Farmers, Livestock Officers, and Butchers all play a role in maintaining consumer interest in pork.

The Pig Tapeworm

Taenia solium cysticercosis is one of the most common infections in pigs, with a significant zoonotic and economic impact. It is caused by a cestode (Tapeworm), *Taenia solium,* whose larval (cystic) stage, *Cysticercus cellulosae* occurs mostly in pigs. The cysts are commonly found in skeletal muscles, tongue, diaphragm, heart and other organs, including brain and eye. The cysticerci are whitish vesicles measuring 8-10 mm with the invaginated scolex appearing as a white spot with a double row of hooks like that of the adult worm. The body of the adult worm is divided into three parts: Scolex (head) is globular in shape and has organs of adhesion (suckers) and may have a rostellum, with one or more rows of hooks; the neck, lies behind the scolex and this is where new segments are formed; the strobila (body) is composed of a variable number of proglottids.

<u>Life cycle</u>

The two-host life cycle of this tapeworm comprises human beings as the only definitive hosts and swine as intermediate hosts. Pigs become infected by ingesting vegetation / feeds contaminated with eggs or gravid proglottids.

In the animal's intestine, the oncospheres hatch, invade the intestinal wall, and migrate to the striated muscles, where they develop into cysticerci / larva. A cysticercus can survive for several years in the animal.

Humans become infected by ingesting raw or undercooked infected pork. In the human intestine, the cysticercus develops over 2 months into an adult tapeworm, which can survive for years. The adult tapeworms then attach to the small intestine by their scolex and reside in the small intestine, leading to the intestinal form of the disease. Length of adult worms is usually 2 to 7 m. The adult worm produce proglottids which mature, become gravid, detach from the tapeworm, and migrate to the anus or are passed in the stool. The eggs contained in the gravid proglottids are released after the proglottids are passed with the feces. Up to 50,000 eggs per proglottid can be produced in one proglottid.

Human beings can also become intermediate hosts, by directly ingesting *T. solium* eggs shed in the faeces of human carriers of the parasite. These eggs then develop into cysticerci which migrate mostly into muscle (causing cysticercosis) and into the central nervous system causing neurocysticercosis (NCC).

<u>Risks of contacting *T. solium* taeniosis / cysticercosis</u>

- Irregular meat inspection procedures
- Eating improperly cooked meat
- Poor personal hygiene eg not washing hands after visiting latrines
- Absence of latrines

- Failure to properly confine pigs

Diagnosis

In humans, direct recognition of proglottids in human faeces is the best option for identification of *Taenia* infections but it may be hard to differentiate eggs of *T. saginata)* and *T. solium* which are similar morphologically

1. Tongue Test
   Diagnosis can be made in live pigs using the lingual palpation method where cysts are palpable on the base / underside of the tongue. It is not easy to see cysts at early stages of the infection.

2. Postmortem Meat Inspection
   This involves palpation and incision of various parts of the carcass including the tongue for the presence of the cysts. Cysts can be seen during routine meat inspection procedures

3. Serological Tests
   This involve use of blood / serum to test for the presence of antibodies / antigens to T. solium

Control

Taenia solium taeniosis / cysticercosis is a potentially eradicable disease.
Why?

1. Humans are the only definite hosts hence carriers can be diagnosed and treated.
2. Pigs are the only intermediate hosts of epidemiological importance

The control and prevention of taeniosis / cysticercosis consists of breaking the life cycle. Therefore, control measures will include;

- Proper inspection of pig carcasses
- Proper disposal of human waste (use of latrines)
- Personal Hygiene
- Total confinement of pigs
- Eating pork that is properly cooked

The Breeding Herd: Sows, boars and the nursing piglet

Sows

Discussion: Sows: Selecting the gilt for breeding (starting with the weaned pig), breeding the sow, keeping breeding records, housing, feeding, weaning the sow, and sow diseases. Question: how long should a farmer keep a sow? What gives a better economic return; selling after one litter or selling after 4 litters? Which choice would you make if you wish to reduce risk?

Gilts are females before they farrow, sows are females after they farrow, boars are intact male pigs and barrows are castrated male pigs

Gilts are needed for replacement of breeding sows. Selection of gilts should begin at birth, based on genetic potential for litter size. Gilts born to sows that show obvious signs of estrus and then produce large litters will likely be successful breeding females as well. Gilts selected should be healthy and have good growth rate, sound feet and legs and good conformation and spacing of functional teats. Gilts can be raised from a piglet born on the farm or they can be purchased. If you raise a gilt born on your own farm, you must find a boar that is not related to this gilt when she needs to be bred. A young gilt mated in her second observed heat (estrus) will have more piglets and a better chance of farrowing than if she is mated in her first heat. Pigs are pregnant for almost 4 months (115 days).

Mature sows need to have strong feet and legs, good conformation and spacing of functional teats, a history of showing strong estrus and weaning a good sized litter. Sows should be in good body condition and not show evidence of drastic weight loss due to nursing the litter. Sows usually wean more pigs than gilts. Sows giving birth to their 3^{rd}, 4^{th} and 5^{th} litters are typically the most productive. A sow can produce 2 litters in a year. Should a farmer keep a female after she weans her first litter? A farmer likely feeds a sow for 14 to 18 months before she weans her first litter. If 5 pigs are sold from the sow, the farmer receives Ksh 2500. If the sow is in good shape after the pigs are weaned, the farmer might get another Ksh 2500 if she is sold for meat. But, if the farmer wants to keep breeding sows, they will wait another 14 – 18 months before another litter is ready to be weaned. If the sow is re-bred after weaning, the next litter might be sold in 7 months. If a farmer wishes to begin selling weaned pigs, it may be profitable to purchase a sow that has already successfully given birth and weaned a good-sized litter.

Correct heat detection during estrus is important for profitable pig productivity enterprises. Sows will come into heat 3 to 11 days after the pigs are weaned as long as all of the piglets are weaned on the same day. If piglets are weaned over several weeks, sows may come into heat while they are nursing. However, these sows may not come into heat until all of the pigs have been weaned and if they are gradually weaned, it is difficult to know when to expect them to come into heat. It is easiest to see signs of heat in a sow that is near a boar. The best method is to walk a sow to the boar every day until she comes into heat. If the sow is around another sow, she will also show more signs of heat and will mount the other sow. Signs of heat are mentioned in the table below. Older sows may stay in heat longer than young sows
Mate the sow every 24 hours while she is in heat (this may be for 3 days)

It is important to have an up to date record keeping system. This allows you to know and tell what is happening in your farm at any one given time. Keep a record of when the sow is bred.

Sows are expected to farrow approximately 4 months after being bred. Typical gestation length is 113 to 116 days. Check the sow 18 to 25 days after she is bred to see if she comes into heat. Check her again at 42 days after breeding. If she does not come into heat at those times, she is likely pregnant and will typically remain pregnant as long as she does not abort due to an infectious disease.
Sows give birth to 6 to 12 piglets at a time. Typically, 10 % of the piglets die before they are weaned.

Below is an example of a record sheet for a breeding sow. Appendix 1 has a full sheet that can be copied for distribution to farmers.

Example record sheet for a breeding sow

Sow Name: ______________________________

Date Bred	Date 21 days later	Date 42 days later	Date due to farrow (115 d)	Date farrowed	Number Pigs born alive	Date weaned	Number Pigs weaned

* Be sure to treat the sow for internal and external parasites 4 weeks and 2 weeks before the sow is due to farrow.

Boars

Discussion: Boar: Selecting the boar, keeping people safe from boars, keeping the boar healthy, how many times a boar can breed in one week.
Why do villages have insufficient boars? Why do farmers not wish to let their boars be used for breeding sows owned by other farmers?

Choose your breeding boars carefully; avoid boars with history of reproduction problem such as reduced libido or penile or testicular abnormalities. Boars need strong feet and legs to mount and breed the sow. In-breeding (breeding a boar to a sibling, parent or off-spring) will result in small litter size, reduced chance of farrowing and increased numbers of piglets with deformities. Boars purchased as weaned pigs may have a nose ring inserted to increase the safety of handling the boar when he becomes older. Boars grow tusks that they use for fighting. The tusks can be removed by a veterinarian who will sedate the boar and then saw the tusks just past the gum line.

Housing is an important part of owning a boar. See the section on Housing.

Table 1: Problems sighted by farmers regarding Breeding pigs

Problem	*Description*
Sow never lets the boar breed her	The sow is in heat (estrus) for 2 – 3 days every 21 days. It is difficult to identify heat when the sow is not mixed with other sows or boars. Sows exposed to a boar every day will show a good heat. Sows in heat have their ears up, vocalize, have a swollen, red vulva and vulvar discharge, and will stand still if you put pressure on her back.
Boars are rare	Most boars are castrated. Neighbours may not let the sow owner use him for breeding. Why is this? Are they concerned about disease transmission? (be sure to treat your sow for lice before taking her to the boar). What do they get paid for a getting a sow pregnant?
Boars are dangerous	Boars can have a nose ring put in their noses with a chain attached for more control. Build a pig house for the boar that is 7.5 m^2. Put the sow in the pen with the boar for breeding. For safety, only go into the pen if you are carrying a board. Boars grow tusks that they use as weapons. A veterinarian can sedate the boar and cut the tusks.
When the sow is to be bred	How to we feed the sow?
Sow gives birth prematurely	There are many infectious diseases that can cause a sow to give birth prematurely
Problems feeding the sow	Sows are large pigs that must be fed more that the household waste. In particular, sows need a lot of feed when they are nursing. Sows also need to be fed extra when they are pregnant. A pregnant sow will need to eat 3 – 4 kg of ugali per day. A nursing sow will need to eat 6 – 10 kg of ugali per day.

The Nursing Piglet

Discussion: Care of the newborn, hypothermia, structure of a pig house for newborn, colostrum and milk intake, why newborn pigs die.

Should a pig be weaned at 4 or 8 weeks? Why? Should a 4 week old pig be sold for the same price as an 8 week old pig?

Piglet Mortality

It is typical that 10% of all piglets born alive will die before weaning. If you have 10 piglets born alive, you will be doing well if you are weaning 9 pigs. If you have 12 piglets born alive, you should be able to wean 10.5 piglets. As the number of pigs born alive increases, the mortality rate usually increases. This is because large litters usually have some very small pigs born alive and these pigs have a high mortality rate. If only 6 pigs are born alive, it may be possible to wean all of the pigs from the sow.

Iron Injection

Pigs are born without enough iron stored in their bodies. Pigs do not get enough iron from milk. More than half of the iron in the body is found in the form of haemoglobin. Pigs without enough iron become anaemic. This anaemia leads to low growth rate, long hair, higher morbidity and higher mortality.

Baby pigs get enough iron from soil if they are farrowed and raised outside or in an enclosure with a dirt floor. If piglets are born and raised on cement, they must be given extra iron in the feed or by injection. Pigs should be injected at 3 – 5 days of age. The injection should be given in the muscle along the side of the neck.

Colostrum

Piglets are born without antibodies needed to fight infection. Colostrum is the first milk produced after giving birth. Colostrum gives piglets antibiodies to fight infection. Pigs will consume most of the colostrum in the first 24 hours of life. If a sow has more than 10 pigs born alive, the smallest pigs and those that are the last to be born may have trouble getting enough colostrum. After the whole litter has been born, put the biggest 5 pigs in a box for one hour and let the smallest pigs drink colostrum without competition. Do this for two, one hour time periods on the day of birth.

Keeping the piglet warm and dry

The baby piglet is born with minimal fat reserves (no energy reserves), no acquired immunity and an inability to control its own body temperature. It undergoes a marked drop in environmental temperature from 39°C in the uterus (102°F) often down to as low as 18°C (65°F). It has no fat insulation, has little hair and a poor thermo-regulating mechanisms Pigs must have a warm environment (39°C) to maintain its own body temperature. If not, the pig will develop hypothermia and die. At birth, piglets need to satisfy three very important requirements.

1. The intake of antibodies from the colostrum, in particular IgG (immunoglobulin G) and IgA (immunoglobulin A). Without these it will die, having no protective mechanisms against the environmental organisms.

2. It must conserve heat to be able to utilize its scant energy resources to compete with litter mates and gain access to a teat.
3. It requires an immediate digestible source of energy (i.e. sows milk).

Clinical abnormalities of the piglet at birth include: Low birth weight; Hypoglycemic. - low blood sugar; Anoxic - short of oxygen; Defective - e.g. splay leg, cleft pallet; Anemic; Diseases e.g. PRRS, E. coli; Trauma / injuries

Table 2: Problems sighted regarding Piglets

Breeding Herd	Comments
Piglets died because they were stepped on or laid on	Newborn pigs cannot keep their bodies warm. If they do not have warm grass to huddle in, they will get very close to the sow for warmth. Be sure the piglets have a nest to stay in as soon as they are farrowed. Piglets should be closely watched because in the first week of life they have a high mortality rate.
It rained and the pigs died	Newborn pigs cannot keep their bodies warm. If they become wet or cold, they will die because of diarrhea or because when it becomes too cold it does not get up to nurse or because it loses all of its energy (glucose) when it becomes too cold. Newborn pigs need shelter from wind and rain and preferably will be kept in a small enclosure (a pig house)

Table 3: Weights of Piglets.

	Weight of the pig in kilograms		
Age of the pig	Too small	Average	Growing well
Less than 2 months	<5	6	9
Less than 5 months	<8	12	16

Discussion: Why is the price of a 4 wk old pig and a 4 – 8 wk old pig the same? Why would a farmer want to sell a 4 week old pig? Why would a farmer want to purchase a 4 week old pig? Does a 4 –week old pig grow? The pig's digestive system matures with its age and body size. A pig that is too small or too young when it is weaned will not be able to digest food properly. That pig will eat a lot of feed but will not grow well. The villi are the hills and valleys of the inside of the small intestine responsible for the absorption of nutrients. Pigs that are taken from the sow too young or too small will develop villous atrophy. This means that the hills become very short and there are few cells and little surface area for the food to be absorbed. This results in stunted growth and diarrhea.

The Growing Pig (3-6 months, 7-12 months)

Discussion: Selecting the right pig at the right price, feeding the pig for growth, housing, management and disease. Why is one 8 month old pig worth Ksh 500 and another Ksh 2000? Is it worth feeding the pig for maximum growth? What criteria would you use to determine the relative value of two 8 month old pigs? What would you look for if you were a butcher?

The purpose of buying a weaned pig for the pork market is to have a healthy, fast growing pig that attains a specific weight in a specific number of months so that the farmer will have a source of income after a few months. Pigs offer a way for farmers to increase the value of their crops by turning the crops into animal protein (pork). Pigs can also turn kitchen waste into protein.

Discussion: Why do farmers choose to purchase a pig instead of a goat or a lamb? What are the advantages of owning a pig?

Feeding is the most important part of raising a growing pig. Feeding a pig properly enhances the opportunity for the pig to be sold for profit. See the section on Feeding. It is recommended that farmers keep a record sheet for tracking weight gain and profits for each growing pig.

Table 4: Weights of Growing Pigs

	Weight of the pig in kilograms		
Age of the pig	Too small	Average	Growing well
Less than 5 months	<8	12	16
5 to 10 months	<22	30	35

Table 5: Problems sighted regarding the prices of pigs

	Comments
Pigs cost a lot when they are still young	People pay Ksh 500 to 600 per weaned pig regardless of the age of the pig. It is appropriate to pay the same price for a 4 week and 8 week old pig? What about pig weight?
Pigs die after you buy them	Especially if people are not used to keeping pigs. It is important to buy a healthy pig. A healthy pig will have a good body weight for its age, and it won't have any abnormalities such lameness, diarrhea, coughing.

Table 6: Problems sighted regarding the profit of pigs

When not properly fed	A well fed pig costs money to raise. However, a well fed pig also will have a higher return for the farmer.
Have to bargain	Not all farmers wish to bargain with the pig buyer What would be the advantage / disadvantage of having a set price per kilogram of live pig?
Estimating the weight of the live pig	We do not know if the mathematical weight model has helped the pig farmer. Perhaps the new weight chart will make this estimation easier.
Profit was a problem before pig husbandry training	Why?

Table 7: Problems sighted regarding sale price of pigs

When in a hurry to sell	Perhaps there is not time to negotiate a price
When selling mature animals	What is the value of a sow or boar to the butcherman? What is the weight of the mature animals?
Keep looking for a better offer from a buyer	Is the pig farmer using different criteria to evaluate the value of the pig than the buyer? Or is the buyer trying to get the pig for an unfair price?
Do not get enough money for my pig	How much money does the farmer need to get so that they make a profit and the pig buyer makes a profit too.
Money	Farmers considered pig management was a problem when money was involved
Deworming and medication	Perhaps find it difficult to get medications for deworming and other diseases or perhaps they do not have the money to pay for the medication or they do not know the types of medication or where to buy them.

Feeding

It is recommended that farmers keep a record sheet for tracking weight gain and profits for each growing pig.

Example record sheet for tracking weight gain and profit
Pig Name: ___________ Month Born: ___________ Purchase Price: ________

Month	Length	Girth	Estimated Weight	Sale price (Ksh)

The pig's feed is the most expensive (75%) part of raising the pig. If feeding is incorrect, profits and income to the pig farmer go down. The feed must contain the nutrients in the right quantities. Pigs are single-stomach animals just like people. They digest and eat the same kind of food as people and require two or three meals a day. Divide the food into two portions;feed half in the morning and the rest in the late afternoon or evening. Pigs will play with feed that they do not consume in 10 minutes. So after 10 minutes, take the feed away from the pig and feed it to the pig later in the day. Young pigs need 3 meals a day. Important nutrients in pig feed include:

1. Proteins- for growth and body repair e.g. fish processing waste.
2. Energy: -for maintenance of normal body functions e.g. cereals (maize, cassava).
3. Vitamins: - for the maintenance of normal body health e.g. sweet potato, sunlight.
4. Minerals: for strong bones and normal body functions

Water: - Necessary for all body functions like digestion, excretion, circulation etc. You must provide clean water. Pigs require 5 to 10 litres of water daily, sows will need more (30 litres when she is nursing a litter of pigs).

Table 8: Problems sighted regarding feeding

Feeding Problem	Comments
Too many pigs on the farm	One pig may be able to be fed on household waste for most of the year. Farmers with more than one pig will have to have a plan to feed the pigs. Each pig will gain 1 kg for every 4 kg of ugali that they consume. The farmer needs to determine how profitable it is to feed the pig for that weight gain (depending on the cost of feed)
When crops are out of season, it is hard to feed the pig	When there is a shortage of food, the farmer may have to decide to sell the pig
Pigs require a lot of feeding	The pig's stomach is similar to that of people. They need to eat the same kind of feed and they need to be fed 2 or 3 times in a day.
Balancing the diet	It is difficult to balance the diet of the pig, but feeding a variety of foods on a weekly basis is one way to balance the diet of the pig.
Food costs	It is too expensive to buy food to raise the pig. Is this referring to commercial foods or locally grown foods as well?

Table 9a: What are pig farmers feeding the pigs that are a very good weight for their sizes?

	Examples of food fed to pig each day: 4 to 5 month old pigs					
Weight	Food 1	Amount	Food2	Amount	Food3	Amount 3
29	Kitchen waste	0.5 kg	sweet potato vines	1 bundle	_	
29	mash	2 kg	Ugali	0.5 kg	Sweet potato vines	Handful
28	Ugali	1 kg	Waste from posho mill	2kg	grass	_

Table 9b: What are pig farmers feeding the pigs that are a very good weight for their sizes?

	Examples of food fed to pig each day: 6 to 8 month pigs					
Weight	Food 1	Amount	Food2	Amount	Food3	Amount 3
50	Ugali	1 kg	Waste (posho mill)	2 gorogoro	omena	1 gorogoro
53	Ugali (mixture)	2 kg	Grass	_	mangoes (seasonal)	6 pieces
56	Ugali	4 kg	Cassava	3 pieces	Kitchen leftovers	_
70	Ugali	6kg	omena	Handful	Kitchen leftovers	1 kg

Table 9c: What are pig farmers feeding the pigs that are a very good weight for their sizes?

	Examples of food fed to pig each day: sow					
Weight	Food 1	Amount	Food2	Amount	Food3	Amount 3
74	Omena	handful	Vegetables	1 kg	Waste from poshomill	1 kg
79	Kitchen leftovers	Whatever remains	Waste from market	2 kg	Plain flour (maize and cassava)	2 kg
80	Cassava	0.5 kg	Hotel food	0.5 kg	Waste posho mill	2 kg
85	Ugali	1 kg	Kitchen leftovers	Whatever remaining	grass	-

Pig Housing

What it entails

Good sanitation and management is crucial in pig housing to lessen the chances of disease. Farmers can build their own pig houses using locally available materials. It is important to consult livestock department for proper planning of your pig house. Pig houses must be strong and well built. Pigs are very strong animals at maturity.

Pig houses may have a cement or dirt floor. In all pens the floor should slope away from the sleeping area and towards the dunging areas to allow drainage of urine.

Pigs are very clean animals, only that they like rolling in the mud. Pigs are sensitive to heat; they can die from heatstroke after being left in the sun with no shelter or water. Pigs roll in mud or water to cool off in the summer. They also cover themselves in mud to prevent sunburn. If pigs are in a pig house with a concrete floor, they can be cooled by having water poured on their bodies. Pigs can also suffer from sunburn. Even though mud is important, pigs do not like being in the mud 24 hours a day. They like to dry off. Another behavior of pigs is that they root as a natural way to investigate and find food.

Pink pigs are more sensitive to sunburn than black or brown pigs. All pigs must be able to lie in the shade out of the sun. Part of the pen must have a roof to provide enough shade for all the pigs. If the roof is made of metal, it may be covered with grass or branches to keep it cool. Ideally, the pig house will be built under the shade of a large tree.

Pigs do not have much hair on their bodies to protect them from the cold. Pigs suffer if they get too cold. Piglets that are cold get diarrhea. Piglets need a small area with bedding (straw) and solid walls to prevent the wind from coming in. Older pigs get pneumonia if left in the cold, wind or rain. Even if the pigs do not die, they will not be as healthy and strong as they should be. Pigs must have a warm, dry sleeping area.

Pig's pens need to be kept clean to reduce the chance of disease, limit the number of flies and parasites and decrease the odor. Pigs always dung in the same place. Make sure that this mess is cleaned out at least twice a week. Pig manure can be dug into the soil to act as a fertilizer. If water does collect in the pen, dig a drainage furrow or ditch, leading out of the pen. Food and water containers must be cleaned thoroughly at least twice a week.

Pigs like to scratch and be scratched. They will rub against fencing, housing and everything else. Pigs like to play, they will run in circles and chase each other, barking and grunting in delight. Also, pigs like toys. These can be anything from an old feed bucket, cardboard box, stone, stick or feed sack.

Table 10: Problems sighted with Housing

Housing	Comments
Buying tethers	Another cost of pig rearing
Pigs cut the rope	Pigs do pull and chew – if pigs do not have adequate access to feed and water or shelter from the hot sun or cold wind and rain, they will work hard to escape. Pigs like to be with other pigs. They may try to escape to get with other pigs.
Housing	Cost of housing, do not know how to build a pig house, use of very weak materials (for example mud wall) pig damages the pig house, the floor of the pig house is muddy and wet when it rains
Damage crops	When pigs are not tethered they damage crops. Pigs naturally dig with their noses (root). They will dig up crops and eat the neigbour's crops.
Neighbours kill the pigs	Why does this happen? What is the value of the crop? How is the pig killed? – perhaps by salt poisoning, hit using blunt objects resulting in fractures or even death.

Management

Management encompasses the care and work of raising the pig. Housing and feed appear to be the two major concerns of the pig farmer with respect to management. (Feed and Housing are covered later in this document.) The time required to care for and feed the pig and the fact that pigs bother neighbours are the other management problems.

Table 11: Problems sighted regarding management

Management Problems	Comments
A lot of time is consumed to feed and watch	Pigs require constant care. They need to be given water many times in a day and they need to be fed 2 or 3 times in a day.

Table 12: Problems caused by poor management

Pig's problem	Cause	Prevention
Collapses	Heat exhaustion or just prior to death	Pig that has a high fever or that gets excessively hot and does not have access to water will collapse and may die.
Foams	Ate poisonous weed	Tether away from poisonous weeds.
Not eating	Not enough water	Pigs will not eat if they do not have enough water to drink. Water can be given separately or mixed with the food
Shiver	Coldness Fever (other systemic infections)	Pig is too cold – provide a warm and dry area. Use cut grass so pig can make a bed and shelter from the rain. A pig with a fever will shiver.
Sudden death, epileptic seizures, trembling	Salt poisoning, not enough water	Pigs need plenty of water two or three times a day. Pigs that are not given water for one or two days will get a swelling of the brain, will have seizures and die. Pigs that are fed salt will have the same problem.
Skin is peeling or body turns red	Sunburn	Keep the pig in the shade – tethered under a tree or in a pig house with a roof Give the pigs a mud wallow – pigs given water and dirt will roll in the dirt to cover themselves with mud to

		prevent sunburn. Can pour water on the pigs body. Add grass to an iron sheet roof to lower the temperature of the pen.
Vomiting	Poisonous plants Crops with mold	Keep pigs tethered away from poisonous plants. Feeding maize or other crops with mold will not kill the pig.
Wounds (around the legs)	Tether	Tethers should be moved to another leg each week. As the pig grows, the tether will cut through the skin and even into the muscle and bone.
Wounds	Sharp objects	Keep pigs from sharp objects. Wounds that become infected need to be cleaned with salt water three times a day and sprayed with antibiotic wound spray.
Body turns red	Not enough water	A pig's body will turn red if you do not give it water 2 or 3 times a day. A dehydrated pig will turn red.

Health and Disease

Pigs get ill because of the combination of poor management and exposure to infectious disease agents. Very young pigs are highly prone to disease which may lead to mortality. Older pigs are more capable of fighting disease with sufficient feed and a good environment. Infectious viruses such as African Swine Fever will cause a high proportion of pigs to die. To reduce the chance of infection it is important to keep pigs on their own farm, isolated from other pigs.

Table 30: Problems that indicate general ill health that can be caused by disease, injury, insufficient feed or weather conditions that cause stress

Pig's Problem	Comments
Fur stands up Long haired pig	Pigs that are ill or poor doing for any reason will grow longer hair
Head down, not eating	Pigs will become depressed if they are ill from any disease. This depression or lethargy shows up as having their head down.
Not eating, getting thinner, stunted growth	Sows need to be tempted to eat when they have decided to stop eating. Pigs would like to eat anything that people eat. If you can spare a little food, try feeding them something different. It may get them eating again.
Grinding teeth	Pigs will grind their teeth when they are in pain. This might be because of a wound (tether wound) or a clinical disease.
Lose body condition after giving birth	Sows need to eat a LOT of food when they are nursing a litter and they also need to consume a lot of water to produce milk. Sows will reduce their feed intake if they are not given enough water. Sows will need to eat 6 – 10 kg ugali per day to maintain their body condition. Sows may also have an infection in the uterus after farrowing and this will stop them from eating. If she has a bad smelling discharge, she will need to be treated with antibiotics.
Swelling on the teats	Sows can get mastitis but usually the udder will be hot and hard and red – - the sow needs lots of water, and the pigs need to be encouraged to continue to nurse. The sow needs antibiotics. If the sow is not nursing well, the piglets will constantly try to get milk and may damage a teat. Teat wounds can also cause swelling of the udder/teats.

Table 13: Problems sighted regarding disease

Pig's problem	Cause	Prevention
Cough	Many diseases	Many viral and bacterial disease agents cause pneumonia and therefore lead pigs to cough. Although growing and adult pigs can often fight the infection, if the pig is poorly fed or if the pig is exposed to cold and wet conditions, the pig will likely become ill due to these disease agents. Coughing can also be caused by lung worms. Pigs with a cough should be kept warm and dry and will need the attention of a veterinarian.
Diarrhea	Many diseases, poor feed, cold and wet conditions	Young pigs get diarrhea very easily due to Ecoli (a bacteria found in sow's manure), poor feed and becoming wet and chilled. Bacterial diseases will respond well to antibiotics given orally or by injection. Pigs with diarrhea need to be given plenty of water to treat the dehydration.
Itching, skin infection	Lice or Mange	Pigs will scratch on walls and trees. Lice you can see crawling on the pig's skin. Mange live in the ears of pigs and leaves black waxy material in the ears and crusty, flaking skin on the ears and neck. Injections (ivermectins) or powders can be used to kill the lice and mange. Powders need to be re-applied in 18 days to treat the adult and immature mite or louse. If pigs run loose, they will quickly get a new infection from other pigs.
Vomiting and diarrhea in older pigs	Virus infection	(Transmissible gastroenteritis) Pig will recover without treatment
Vomiting and diarrhea in nursing pigs	Viral and bacterial infections	Piglets will die of Transmissible gastroenteritis. Pigs with severe diarrhea due to E coli will vomit. Affected pigs need to be kept warm and dry and given water (mixed with a little sugar and salt) in a bowl so they rehydrate. Treat with antibiotics
Worms, swollen stomach	Intestinal worms	Must be treated with injections (ivermectin) or with powders in the feed that kill worms. The treatment needs be repeated in 18 days to kill both the adult and the immature worm.
Sow gives birth prematurely	Infectious diseases	Many diseases can cause abortion in sows, including viruses such as African Swine Fever and bacteria such as Leptospirosis and *Brucellus suis*
Eye infections	Injuries Infections	Pigs running loose will injure their eyes and predispose pigs to secondary bacterial infections.

Dying without clinical signs	Diseases and salt poisoning	Pigs that are infected with many viral diseases (such as African Swine Fever) or bacterial diseases such as *Actinobacillus pleuropneumonia* or *Strep suis* may die suddenly without showing clinical signs. However, the body will likely show some abnormal signs.
Hook worm and tapeworm		Deworm pigs on a regular basis (3 times per year) Deworm sows 4 and 2 weeks before farrowing

African Swine Fever (ASF)
This disease causes high fever (40.5 to 42.2 C), redness of the skin, abortions, swelling under the skin, and may lead to death. The disease is caused by a virus that is passed from pig to pig by contact and by ticks. The virus lives in pigs, ticks and warthogs. Pigs that recover from the disease carry the virus for a long time.

When ASF first comes into an area, the mortality rate is very high. After a while, the mortality rate is reduced but there are chronically affected pigs that do not grow well.

Spread of the virus
The disease most easily moves from one pig to another by direct contact between pigs. Healthy looking pigs can shed the virus to naïve pigs. Allowing pigs to eat uncooked pork or scraps from the pig butchery is another very good way to spread the disease. People can move the disease by having pig saliva, feces or blood from a carrier or sick pig on their boots or clothing. Ticks, mosquitoes and horseflies can spread the virus by biting a sick pig and then biting a healthy pig. Ticks spread ASF from warthogs to domestic pigs.

Clinical Problem
Sudden death of pigs with no previous illness may be the first sign. Sows are usually first affected and then other age groups of pigs become sick. Sows will have a high fever, stop eating, lie down a lot and abort. The nose, ears, legs and belly of the pig will be red. Pigs develop clinical problems 2 to 14 days after exposure to the virus.

Diagnosis
The skin of the aborted fetus will have streaks of hemorrhage. In a dead pig, there will be streaks of hemorrhage and edema (watery looking swelling) on may organs; lymph nodes, heart, lungs, kidneys, and large intestine. The spleen and the liver will be enlarged and congested (very dark red). The clinical signs and the pathology look like Hog Cholera and salmonellosis. Laboratory diagnoses are the only way to confirm the disease. However, the spread of this acute viral disease in a pig population and these abnormal signs may suggest ASF.

Treatment – none. Good husbandry and supportive treatment; keep the pig warm and bring it water, may reduce the mortality.

Prevention

There is no effective vaccine for ASF. Keep pigs from one farm away from pigs from another farm. Do not allow pigs to eat the carcass of pigs that have died of ASF. Garbage feeding (from a hotel) should only be used if the garbage is well cooked. Treat the pigs for ticks.

Appendix 12.12: A sample record sheet prepared by one of the farmers after the pig farmer training workshop