THE IMPACT OF IMPROVED HOUSING AND EARLY NUTRITION ON THE PRODUCTIVITY OF LOCAL CHICKENS IN MOZAMBIQUE

M.Sc Thesis

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(ISO02002)

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DEDICATION

**Dedicated to my mother Joanete Fernandes, my son Elton Gonçalves,
my brother Camilo Antão, my sister in law Birgit Antão,
my nieces Iracema, Yara and Lea
and my nephews,
Lisandro and Paulo.**

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Copenhagen, 12th April 2005
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SUMMARY

The thesis focuses on free-range chickens in Mozambique and consists of two experiments.

Experiment 1 was carried out on-station with 69 local chickens from 0 to 8 weeks of age. The chickens were randomly allocated to 3 treatment groups in a parallel study design. Chickens were fed *ad libitum* with 18.4%, 11.6% and 12.6% Crude Protein (CP). The first diet (A) was a commercial ration purchased directly from the feed factory - and considered as a control diet. The other two diets were formulated with maize, sorghum, and cowpea with two inclusion levels, 20% (B) and 30% (C), respectively. Due to a lower content of protein both diets B and C were supplemented with fresh maggots (larvae of domestic fly, musca domestica) and green leaves from cowpea. Diet B which obtained the best result, were implemented in the 2nd Experiment.
The final Body Weigh Gain (BWG) of chickens fed diet A was 588.1g; being respectively 45% and 35% heavier than the groups fed on Diet B and C. Although there was no significant difference between the local B and C Diets chickens fed diet B (with 20% of cowpea) grew better, having numerically higher values in all weeks during the experiment.
There was no significant effect of feeding on mortality in Treatments A, B and C.

Experiment 2 was carried out on-farm with 52 farmers and included a total of 535 day-old-chicks to investigate the impact of improved housing and early nutrition on the productivity of local chickens. The study was carried out in Manica province and involved farmers in two different villages. Chickens were randomly allocated to the treatments in a 2 x 3 Factorial design. The first factor was housing system (simple shelter and basket system) and the second factor was feeding system (pure scavenging, semi-scavenging, and gradual scavenging after having 1 month with *ad libitum* feed). Restricted feeding was provided in a creep feeder twice a day early in the morning and late in the evening, while *ad libitum* feed was provided in the basket system during the first 4 complete weeks after hatch. From the 4th to the 8th week chickens were submitted to gradual scavenging. In general three treatments were considered: Treatment 1 - Pure scavenging (and no basket), Treatment 2 – Semi-scavenging system (and no basket) and Treatment 3- Basket system and gradual scavenging.

The results obtained from the BWG, Mortality and causes of mortality were different for each village. In terms of BWG in In Village 1, treatment 3 based on young chickens' confinement in a basket system during the first 4 weeks of life and gradual scavenging from 4 to 8 weeks, showed significantly lower BWG compared with treatments 1 and 2, during the whole 8 week period. Although there was no significant difference between treatments 1 and 2 in village 1 chickens in treatment 2 tended to grow better compared to treatment 1. In Village 2, no significant difference among the three treatments was found. However, in the last two weeks of the experiment, chickens subjected to treatment 1 tended to slow their growth rate, compared to chickens from treatment 2 and 3.

Comparing the villages 1 and 2, treatment 3 resulted in a significantly higher BWG in Village 2, compared with the BWG obtained in village 1 during the 8-week period.

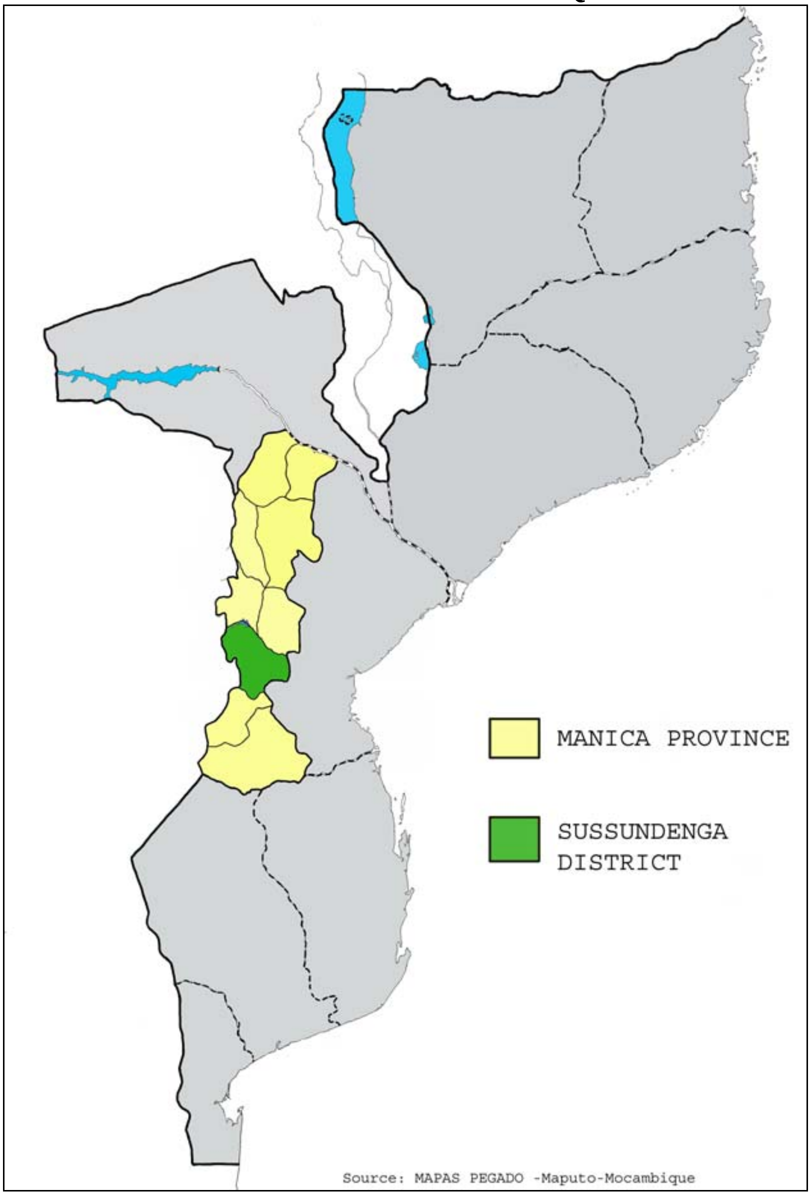
In general, the mortality was highest in treatment 1, reaching 64% in village 1 and 74% in village 2. The predators caused the highest mortality (37%, 50%). The incidence of diseases was much higher in village 2 compared to village 1. In treatment 2 mortality was considerably lower reaching a level of 42% in village 1 and 46% in village 2, increasing survivability to an average of 56% compared to an average of 31% in treatment 1. The results obtained with

treatment 3, using the basket in village 2, improved survivability from 54% observed with treatment 2 to 62% with treatment 3. Apparently, the use of the basket system, in village 1 did not improve survivability compared to treatment 2, where chickens received supplemented feed in the morning and afternoon, but were released to scavenge with mother hen during the day. The impact of predators in treatment 3 was decreased to a large extent in both villages.

It was concluded that providing some practices of management the mortality in general decrease due to the reduction of the predator activity. However, mortality caused by diseases did not reduced.

To improve the productivity of village chickens there is a need to have a holistic view considering the integrated management of nutrition, housing and diseases.

MAP OF MOZAMBIQUE



CHAPTER 1

INTRODUCTION

1.1. Poultry production in Mozambique

Mozambique is located on the western coast of Africa and covers an area of 799,380 square Km. It is bordered by South Africa, Swaziland, Zimbabwe, Zambia, Malawi and Tanzania. Mozambique has a long coast of 2500 Km along the Indian Ocean. Mozambique is administratively divided into 11 Provinces, and subdivided on 144 Districts. According to the National Institute of Statistics the population of Mozambique in 2000 was estimated to be 17, 2 million. Over 60 percent of Mozambicans live in absolute poverty. Widespread coastal production of cashew is important, and other main crops are sugarcane, cassava, sorghum, cowpea, vegetables, rice, and groundnuts. The last Agricultural Census 2003 indicates the total number of native chickens in Mozambique to be approximately 23 million, and more than 70% of the farms situated in the rural area rear local chickens. The average number of chickens per household in rural areas is about 7 chickens (Wethli, 1995). Hens lay 40-50 eggs/year in 3 to 4 different periods and almost all the eggs are destined for incubation. They usually hatch about 8 to 12 chickens (GRM International 2001). Fertility and hatchability seems to be satisfactory, but the survivability of the hatched chickens is a serious constraint since each hen raises only 2 to 4 chickens to maturity (Mavale, 2001).

Chickens play an important role not only because they provide food but also because they are under the responsibility of women and they can sale or barter chickens for food products (salt sugar and oil), cleaning products (soap), paraffin, clothes, school supply for the children or hospital expenses (medicinal drugs) for the different members of the family. Chickens are raised to respond to emergencies and prime necessities and not for the family consumption. Poultry is a favorite food for receiving visitors. Chickens are the smallest animals raised for consumption on special days and to cover to supply family necessities (Bagnol, 2001), and to cover the cost of services such as the traditional healer or midwife. Studies have demonstrated that chickens are the most widely owned and raised species in Mozambique, and the most important species in animal production for the supply of animal protein to the Mozambican population, particularly in rural areas.

Chickens represent an important tool in poverty alleviation and food security at the household level. The number and production level of poultry depends on many factors like breed, production system, feed, environmental factors, health status and etc. Feeds are mainly determined by the availability of feed resource either coming from natural vegetation, cultivated forages or from crops residues. The chickens raised are, in general, of local breeds and the level of production is extremely low. However, this production is achieved with very few inputs. These breeds used are of indigenous type and are generally multicolored with small size. The average body weight of a hen is about 1 kg and a cock about 2 kg (Mavale, 2001). According to Tadelle et al (2001) scavenging poultry is the system appropriate for smallholders as allow the best use of locally available resources without competition with human beings.

Village poultry production is a subsistence system under which the majority of chickens in the country are raised. People living in the rural areas in general keep chickens.

The overall standard of husbandry is usually poor because of the low level of inputs and there are a considerable number of constraints to the village poultry production in Mozambique. Because of the high mortality in their flocks, farmers are reluctant to increase their level of inputs into local chicken production (Mavale 2001). Swatson et al., (2003), describe the main reasons for the low productivity of the free range village chickens as their slow growth rates, poor egg production, high rearing mortalities and susceptibility to diseases. Mavale (1995) revealed that Newcastle Disease is the main constraint to chickens production in rural areas causing mortalities of 50% to 100% annually. Alders *et al* (2001) refers that the implementation of a Program to Control Newcastle Disease increased the number of chickens kept per household, however it is also reported that vaccinations campaigns, although very important, required a better management of chickens through the better utilization of the alternative feed resources.

1.2. Major constraints in rural poultry production

The main causes of mortality in chickens when there are no ND outbreaks are predators, deficient feeding and chilling in the first weeks of life.
According to Tadelle et al (2001) in the Central Highlands of Ethiopia the major constraints on village poultry production was the high mortality of chicks. And the causes for that in their order of importance were disease, predation, lack of feed, poor housing and parasites. Insufficient water supply was also one of the causes of mortality on young chickens and older birds and an important factor for the low productivity.
The same author reported that feed deficiency and malnutrition weakened the birds and made them more vulnerable to predators and increased their susceptibility to disease. The birds needed to travel long distances searching for feed and became more vulnerable to predators.

1.3 Objectives:

The purpose of this study was to determine the productivity of “local chickens” from 0 to 8 weeks under improved conditions of management.
Before the on-farm experiment was carried out it was decided to perform an on-station study to evaluate the effect of two alternative diets with low content of protein, supplemented by maggots and fresh green leaves of cowpea.
From the results obtained in the 1st experiment, the best alternative diet was identified and implemented in the second experiment to assess the effect of early feed supplementation. In addition, the impact of improved housing on the chickens’ survival rate was evaluated.
Finally in order to get a better understanding of the husbandry practiced in selected villages, in village chicken production in two villages in Manica Province were described.

Overall objective

- To determine the productivity of “local chickens” from 0 to 8 weeks under improved management conditions in two villages in Manica Province.

Specific objective

1st Experiment (On-Station)

- To evaluate the effect of two alternative diets with low protein content, supplemented by maggots and fresh green leaves of cowpea.
- To identify the most economic and viable level of cowpea added to the alternative diets for farmers to implement.

2nd Experiment (On-Farm)

- To assess the effect of feed supplementation on very young chicks.
- To monitor and evaluate the impact of improved housing on the survival rate of chickens per clutch.
- To describe village chicken production system in two villages in Manica Province.

Chapter 2

LITERATURE REVIEW

2.1. Poultry production and management in rural areas

Poultry plays a very important role in most developing countries, as poultry contribute to the livelihood of the rural smallholder farmers keeping village chickens (local, indigenous) under scavenging management (Ndegwa, 2001; Safalaoh, 2001). Poultry production in rural areas are considered as a low input-low output system, which makes it a valuable system for farmers having very few resources available for the family to exist, and therefore seldom have means to improve management and production (Scones, 1992; Kusina et al. 2001). The growth rates of local chickens are low and the reasons include different problems relates to the genetic, poor nutrition and disease including parasite infestation (Gunaratne et al., 1993; Tadelle, 1996; Permin et al., 1997). The productive potential of indigenous chickens under an improved nutritional regime and disease free situation is unknown. Therefore, it would be valuable to carry out studies in order to establish this productive potential of local breeds, as they are also believed to be more resistant to some diseases than improved breeds.

However, some initiatives have been taken to improve the productivity of village chickens such as vaccination campaigns and cockerels exchanges program and implementation of the commercial system in a small scale in the villages. However the impact of these interventions has been minimal. A strategy for improving the viability of village chickens must be based on utilization of the scavenging feed resource base (SFRB) to a large extent but in combination with some kind of supplemented feed. At village level the SFRB are estimated to provide more than 60% of the feed needed (Kitalyi, 1998), but the amount and quality of feed resources available differs with the season over the year. In humid areas or during the rainy season plenty of food sources can be found in the surroundings as fresh weed, worms, snails and insects, which is not the case during dry periods. (Mwalusany et al., 2002). Probably for this reason most hens lay and hatch eggs during the rainy season and very few chickens are seen during the dry season. This may be linked to the availability of the food that may influence fertility and the incidence of disease.

High chickens mortality is a major problem facing farmers with local chickens (Tadelle et al., 2001; Mwalusany et al., 2001). Diseases and predation is observed to be the main causes of the high losses of chickens, whereas management factors appear to be more important for survival of the individual bird and for the overall productivity of the flock. Mwalusanya et al. (2001), stated that the protection of chickens up the age of 8 weeks should reduce losses due to predators but this will only be possible with improvement management as proper chicken housing and feeding.

Kumtakar (1999) found that the maximum mortality occurs in the young chicken stage. Some kind of management is crucial and simple management skills like covering the bamboo baskets with newspapers or cow dung for insulation during brooding and protection in winters is very effective. In addition, creep feeding, low-cost balanced feed formulations, awareness about hygiene for feeding and watering of birds, burning of a lamp or charcoal burner inside the brooder in winter to give warmth to the chickens, are some of the simple low-cost management practices suggested to reduce early chick mortality. However, the problems of introducing means to improved management can be illustrated by the fact that some farmers are unaware of the importance of providing water for their chickens (Mwalusanya et al, 2001).

2.2. Mortality

The main causes of mortality in chickens, when there are no ND outbreaks or other serious diseases, are predators (eagles, snakes and wild cats), chilling in the first day of life and deficient feeding. In Nigeria, a mortality of more than 80% within one year after hatching was reported (Matthewman, 1977), and according to Banhare (2001), a mortality rate of 60% before the chickens reach 4 weeks of age is common in North Central Region of Namibia. Mwalusany et al. (2001), reported that mortality in early life was very high with only about 60% of the chickens surviving by the age of 10 weeks. The same authors refer that this 40% cumulative chick mortality is comparable to those reported in Nigeria, Mali and Sri-Lanka (Matthewman, 1977; Wilson et al, 1987; Gunaratne et al, 1993).

According to Tadelle et al (2001) chicken mortality was high in the first two months after hatching and higher when there was a disease outbreak in the area. The author refers that it is difficult to associate the high mortality with a single factor, as it is a combination of several factors, including diseases, predation, feed deficiency and the hostile environment encountered by newly hatched chicks. Kusina et al. (2001), reported that mortality was most severe during the hot, dry season, and that losses were highest in chickens during the first 3 weeks after hatching. With lack of feed in the dry season, chickens are easily weakened, and more susceptible to disease and vulnerable to predators.

2.2.1. Diseases and Predators

Mavale (1995) and Wethli (1995) stated that Newcastle disease is the most important production constraint for poultry production in developing countries causing 50%-100% losses about every year in village flocks in Mozambique. Harun and Massango (2001), reported that the main diseases in Angonia and Tsangano Districts are ND and fowl pox and in addition lice and fleas infestation can be fatal for young chickens. Kusina et al. (2001) also referred to a number of external parasites, fleas and mites that are associated with a reduction in growth of poultry through irritation. Some parasites suck blood causing anaemi, cause hens to abandon brooding resulting in poor hatchability and killing of young chickens. Disease prevention measures are rare and high mortality rates are common (Pandey and Khan, 1992; Wilson et al. 1987; Matthewman, 1977; Permin et al., 2001). In the study by Mwalusany et al. (2001), it was observed that most farmers tried to use traditional medicine (different herbs) during ND outbreaks, but found no effect. In addition it was demonstrated that a lack of cold facilities for keeping vaccine and lack of proper information related to the use of termotolerant ND vaccines are problems that must be solved before efficient use of vaccine can be achieved.

Branckaert and Guye (1999) concluded in their studies that predators such as snakes, rats, dogs, cats, foxes, raccoons and birds of pray represents the main causes of losses in rural areas, especially among young birds. Kusina et al. (2001) also consider in the group of predators, baboons, monkeys, hawks eagles and crows. Harun and Massango (1991) reported that losses to predators as dogs, rats, owls, eagles, hyenas, wild cats, squirrel and thieves are significant and reducing village chicken production. Tadelle *et al* (2001) divide the predators in two categories; those that attack only young chickens (vultures) and those that

attack the young chickens and mature birds (wild mammals currently called wild cats and foxes). Human beings are also considered for all authors as another important predator for adult birds due to comprehensive theft.
According to Tadelle et al (2001) the predation is associated with the rainy season because in this period there is a high density of vegetation, which provided cover for the predators.
Kusina et al. (2001) refers as predators as a menace during the dry season. On one hand the shortage of natural food for baboons and other predators force them to forage as close to the homesteads as possible. On the other hand the vegetation cover declines during the dry season. Particularly young chickens are more exposed to airborne predators such as hawks and eagles. In rainy season the good vegetation cover provides some form of protection against flying predators.

In areas with a major loss of chickens caused by predation, farmers are often reluctant to invest any time to improve productivity as it considered a waste of time. They suggest different ways to prevent these constraints, where one important method could be to construct housing using locally available materials as some sort of housing to protect the chickens. They also recommended that predators should be trapped, hunted or repelled by specific plants. For example, in Nigeria, sliced garlic (Allium sativum) is placed around poultry houses to keep off snakes
Kusina et al. (2001), presented as other causes of mortality exposures to heat and cold. Heat will cause the death of many chickens at the same time. This loss may be seasonal and for that reason management it is very important, because in this case the provision of water is very important in combating effects of heat stress in chickens.

2.3. Nutrition and scavenging feed

The major feed resource base for rural poultry is scavenging and it consists of anything edible found within the environment, Kusina et al. (2001).
In terms of nutrition, Mavale (2001) referred that village chickens obtain food predominantly by scavenging in the surrounding environment close to the homesteads. Their food consists of worms, insects and greenery that are abundant during the rainy season and scarce during the dry season. The productivity of scavenging chickens is determined by the capacity of the scavenging feed resource base (SFRB), which will fluctuate throughout the year dependant on the season (rain – or dry season), harvesting and crop processing (Robert and Gunaratne, 1992), however, the actual quantity and quality of the scavenged feed is seldom known.

Robert (1999) described the possible feed resources in different categories as household waste, materials from the environment, cultivated and wild fodder materials (grasses, herbs and fodder trees and water plants), non traditional feed materials (including sources of animal protein such as cultured snail, earthworms, termites, frogs and unicellular protein and vegetable protein particularly from water plants) and others not important for scavenging condition. In the materials from the environment, it is possible to include: metazoans such as worms, snails and insects, grain products from cultivating, harvesting and processing, green pick and seeds. Village populations of scavenging most likely grow until the capacity of the SFRB is inadequate for young chickens and growers. Consequently the weakened chickens and growers die of starvation when there is competition for scavenging feed (Roberts, 1999). In addition they are more susceptible to disease and predators. Examination of crop contents from local chickens in Tanzania, showed clearly that the feed obtained during scavenging was dependent on the surrounding environment, including household refusal (Mwalusany et

al., 2002), and it was concluded that the feed eaten was below the nutritional requirement of the chickens and varied with season, climate and age of birds.
Yongolo *et al* (2002) reported that under the village system chickens depend on the environmental feed resources base, which shows seasonal fluctuations. In the rainy season protein “might be plentiful” when there is much vegetation and many insects. During the dry season, insects, worms, and even grains are scarce. This could induce seasonal malnutrition, and seasonal immune-suppression, which in turn could contribute to seasonal disease occurrence in village poultry. According to Tadelle (1996) protein supply may be critically, particularly during the dry months of the year while energy may be critical during the rainy season.

The SFRB is not a constant entity and it varies from village to village and between homesteads and over the season (Gunaratne et al, 1993: Mwalusany et al., 2002). During periods with a low capacity of the SFRB it is important to offer local chickens some kind of supplementary feed. The purpose of supplementary feed is to fill the gap between the scavenging feed actually consumed and the nutrition required to maintain growth and decrease mortality. The local breeds only need supplementary feed in periods with shortage of scavenging feed. As the local breeds raised are well adapted to the extensive production conditions, Mavale (2001) recommended conducting studies in order to determine levels of productivity under improved conditions. The main constraint is to compose a supplementary diet in such a way that the scavenging feed consumed and the supplementary feeds together constitute a balanced diet to some extent.

The feed supply for scavenging rural poultry is relatively stable when the environment is able to provide an abundance of worms, insects and post harvest leftovers and water during the rain season (Mavale, 2001). Supplementary feeds are rarely provided apart from household scraps and, in some cases crop by-products and water is seldom provided. Wide variation in seasonal availability of feed is likely to be a major constraint. A study carried out on scavenging feed resource base (SFRB) in a rainforest ecozone in Nigeria showed that SFRB were low in nutritive value with less than 2g crude protein available to each bird per day (Sonaiya et al., 2002). The quantity that was available seems to be very low for the birds’ requirement in terms of maintenance and production. According to Preston et al., (1999) protein improves greatly the survival and early growth of chickens. However crops high in protein are scarce and costly in most tropical countries, and the poor farmers cannot afford to use these valuable crops for poultry feed.

According to Kusina et al. (2001), in order to improve the nutrition of village chicken and the productivity, supplementary feeding may be necessary, as it will reduce pressure on the available SFRB. This will increase the biomass supported by system and reduce survival pressure and selection against the weakest members of the flock and reduce the mortality of young chickens.

Different plants, grass, bushes, trees, vegetable, roots and insects are accessible in the environment and could be considered as an important source of feed for chickens as the described feed resources are not competitive with human food. Kusina (2001) recommend the development of feeds based on locally available ingredients to supplement the SFRB of rural chickens. Riise et al (2003) refers that protein may come from either animal sources or plants. One example of excellent and cheap source of protein is the maggots, which can be grown by a simple technique and is used to supplement the diet of the young chickens. According to Nzamujo (1999), a maggot (the larva of the domestic fly, Musca domestica) as a source of nutrients is a solution to the high cost of feed in fish and livestock. Maggot production is an aerobic fermentation process using as a substrate fermented grain residue namely brewery spent grain and as a fly attractants animal manure (pig and poultry wastes) animal offal (abattoir) dead animals (lizards, birds, rats and other animals) and decaying fruits (mango). The maggot´ harvest begins on the 4th day after first contact the fly has with the substract and reach the right size at this stage. In poultry production fresh maggots are used as basic component of feed for quail and young chickens and are included in the ration of poultry and guinea fowls. The Chemical Composition of maggots is mentioned as: Dry Matter -24,7%, Crude protein- 47,5-50,1%, Lipid 19,3%, Cellulose 23,2%, Minerals 9,1%, Calcium - 1,5%, Phosphorus - 1,2%, Magnesium - 0,3%, Potassium - 1,3%, Sodium - 4528 ppm , Manganese -196,5 ppm , Iron - 425,7 ppm, Cupper- 19,7 ppm and Zinc -235,8 ppm.

2.4 Housing

According to Kusina et al. (2001) indigenous chickens and other kind of poultry were released to scavenge during the day and enclosed or left in the open at night. Some farmers left birds to stay in trees or in open spaces.

Mavale (2001) stated that the general lack of housing is an important factor that favors the loss of birds through predation. The lack of housing system has meant that at times of climate extremes such as heavy rains, cyclones and low temperatures many birds especially the younger ones, are often lost. Khieu (1999) supports the idea that housing will provide safe shelter to the chickens during the night, provide facilitation for vaccination and give farmers better control of their chickens.

The same author refers that appropriate housing provide adequate ventilation, which can help in reducing effects of heat stress in chickens.

Harun and Massango (2001) reported that most farmers in the central part of Mozambique provide some kind of housing for their chickens. Houses are built to protect the birds from predation, to control egg production and to keep the birds away from the fields during the planting season. Chickens are released from their houses during the day and allowed to scavenge, and are enclosed at night. In this area there are basically three types of housing.

Houses at ground level are usually made from mud, rocks or baked bricks, with a roof made of straw. The entrance to these houses is only large enough to permit the entry of chickens and prevent the entry of many predators, especially dogs and hyenas. However the interior is generally small and dark, making access for cleaning difficult. A house of this type does conserve heat, which is especially important in the colder seasons.

Enclosures are sometimes made for chickens under maize granaries. These protect the birds from predators. Rocks or baked bricks are laid around the perimeter of the granary, leaving a small opening to the interior.

However in general housing is not always provided according to Wethli (1985). When it does exist, it is constructed of local material and is intended to prevent predation during the night. In some families, chickens are accommodated in the owner's house, particularly during the brooding period. Where there is no provision of housing chickens roots in trees and they make their nests in the bush, which increases the losses due to the predation.

Riise et al., (2003), recommend for hot climates, the best and cheapest method to apply is the so-called "basket system". When the weather is hot, the chickens often do not need extra heat, but they should be protected against wind and rain. To keep out predators and other poultry, the chickens should be fenced in the basket with access to clean water and feed and can gradually be let out during the day.

2.5. Supplemented feed resources

It is estimated that 60-70% of the general cost spent in commercial poultry production enterprise is represented by feed.
According to Iyayi and Fayoyin (2005) feed resources are a major input in poultry production systems in Nigeria and it is estimated that feed accounts about 60% of total production costs in the commercial poultry sector.
Sonaiya (1995) states that to improve the productivity in smallholder poultry production in free range, backyard and semi-intensive system it is essential to supply the low cost feed. The same author refers that on free range feed supply is not optimal because as not all of the nutrients required by the birds are found all year round.
The use of unconventional feed resources could be the way to expanding the feed resource because the unconventional ration is cheaper than grain based ration, but the smallholders cannot afford it.
Especially during the dry season poultry can develop vitamin deficiencies as a result of lack of succulent vegetables in the scavenging area. The low concentration of energy is due to the fact that the materials contain high levels of crude fiber. The same author refers that smallholders can use the unconventional feedstuffs when feed is scarce. However is important to consider the unconventional feedstuffs that not compete with human consumption if possible.

Maize (*Zea mays*)
Cereals in general are used is developed countries as a livestock feed while in developing countries it is used as a human feed (McNab and Boorman, 2002).
There are different types of maize and the grain appears in variety of colours, yellow, white and red. Yellow maize contains a pigment cryptoxanthin, which is precursor of Vitamin A (Mc Donald et al, 2002).
According to Ravindran and Blair (1991) maize is the cereal most common energy feedstuff used in poultry diets. This cereal is highly palatable and considered as a source of readily available energy however the crude protein is low, 9%. The amino acid profile is very unbalanced with deficiencies in lysine, tryptophan and suphur and excess of leucine (Larbier and Leclercq, 1994). The most common by product used in the rural areas after this cereal processing is the maize bran.

Millets (*Paniicum miliaceum)*
The millets are annual cereal grasses adapted to hot, drought-prone arid climates. Millets generally contains more protein than maize especially the pearl millet with 14.5% CP. Pearl millet when used as an energy source can completely replace maize in balanced diets (Ravindran and Blair, 1991)
However the high fiber content along with the coarseness of the seeds and the presence of high levels of tannins in the hulls reduce the use as a feed for energy ingredient. It can replace maize at levels ranging from 20% to 40%.

Sorghum (*Sorghum bicolor)*
Sorghum is a popular crop with the ability to grow and produce under conditions of drought in low rainfall areas. Sorghum is comparable to maize in nutrient composition and contain more protein (8%-16%) than maize. The use of sorghum in poultry feeding could be an excellent source of energy when adequately supplemented because of the tannin contents. The tannin contents affect the energy utilization, protein digestibility, amino acids availability and palatability (Ravindran and Blair, 1991)

Cowpea (*Vigna unguiculata*)

Cowpea seed is a nutritious component in a human diet and a nutritious for livestock feed. The protein in cowpea seed is rich in the amino acids lysine and tryptophan, compared to ceral grains but deficient in methionine and cystine when compared to animal protein (Davis et al, 1991).

Marconi et al (1993) reported that protein content varied between 20.8% and 27.5%, and explained that the anti nutritional factors content is cowpea is principally tripsin inhibitors, while lectins are not present in great quantities. Trompiz et al (2002) recommended the use of 16% of partial replacement of balanced feed by cowpea flour in the feed for chickens without to affect the body weight gain

According to Nell et al (1992) cowpea could make a valuable contribution to supply proteins for animal feed in South Africa. Cowpeas meal is valuable proteins source, which can provide protein to the animal feed industry. However cowpea has the disadvantages that contain anti nutritional factors, which must be removed by expensive heat treatment in order to make the meal acceptable for use in the diets of monogastric animals.

Chapter 3

SHORT PRESENTATION OF RESULTS

Materials and methods for the two different experiments are described in manuscript 1 and 2, respectively.

3.1 Experiment 1

Table 4a shows the chemical composition of a commercial and two diets, based on local ingredients. The commercial feed has a protein content of 20.82%DM while local diets (B and C) had a protein content of 13.66% DM and 14.75% DM, respectively. To increase the level of protein and vitamins, the local diets were supplemented with maggots and fresh cowpea leaves.

Fig 1 shows that feed A, representing the commercial, balanced feed, resulted in significantly higher BWG compared with diets B and C. The final BWG of chickens fed diet A was 588g; being 45% and 35% heavier than the groups fed on diets B and C, respectively (Table 5).
There was a significant higher body weigh growth in birds feed on commercial feed, where the nutrient requirements for the optimal growth was covered compared with birds fed on local diets B and C.
Although there was no significant difference between the groups B and C, there was a clear tendency that chickens fed diet B grew better, having numerically higher values in all weeks during the experiment. The BWG obtained per week in each treatment is presented in table 6 It can be seen that the gain per week is increasing continuously with chickens fed diet A, until week 6-7, where the gain per week starts to decrease. In treatment B and C the gain per week are lower than treatment A, being significantly different from week 4 onward.
The effect of the diets on the chicken mortality did not show statistically significant differences between the three treatments. The mortality recorded was 16.7%, 18.2% and 21.7% for treatment A, B and C, respectively, indicating that the diet B and C contained nutrients adequate for growth to some extent and to keep the birds healthy when provided feed with maggots and fresh leaves.

3.2 Experiment 2

3.2.1. Chemical composition

The chemical composition of the local diet is shown in Table 4. The local diet was simple and based on locally grown ingredients (maize, sorghum and cowpea). The content of protein and amino acid was very low and below requirement for optimal growth for layer chickens (NRC, 1994). The protein content was 12.8% DM and the amino acid content was 2.32g/kg DM for cystine, 2.33g/kg DM for methionine, 4.84g/kg DM for lysine and 4.43g/kg DM for threonine. The total content of non-starch polysaccharides (NSP) amounted to 8.1%, where approximately 20% were soluble NSP. The content of dietary fibre was 11.8% DM.

3.2.2. Body weight gain

Table 5 shows the body weight gain according to three treatments established in two selected villages: Nhambamba and Bairro dos Trabalhadores in the Sussundenga district. Treatment 1 is referred as a pure scavenging system, treatment 2 is referred as a semi-scavenging

system and treatment 3 is referred as a gradual scavenging after confinement in the basket system during the 1st full month.
In Village 1, treatment 3 showed significantly lower BWG compared with treatments 1 and 2, during the whole 8-week period. Although there was no significant difference between treatments 1 and 2 in village 1, chickens in treatment 2 tended to grow better than chickens in treatment 1. In Village 2, no significant difference among the three treatments was found. However, in the last two weeks of the experiment, chickens subjected to treatment 1 tended to slow their growth rate, compared to chickens from treatment 2 and 3.
Comparing the villages 1 and 2, treatment 3 resulted in a significantly higher BWG in Village 2, compared with the BWG obtained in village 1 during the 8-week period. A significant ($P<0.05$) interaction effect was found between village and treatment in all weeks except in week 4, indicating that the effect of treatment was not the same in the two villages.

3.2.3. Survivability and mortality

The average mortality (%) within each treatment per Village is given in Table 6. The results showed that no significance difference between villages per Treatment.
The possible causes of mortality was recorded and divided into 3 main groups being predators, disappearance (cause of mortality not ascertained), and disease. The distribution in the different groups of the total number of chickens involved in the experiment is shown in Table 7. The results contain data from both villages. In order to discuss the effect of the three treatments within village and between villages, the results are presented as percentages in Figures 1-6.
In general, the mortality was highest in treatment 1 (Figures 1-2), reaching 64% in village 1 and 74% in village 2. Predators caused the highest mortality 37%, for Village 2 and 50% for Village 1(1%). The incidence of diseases was much higher in village 2, (37%). compared to village 1. All experimental birds were vaccinated against ND. In treatment 2 (figure 3-4) mortality was considerably lower reaching a level of 42% in village 1 and 46% in village 2, increasing survivability to an average of 56% compared to an average of 31% in treatment 1.
The survivability of chickens subjected to treatment 2 and 3 (Figure 5-6) did not differ in village 1, being 58% and 52%, respectively.
The results obtained with treatment 3, using the basket in village 2, improved survivability from 54% observed with treatment 2, to 62% with treatment 3.
The causes of overall mortality and causes of mortality during the 8 weeks is illustrated in Figures 7a-d and 7e-h (cumulative mortality). Clearly, there are rather different responses for the two villages. In village 1, treatment 2 yields significantly ($P<0.05$) lower mortality rates as compared to the mortality rates from treatment 1 (Figure 7a). The difference between treatment 1 and 3 was not significant. In village 2, the chickens subjected to treatment 2 and 3 presented significantly lower mortality rates relative to treatment 1 (Figure 7b). However, concerning overall mortality, treatment 1 caused the highest mortality rates in both villages. In relation to predation, the cumulative mortality was comparable between the two villages, as mortality was significantly higher ($P<0.001$) with treatment 1 (Figure 7c and 7d). The curves between the villages differ, however, since the curve for treatment 1 in village 1 increases at a faster rate compared to the same treatment in village 2, indicating that these chickens will be taken by predators at a faster rate, compared to village 2. In figure 7e and 7f, the cumulative curves due to disappearing shows that the risk is highest with treatment 3 in both villages. Concerning disease, the development in cumulative mortality over time differs between the villages (Figure 7g and 7h) as the disease is higher in treatment 3 in villages 1, whereas in village 2, the highest incidence of disease is seen in treatment 1.

Chapter 4

GENERAL DISCUSSION

4.1. Experiment 1

The results obtained in the present study, showed that the body weight gain (BWG) obtained with commercial diet (Diet A), used for the control group, was significantly higher (P<0.05) compared to the BWG seen with diet B and C during all 8 weeks in the experiment (Table 5 or 6). Diet A had an approximate level of protein of 20.8% % DM and apparently sufficient nutrient composition to fulfill the requirements for young chickens' growth. Chickens fed diets B and C with an inclusion level of cowpea of 20% and 30%, respectively, and lower protein content, grew more slowly, and the results indicate that the diets B and C didn't have an optimal content of nutrient for optimal growth.

It was expected to obtain better results with the chickens given diet C with higher inclusion level (30%) of cowpea as a source of protein thereby increasing the protein content of the diet. The results, however, showed that chickens fed diet B, with a lower inclusion level of cowpea (20%) grew better during the experimental period. Even though the difference in BWG between treatment B and C was not significant, the average BWG of chickens fed diet B was on average 45-50g higher than chickens fed diet C, from week 6 onward. The explanation to the present results could be due to the presence of anti nutritional factors in cowpea, which can depress growth. According to Marconi et al. (1993), the principally anti-nutritional factor in cowpea is trypsin inhibitors, which decrease the nutritional value of the protein unless the inhibitors are destroyed by heat processing. From the present study, it can therefore be concluded that it is important to limit the inclusion level of cowpea in diets for young chickens below 30%.

The chemical analyses of cowpea leaves (Table 4b) showed very high protein content, 36.04% and amino acids Lysine and Threonine with 15.91g/kg DM and 14.09g/kg DM, respectively. When the cowpea leaves can be provided fresh and before lignification increases too much, the leaves could be valuable both as a protein source and partly as a source of minerals and vitamins.

The unconventional animal protein sources considered in this study were fly larvae. Kohie et al (2001) considered fly larvae against more conventional poultry feeds because birds commonly eat insects in the wild and a diet containing insects could be readily used by poultry. This research indicated that fly larvae contain 4291 Kcal/kg of energy and 59% crude protein. The same authors reported that soybeans meal contains 3500Kcal/Kg energy and 47% protein. Fresh maggots were not submitted to a laboratorial chemical analysis but Nzamujo, 1999, indicated a very high protein content of 47.5-50%. Kohie et al (2001) and Nzamujo, (1999) on their studies agree that fly larvae have a high concentration of protein, comparable with the nutritive value of soybean.

There was no significantly effect on mortality between Treatments A, B and C, probably because birds were confined and supplemented with maggots and fresh leaves of cowpea. In confinement condition they didn't travel longer distances searching for feed neither were submitted to the harsh conditions of the environment nor exposed to the predation and diseases as the birds in scavenging.

4.2. Experiment 2

The results obtained after implementation of the three treatments showed a different response in body weight gain (BWG), mortality and causes of mortality in two villages where the experiment was carried out.

To explain the results obtained, it is necessary to associate them with direct observations environmental conditions of each village, the socio-economic condition of the farmer and farmers' management.

In village 1, treatment 2 resulted in the best BWG (Table 5), probably because birds received supplementary feed and also obtained additional feed items from the scavenging activity. Contrary to what was expected, chickens subjected to treatment 3 (basket and supplemented feed), had a lower growth compared to chickens in treatment 2 during the whole study period. One reason for this finding could be lack of necessary farmers management skills needed to rear chickens in the basket.

In village 2, the growth curve for the three treatments was almost similar, except for treatment 1, which had a decreased growth in the last 2 weeks. The reason for this result with treatment 1 was most likely, that in the beginning of the experiment the chickens were able to find enough feed in scavenging area to cover their nutrient requirement.

The mortality in treatment 1 (figure 1 and 2), was highest in both villages compared to the other treatment, being 64% and 74% for villages 1 and 2, respectively. The reason for that could be that chickens did not receive water, supplementary feed and in addition had to walk long distances searching for feed. They were more exposed to predators and all the extremes weather climates in the field conditions. In village 1 it can be seen that young chickens disappear frequently probably because they have to walk long distances with mother hen to search for feed, increasing the risk of chicken weakness. Being weak they become more vulnerable to predators because they could not follow the mother hen and could not receive her protection when attacked by predators or even died on the way. Probably this was the reason that in village 1, (13%) of young birds disappeared while there no chickens disappeared in village 2. However, the percentage of disease in village 2 is really very higher, being 37% compared with 13% in village 1. The integrated system of management of livestock in general could be the main reason for that. The results obtained in the present study can be compared with other studies, where Tadelle (2001) reported that in the Central Highlands of Ethiopia the major source of loss in the system, characterized by few or no inputs and a low output level was the high mortality of chicks, reaching 61% during an 8 week period. Mwalusanya (2001) reported the survival rate of local chickens up to 10 weeks in Mororo district of Tanzania to be 59.7%. In the present study 64% and 74% in mortality were found in two different villages during the 8-week period.

In treatment 2 (Figures 3- 4), mortality represents less than 50% and it varies from 42 – 46% respectively for Village 1 and 2. Probably after receiving some supplementary feed young chickens were not so weak and probably could easily follow the mother hen while searching for feed. Being close to the mother it was probably easier to receive some protection from her against the predators. There was a considerable reduction in predation from 50% (Village 1) and 37% (Village 2) to 27% in both Villages.

Concerning disease in village 1, it increased from 1% to 12% between treatment 1 and 2, which was not expected. After supplementation probably the mother hen did not take young chickens to scavenge so far as. However, as the density of chickens was very high in that area chickens were in more close contact with the others and consequently more exposed to some diseases. In Village 2 the percentage of disease decreased by 24% when compared with Treatment 1. The percentage of chickens that disappeared (6%) was twice as high in

village 2, which probably could be explained by the observation that scavenging was often done near the houses, and the risk for theft higher.
Roberts (1999) reported that providing household refuse in a creep feeder for a short period twice a day increased the survival rate but did not improve the growth rate. However supplementing the household refuse with protein improved both survival rate and growth rate. It was shown that the control group reached a mortality of approximately 47%, whereas the group fed with 9% of protein presented around 30% of mortality. Finally, the group fed with 15% protein showed about 18% mortality, indicating a direct relation between the protein level containing in the feed and the rate of survivability, and the best survivability rate is achieved with the highest protein content. In the present study birds fed with 13% of protein showed 44% of mortality. As the quality and the quantity of scavenging feed resource base changes over the year and in addition varies from area to area, depending on the season (rainy season or dry season), and also is influenced by the density of birds scavenging in that area, it is difficult to obtain the same results under different conditions (Gunaratne et al., 1993; Mwalusany et al. (2002).

In the present study, treatment 3 represented the confined system in the basket and in village 2 the mortality was decreased (38%) in the treatment, which could be explained by the factor farmers' management, following carefully the instructions given for rearing chickens in the basket system and giving not only the feed but also the termites and fresh green leaves. They also were more compliant about moving the basket to promote better environment for chickens. The portion of chickens that disappeared in treatment 3 was relatively higher in village 1, probably because farmers provide less care to the management system introduced, and in the confined system young chickens can be easily stolen if not kept under observation, or even be disturbed by children or other animals, which simply wanted to eat. Cases were recorded when another hen, pig or goat entered in the basket to eat and drink feed and water provided *ad libitum* in the basket. During this action all movements caused by the downfall of basket caused the quick disappearance of the chicks from the basket that easily got lost.
Disease constitutes the largest proportion in treatment 3 in both villages. The disease was always higher in village 2, probably because they had the integrated system of rearing all the animals together. In addition, when using a confinement system such as the basket, farmers must be more careful about the management, as young chickens are very sensitive. In a field trial carried out during 16 weeks, it was assumed that keeping the young chickens enclosed during the first 3 weeks, would improve the survival rate during the growth period (Pedersen, 2001). However, the same author found that mortality was lower during the first three weeks (23%) but higher in the following weeks reaching the level of 55%.

4.3. Economic Analysis

The economic analysis was based on supplementation of local feed to the existing poultry management system, assuming the production level of 10 chickens per hen. Ali (2002) concluded that the amount of supplementation depend on the location, availability of feed resources around the farmers' house and better economic conditions of the farmer. With feed supplementation there was an increase of survivability rate from 3 to 6 chickens reaching the adult stage or at least overcoming the critical period of death.
The market price was considered both to purchase raw material and for posterior grinding and feed mixture. The price could be considered lower if the product was produced on the farm. Comparing the number of birds to be sold when some feed supplementation was provided with the number of birds survived if there was no feed supplemented and removing the price of feed provided, there is a minimum profit of 64.800,00 MZM, which means about 3 USD per clutch.

It was the first experiment implementing different poultry management in those villages. If farmers were more aware on this activity, having a higher number of chickens due to the extra feed provided, they would increase the interest to develop this activity and get more profit.
In the basket system the profit is lower being around 2.5 USD due to the feed consumption of mother hen and young chickens. However it could bring another benefit because due to the extra feed got in the basket mother hen can brood again earlier having more than 3 clutches per year. In addition if the basket system is managed properly, the chicken survivability will increase considerably.

Chapter 5

CONCLUSION AND PERSPECTIVES

5.1 Experiment 1

The chemical analysis of local diets, which were based on locally available feed (maize, cowpea and sorghum) showed a relative low content of protein in diets B and C, being 13.66 % DM and 14.75 % DM, respectively.

Cowpea, which is a feedstuff rich in protein (20.8% to 27.5%), was the alternative source of protein used for both diets, and was included with the levels of 20% and 30%. Although there is a minor difference between the two levels of inclusion on the diets, birds fed on diet B grew better, having numerically higher values during all 8 weeks of the study period. This difference can be caused by the existence of anti nutritional factors, namely trypsin-inhibitors that depress body growth. Both diets were supplemented with maggots and fresh green leaves in order to increase the low level of protein, but even with that supplementation the curve of body weigh gain recorded by birds fed on diet B were significantly lower compared with birds fed on the commercial feed.

On the other hand there was no significant difference in terms of mortality which means that from the point of the view of the farmer it is better to prepare feed formulated with 20% of cowpea, because this raw material is more expensive than the others included in the feed, but is an important protein source in order to increase chicken production.

5.2 Experiment 2

It can be concluded, that the use of the basket system in village 1 did not improve survivability compared to treatment 2, where chickens received supplemented feed in the morning and afternoon in a creep feeder, but were released to scavenge with mother hen during the day. The impact of predators in treatment 3 was decreased to a large extent in both villages being 5% in village 1, and 0% in village 2.

In conclusion, family poultry in Mozambique is raised using a traditional extensive system characterized by poor feeding and housing system. To develop any poultry activity under the present situation in rural area it is necessary to understand options available to farmers and raise awareness to how chickens can be raised under improved cost-efficient conditions. Basic skills in poultry´ management and health and access to veterinary extension services must be promoted on order to improve the productivity on village poultry and increase the number of chickens.

CHAPTER 6

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Manuscript 1

The effect of locally available feed resources on the growth of local chickens in Mozambique

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The effect of locally available feed resources on the growth of local chickens in Mozambique

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Abstract

An on-farm experiment was carried out to investigate the growth response of local chickens provided with *ad libitum* diets with 20.8% DM, 13.7% DM and 14.8% DM of protein from day-old-chickens to 8 weeks. The experiment consists of three feeding treatments distributed over 12 pens in four replications. Treatment A was composed of commercial feed while Treatments B and C were formulated using local ingredients including maize, sorghum and cowpea. The difference between B and C local diets was the level of inclusion of cowpea respectively 20% and 30%.
To increase the low nutritive value and vitamins of the local feeds used in the experiment, maggots and fresh leaves of cowpea supplemented both alternative diets.
The statistical analysis performed showed that there is no significant effect of pen and hatch period on body weight gain (BWG).
The final BWG of chickens fed diet A was 588.1g; being respectively 45% and 35% heavier than the groups fed on Diet B and C,
Although there was no significant difference the local B and C Diets there was a clear tendency that chickens fed diet B (with 20% of cowpea) grew better, having numerically higher values in all weeks during the experiment.
There was no significant effect of feeding on mortality in Treatments A, B and C.

Key words – Local chickens, scavenging, supplementation, non-conventional feed, larvae, maggots, and body weigh gain, survivability.

1. Introduction

Several constraints prevent the improvement of family poultry production. Among the constraints is high chick mortality according to Nquindi (2005), caused by inadequate feeding, poor housing, diseases or predators**.** In the family sector the main feeding system for poultry is based on scavenging activity and supplementary feed consisting mainly of household wastes, and grains of maize or sorghum if available (Permin et al., 2001). This traditional management system results in a low level of productivity.
According to Roberts (1999) the protein requirements must be qualified by the need of essential amino acids. If the diet is deficient in essential amino acids then utilization of protein is inefficient and expensive. Vitamins are usually available in a mixed diet, which includes green feed. If there is more than about 7% of fibre in the diet, the efficiency of utilization falls (Roberts, 1999).

However in most tropical countries feed with high protein content is scarce and costly, and not used for poultry (Teguia et al, 1993) The poor smallholders living below the poverty line with less than a quarter of a USD per day and cannot afford such expensive inputs. In terms of nutrition, Mavale (2001) referred that chickens obtain food predominantly by scavenging in the surrounding environment. Their food consists of worms, insects and greenery that are abundant during the rainy season and scarce during the dry season. Robert (1999) describe the possible feed resources divided in household waste, materials from the environment, cultivated and wild fodder materials (grasses, herbs and fodder trees and water plants), non traditional feed materials (including sources of animal protein such as cultured snail, earthworms, termites, frogs and unicellular protein and vegetable protein particularly from water plants) and others not important scavenging. In the materials from the environment, it is possible to include: metazoans such as worms, snails and insects, grain products from cultivating, harvesting and processing, green pick and seeds.

The feed supply is relatively stable when the environment is able to provide an abundance of feed (e.g. worms, insects and post harvest leftovers) and water during the rain season (Mavale, 2001). Wide variation in seasonal availability of feed is likely to be a major constraint. A study carried out on the scavenging feed resource base (SFRB) in a rainforest ecozone in Nigeria showed that scavenging feed resources were low in nutritive value with less than 2g crude protein available to each bird per day (Sonaiya, 2002). To meet the young chickens' requirement, alternative feed should be provided as a supplementary feed.

Knowing that feed suplementation can increase the survivability rate, it's important to establish a feeding strategy in order to reduce mortality in the critical period from 0 to 8 weeks of age.

Ndegwa *et al* (2001) found in their study that sources of feed obtained from the scavenging around the homesteads and household wastes are mainly composed by energy, apart from the insects. As a consequence indigenous chickens are undernourished as they receive an inadequate feed intake with protein supply limiting (references) The use of unconventional or alternative feed resouces could be implemented as a feeding strategy to supply suplements of low cost.

Cowpea and sorghum, as well as fresh leaves and housefly larvae could be potential protein sources for poultry, which are available locally.

Riise et al (2003) noted that protein may come from either animal sources or plants. One example of excellent and cheap source of protein is the maggots. Maggots can be grown by a simple technique and used to supplement the diet of the young chickens. According to Nzamujo (1999), a maggot is the larvae of the domestic fly (Musca domestica) and is an alternative to the high cost of feed in fish and livestock. In poultry production fresh maggots are used as basic component of feed for quail and chickens and are included in the ration of poultry and guinea fowls. The chemical composition of maggots reported by the same author is mentioned as: Dry Matter -24,7%, Crude protein- 47,5%-50,1%, Lipid 19,3%, Cellulose 23,2%, Minerals 9,1%.

The present experiment was conducted to evaluate the effect of two local diets with low nutritive value, supplemented by fresh´ maggots and fresh green leaves on the growth of young chickens from day old to 8 weeks of age.

As the feeds are composed of ingredients normally produced by farmers and locally available they can easily adopt the technical.

2. Materials and methods

2.1 Feed

2.1.1. Composition of diets

Two experimental diets were produced based on maize, sorghum and cowpea, crops mostly found at farm level of rural area in Manica Province. The last diet included in the experiment was a commercial feed bought at the feed company "Companhia Industrial da Matola" in Maputo and was used as the control diet (A). The very simple composition of the B and C diets was formulated to allow the smallholders themselves to easily prepare the feed, with products harvested from their own farms.
The inclusion level of cowpea in the feed B and C diet was 20% and 30%, respectively, and the composition of these diets is shown in Table 1. It was not possible to obtain any information concerning the ingredient composition of the commercial diet considered as a Treatment A, and therefore diet composition is not included in table 1.

Table 1. Diets Composition

Local Feed/Diet		Local Feed/Diet	
Treatment B		Treatment C	
Items	% Inclusion	Items	% Inclusion
Maize	65	Maize	55
Sorghum	15	Sorghum	15
Cowpea	20	Cowpea	30
Sal (NaCl)	0.3	Sal (NaCl)	0.3
Maggots	3 grams/day	Maggots	3 grams/day
Fresh cowpea leaves	Ad-libitum	Fresh cowpea leaves	Ad-libitum

The ingredients of the diets are based on local raw materials.
The preparation of the local feed included the milling of the raw materials in suitable size for chickens and the mixture of the ingredients according the formulation. The diets were provided as mash in the 8-week experimental period.

All chickens had access to feed and water ad libitum. Furthermore, the groups fed on the diets B and C were offered maggots (larvae of domestic fly) and fresh green leaves of cowpea daily. As the supplements is expected to supply the diets with additional protein and vitamins.

2.1.2. Supplementation of fresh products: maggots and cowpea green leaves

Maggots were raised close to the place where the experiment was carried out. Fresh green cowpea leaves were cultivated in a small area close to the Experiment to supply daily *ad libitum* to the chicks.

The substrate used for raising larvae was composed of by-products of beer production (barley yeast) and layers´ excrements and sometimes mixed with animal carcasses. It was kept humid and mixed with some quantity of commercial feed to attract flies to laying eggs.

To separate larvae from the substrate a table that was 100cm high, 80cm long and 50cm wide was built. A box was placed near to the top of the table to keep the substrate with the larvae. The lateral side of the box was limited by corrugated iron that was 15cm high. Two pieces of ordinary window net containing holes of different sizes covered both the top and the bottom of the box.

The net from the top of the box that served, as a lid was large, 4cm, and the net from the bottom part of the box was small, 2.2mm.
The bottom of the box had some horizontal supports to bear the weight of the substrate containing the maggots while the 4 vertical supports of the table were placed inside 4 small tins contained burnt oil inside to prevent ants from accessing the maggots.

The normal behaviour of maggot is to move into the substrate from the surface to the deeper and darker part, falling down through the fine sieve without any substrate left.
Larvae were collected in the tray full of water with same surface as the table, placed 10 cm above the floor. After removal from the water the maggots were weighted and distributed in equal weight per pen fed with B ands C diets.

2.2. Eggs and birds

The experiment was conducted at the Faculty of Veterinary Science in Maputo, with local chickens from 0 to 8 weeks of age. Five hundred eggs (500) from local chickens were bought from smallholders living in different localities situated in Maputo and Gaza Provinces and incubated to obtain the required number of viable chickens for the experiment.
It was not possible to obtain all 500 eggs, so the study was carried out during three different periods with approximately 2 months between the first and the last group of hatched chickens. The periods were named 1, 2, and 3 in chronological order.

A total of 69 local chickens (57 hatched in incubators and 12 naturally incubated) were included in the experiment. All birds were wing-tagged for identification with individual numbers and individually weighted at the beginning of the experiment and then every week, on the same weekday, during the 8-week study period. An electronic scale having a precision of 0.5 g was used.
All chickens involved were local breed, generally multicoloured and with adults being smaller in size than commercial breeds. The breeds included the naked neck, frizzled feathered and Dwarf breed, respectively, being characterized by featherless on the neck to be a natural adaptation to avoid stress, curly feathers, and short shanks with 2/3 reduction of body size.

Chickens were vaccinated against Newcastle Disease, Infectious Bronchitis, Gumboro Disease and Fowl Pox.

2.3 Housing and experimental design

Chickens were randomly allocated to three Treatment groups (Diets A, B and C) across 4 blocks each (1block=3 pens) in a confined system during the experimental period. Twelve individual pens were placed in one single row, next to each other. Each pen measured 80 cm long, 72 cm wide and 55cm high with a floor area of 5.76 cm^2. The temperature and humidity were recorded daily with a thermo hygrometer and the range was 24 to 33˚C and 60 to 85%, respectively, indicating that the conditions of temperature and humidity were apparently equal for all pens.

The front, lateral and topside of the pens were covered by small net to avoid the entrance of predators. Curtains, to avoid the cold temperature in the morning and night, also covered the front and lateral sides. Each pen was equipped with one feeder, one drinker and a plate to supply maggots and fresh cowpea green leaves.
Before receiving chickens each pen was cleaned, disinfected (Vircon S), placed with soft wood shavings on the floor and warmed individually by an incandescent lamp of 100 Watts. Each of the three diets A, B and C was assigned randomly to one pen per block,

each pen representing one replicate resulting in four replicates per treatment. The design is represented in detail in Table 1 and 2.

Table 2. Chicken and diet distribution per pen

Pen	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Period	2	3	2	3	2	1	1	1	1	3	1	1
Feed	A	B	B	A	C	B	C	B	A	C	C	A
Replica	3	4	3	4	3	1	1	2	1	4	2	2
Chickens	5	4	4	4	4	7	7	7	7	4	8	8

Table 3. Chicken Distribution per Treatment

Treatments	Treatment A	Treatment B	Treatment C
Diets	Diet A Commercial Feed	Diet B Local Feed	Diet C Local Feed
Replication 1	7	7	7
Replication 2	8	7	8
Replication 3	5	4	4
Replication 4	4	4	4
Total No of chickens	24	22	23

2.4 Laboratory analysis

Samples of the commercial diet (A) and diets based on local feeds (B and C) were analyzed in the Laboratory Ministry of Health (Mozambique) for determination of dry matter (DM), crude protein (CP), ash, fat (EE), calcium, phosphorus and crude fibre (CF). Analysis was done in accordance with AOAC (1990). Cowpeas seed and cowpea leaves were analyzed at DIAS for dry matter, protein by the Kjeldahl method (987.02) using a Kjell-Foss 16200 autoanalyser, amino acids (Mason et al., 1980), ash (AOAC), non-starch polysaccharides (NSP) and dietary fibre (DF) (Bach Knudsen, 1997). Diet B and C was also analyses for these components at DIAS, whereas it was not possible to obtained results from diet A as this sample unfortunately was destroyed.

2.5 Data registration

Body weight per chick (g/chick) and per pen, was recorded weekly from day-old until 8 weeks of age. Feed given and feed remaining in the feeders were recorded weekly. The indigenous breed used in the experiment was very lively and often flapped their wings. Probably due to their natural feeding behaviour, the chickens often scraped in the bed material and tried to scrape in the feeders. At the end of the experiment feed spillage on the floor was mixed with the chicks' bedding material. The bedding material was removed along with feed spillage and an attempt was made to roughly estimate real feed spillage in order to calculate feed conversion for the whole experimental period. It was not possible, however, to make this separation sufficiently accurate, as the daily feed intake was found to be extremely high in some of the replicates within each treatment. For this reason it was not possible to calculate actual feed intake and feed conversion. Mortality was recorded daily.

2.6 Statistical analyses

A randomized block design was used with a single pen representing the replicates. The 12 pens involved were divided in 4 blocks with each 3 pens.

To study the effect of treatment (diet A, B, C) on body weight gain, the General Linear Model Procedure was used (SAS Institute Inc., Cary, NC, USA, 2001) based on the following statistical model:

$$Y_{ij} = \mu + B_i + \varepsilon_{ij}$$

Y_{ij} - Dependent variable of the n^{th} chickens in the i^{th} diet;
μ - The overall Mean of Body weight Gain;
B_i - The Effect of i^{th} diet, i=1 to 3; and
ε_{ijl} - The Effect of Random Error, associated with each observation assumed to be normally and independently distributed with 0 mean and variance $I\sigma^2_e$

3. Results

3.1. Chemical composition of the diets

The results of the laboratorial analysis made in Mozambique (Table 4a) showed that the protein content was 20.8% of DM i diet A, and as expected higher than the protein content found in diet B and C, being 13.7% and 14.8% of DM, respectively. The fat content was also considerably higher in diet A.
Diet C with 30% of inclusion with cowpea showed higher level of cellulose compared to diet A and B, which could decrease the nutritive value of Diet C, as birds are not able to digest this fibre component. The calculated Available Metabolizable Energy (AME) emphasized this as the AME value for diet C was 12.19MJ/kg DM and lower compared to the other diets.

The chemical composition of diets B and C, cowpea seed and leaves, performed at DIAS in Denmark are shown in Table 4b. The protein content in the cowpea seed was 27.1% of DM and the amino acid content showed a high content of lysine, being 17.3g/kg DM. The green leaves of cowpeas had a very high content of protein being 36% DM, and like the cowpea a high content of lysine (15.9g/kg DM) was seen. The total content of non-starch polysaccharides (NSP) amounted to 13.3% in the cowpeas seed, where approximately 33% were soluble NSP. The content of dietary fibre was 18.7% DM. The NSP content in cowpeas leaves was higher being 26.4% DM and with the soluble part amounting to 40%, showing a high content of insoluble an less fermentable fibres in the leaves. The lignin content was high in the leaves resulting in a content of DF of 36.2% DM. This could indicate that the leaves were at a later stage in their growth, where lignifications start to increase.
The protein content in the diets are slightly higher, compared with the values in Table 4a, but shows the same tendencies, that the protein content was highest in diet C. The lysine content was highest in diet C (5.44g/kg), whereas the content of methionine and cystine was almost at the same level between the two diets, due to the amino acid composition in cowpea. The threonine content was also higher in diet C (5.17g/kg DM). The content of

DF amounted to 13.3% DM in diet C, having a higher value that in diet B due the increasing level of cowpeas in diet C.

3.2 Chicken growth performance

Feed A representing the commercial, balanced feed, resulted in significantly higher BWG compared with diets B and C. The final BWG of chickens fed diet A was 588g; being 45% and 35% heavier than the groups fed on diets B and C, respectively (Table 5). Although there was no significant difference between the groups B and C, there was a clear tendency that chickens fed diet B grew better, having numerically higher values in all weeks during the experiment. An overall impression of the growth development within the 3 treatments is illustrated in Figure 1.

The BWG obtained per week in each treatment is presented in table 6. It can be seen that the gain per week increased continuously with chickens fed diet A, until week 6-7, where the gain per week started to decrease. In treatments B and C the gain per week were lower than treatment A, being significantly different from week 4 onward. The results clearly indicate that the nutrient composition in diet B and C are insufficient for optimal growth (NRC, 1994) when compared with the commercial diet. The chemical analyses showed that the content of amino acids, which is below the requirement for optimal growth of layer chickens. However, in spite of the large difference comparing the BWG as a result of the feed composition of the balanced feed (Diet A) and the diets based on local ingredients (B and C), there was no significant difference in mortality between groups. The mortality was 16.7%, 18.2% and 21.7% for treatment A, B and C, respectively, indicating that the diet B and C contained nutrients adequate for growth to some extent and to keep the birds healthy.

4. Discussion

The results obtained in the present study showed that the body weight gain (BWG) obtained with commercial diet (Diet A), used for the control group, was significantly higher ($P<0.05$) compared to the BWG seen with diet B and C during all 8 weeks in the experiment. Diet A had level of protein approximately of 20.8% % DM and apparently sufficient nutrient composition to fulfil the requirements for young chickens' growth. Chickens fed diets B and C with an inclusion level of cowpea of 20% and 30%, respectively, grew more slowly although they were offered maggots and fresh cowpea fresh green leaves daily to supply with additional protein and vitamins. The results indicate that diets B and C did not have an optimal content of nutrient for optimal growth. The chemical analyses of the diets and the cowpea having a protein content of 13.7% and 14.8% DM, respectively, confirming the results seen with BWG.

The content of protein in the cowpea used in the present study was 27.5% (DM), which is comparable with the level found in other studies (Nell and Siebrits, 1992; Marconi et al., 1993; Tshovhote et al., 2003). Nell et al. (1992) found, that the protein content of 150 samples of South African cowpea cultivars to be in the range from 24.5% to 33.9% with an average of 28.4% (DM). Even though the protein content in cowpea is lower than normally seen on other protein sources as soya bean and lupin (Ravindran and Blair, 1992; Pettersson 2000), the cowpea seems to be well adapted to agricultural areas often exposed to extreme growing conditions such as heat and drought (Nell et al., 1992). In rural areas where protein can be scarce, protein sources as soybean is mainly for human use, whereas poultry, and other farm animals, have to search for feed themselves in the surroundings by scavenging (Mwalusany et al., 2002b). Introducing cowpea as a protein source for poultry could be a valuable input with regard to increasing protein intake and therefore production and survivability of local chickens.

It was expected to obtain better results with the chickens given diet C with higher inclusion level (30%) of cowpea as a source of protein thereby increasing the protein content of the diet. The results, however, showed that chickens fed diet B, with a lower inclusion level of cowpea (20%) grew better during the experimental period. Even though the difference in BWG between treatment B and C was not significant, the average BWG of chickens fed diet B was on average 45-50g higher than chickens fed diet C, from week 6 onward. The explanation to the present results could be the possible existence of anti nutritional factors in cowpea, which can depress growth. According to Marconi et al. (1993), the main anti-nutritional factor in cowpea is a trypsin inhibitor, which decrease the nutritional value of the protein unless the inhibitors are destroyed by heat processing. Measurements of true metabolizable energy with poultry showed significantly higher values for autoclaved cowpeas than for raw cowpeas (Nell et al., 1992), indicating that protease inhibitors have negative effects on the quality of the cowpea. From the information obtained in the above mentioned literature related to the negative effect of anti-nutritional factors in cowpea and from the present study, it can therefore be concluded that it is important to limit the inclusion level of cowpea in diets for young chickens to less than 30%.

According to Swatson *et al* (2003) the protein requirements for scavenging birds can be a combination of unconventional animal and plant protein sources. The use of fresh cowpea leaves provided *ad libitum* together with the fresh maggots supplement might increase the total nutritive value of feed provided.
The chemical analyses of cowpea leaves showed very high protein content, 36.04% and amino acids Lysine and Threonine with 15.91g/kg DM and 14.09g/kg DM, respectively. When the cowpea leaves can be provided fresh and before lignification increases too much, the leaves could be valuable both as a protein source and partly as a source of minerals and vitamins.
The unconventional animal protein sources considered in this study were fly larvae. Kohie et al (2001) compared fly larvae to more conventional poultry feeds because birds commonly eat insects in the wild and a diet containing insects could be readily used by poultry. The same authors indicated that fly larvae contain 4291 Kcal/kg of energy and 59% crude protein. They reported that soybeans meal contains 3500Kcal/Kg energy and 47% protein. Fresh maggots were not submitted to a laboratorial chemical analysis but Nzamujo, 1999, indicated the following chemical composition of maggots: Crude Protein 47.5-50.1%, lipid 19.3%, minerals 9.1%, Ca 1.5%, P1.2%, Mg 0.3%,K1.3%, Na 4528 ppm, Mn 196.5 ppm, Fe 425.7 ppm , Cu 19.7 ppm and Zn 235.8 ppm. Kohie et al (2001) and Nzamujo, (1999) on their studies agree that fly larvae have a high concentration of protein, comparable with the nutritive value of soybean.
Swatson *et al* (2003) stated that the nutrient and energy concentrations of several insects such as Mopane worm (Imbrassia belima), the Stink bug (Pentatomidae) and termites are also comparable with fishmeal and soybeans with similar amino acids profiles. Mopane worms are a delicacy to people in some areas so it is unlikely that they would be fed to birds. The advantage of the use of these sources of unconventional source of protein is the high content of cheap protein source.
The fly larva seems to be very attractive for chickens because they do some movements.

After birds finished the experiment they were subjected during 6 months to the same environment and management in terms of poultry house, feed and water and although they have not been weighted they apparently presented the same body size, considering the characteristics of their own local breeds and the sex. Similar results were obtained by Ndegwa et al (2001), which reported that indigenous chickens have a lower growth rate. The younger birds fed with higher protein diet will show an increase in growth rate at beginning compared with other groups fed with lower protein diet. However latter the difference will be lose and although they were fed with different levels of protein diets the groups will present the approximate body size.

There was no significant effect on mortality between Treatments A, B and C, probably because birds were confined and supplemented with maggots and fresh leaves of cowpea. However it is important to take in consideration that in confinement they did not spend so much energy travelling long distances searching for feed neither were they submitted to the harsh conditions of the environment nor exposed to the predation and diseases as the birds would spend in scavenging.

Conclusion

Although the local diets (B and C) had low level of protein content as indicated in the chemical analysis the birds did not die probably because they were supplemented in some way with maggots and fresh green leaves.
For economical reasons it is better for the farmers to include in the feed 20% of cowpea (Diet B), because it provides high body weight gain with less cowpea added and cowpea is more expensive than maize.

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Tables and figures.

Table 4a. Chemical composition of commercial and local diets (% of dry matter)

Nutrients	A	B	C
Dry matter	88.20	85.16	85.43
Ash	7.62	2.42	3.13
Protein (N*6.25)	20.82	13.66	14.75
Fat (EE)	8.12	4.40	3.89
Crude fibre (CF)	8.42	8.76	12.64
Calcium	2.62	0.50	1.60
Phosphorous	1.01	1.00	0.39
AME[1] (MJ/kg), calculated	13.95	13.87	12.19

[1]AME of compound feed and mixed feed: 3951 + 54.4*EE – 88.7*CF – 40.8* Ash. (Wiseman, 1987)

Table 4b. Chemical composition (% of dry matter, amino acids: g/kg dry matter) of cowpea seeds, cowpea leaves, diets B and C.

Nutrients	Cowpea seed	Cowpea leaves	B	C
Dry matter	90.12	70.49	85.39	86.64
Ash	4.59	11.52	2.73	3.20
Protein (Nx6.25)	27.12	36.04	14.81	16.31
Cysteine	2.20	3.58	2.38	2.37
Lysine	17.30	15.91	4.39	5.44
Methionine	3.63	3.85	2.52	2.53
Threonine	9.26	14.09	4.81	5.17
NSP[1]	13.30	26.40	9.80	12.20
S-NSP[1]	3.30	10.40	2.00	2.80
I-NSP[3]	10.00	16.00	7.80	9.40
Cellulose	4.50	9.50	2.50	3.50
Lignin	5.40	9.80	3.00	2.60
DF[4]	18.70	36.20	12.80	14.80

[1]Non-starch polysaccharides, [2]Soluble non-starch polysaccharides,[3]Insoluble non-starch polysaccharides, [4]Dietary fibre=NSP+lignin

Table 5. Body weight gain[1](g)

Week	Feed A	Feed B	Feed C	P-value	SEM[2]
Day-old weight	25.7[a]	15.4[b]	15.0[b]	0.0031	1.8
Week 0-2	68.5[a]	39.6[b]	35.2[b]	0.0253	6.1
Week 0-3	125.8[a]	74.8[b]	66.9[b]	0.0523	11.5
Week 0-4	193.8[a]	115.3[b]	95.2[b]	0.0310	17.7
Week 0-5	279.3[a]	158.9[b]	124.4[b]	0.0170	26.3
Week 0-6	392.0[a]	205.9[b]	152.6[b]	0.0037	37.4
Week 0-7	482.7[a]	237.8[b]	181.2[b]	0.0032	47.5
Week 0-8	588.1[a]	266.7[b]	208.5[b]	0.0004	57.5

Values are means of 4 replicates. Means within the same row with the same character are not significantly different (P>0.05).

Table 6. Body weight gain[1] obtained per week (g)

Week	Feed A	Feed B	Feed C	P-value	SEM
Day-old weight	25.7[a]	15.4[b]	15.0[b]	0.0031	1.8
Week 1-2	42.8	24.3	20.2	0.0811	4.6
Week 2-3	57.2	35.2	31.6	0.1213	5.6
Week 3-4	68.0[a]	40.5[ab]	28.4[b]	0.0337	6.9
Week 4-5	85.5[a]	43.6[b]	29.2[b]	0.0068	8.9
Week 5-6	112.7[a]	47.0[b]	28.1[b]	0.0068	12.7
Week 6-7	90.7[a]	31.3[b]	28.7[b]	0.0064	10.8
Week 7-8	105.4[a]	29.0[b]	27.3[b]	0.0031	13.3

Values are means of 4 replicates. Means within the same row with the same character are not significantly different (P>0.05).

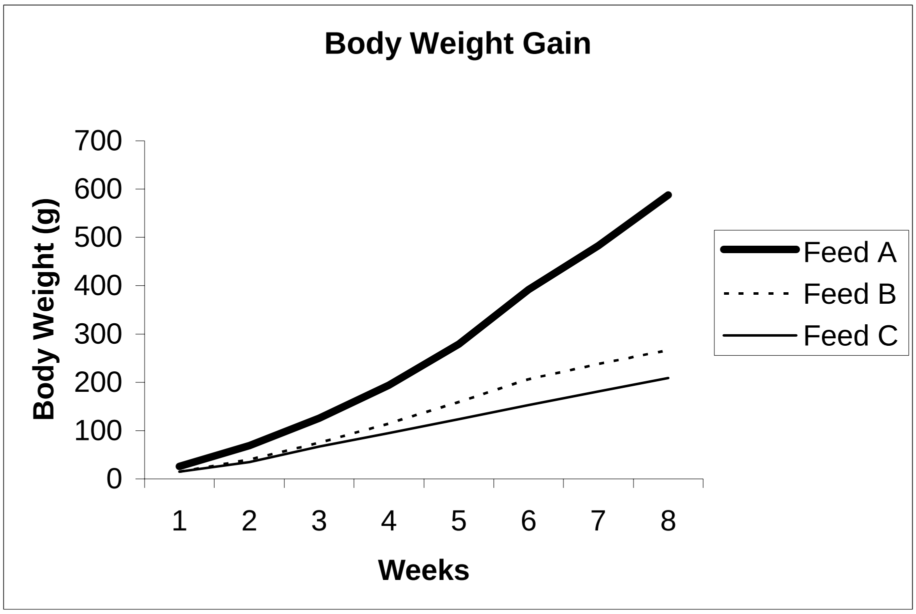

Fig 1. Body weight gain of chickens fed diet A, B and C from 0-8 weeks of age

Manuscript 2

The effect of early nutrition and improved housing on growth and survivability of local chickens in Mozambique

Manuscript 2

The effect of early nutrition and improved housing on growth and survivability of local chickens in Mozambique

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Abstract

Trials were conducted with 52 farmers from two villages (Nhambamba and Bairro dos Trabalhadores) in Sussundenga District situated in Manica Province, and farmers was selected if they owned a broody hen that reared the respective young chickens from day-old till 8 weeks age. 535 young chickens were submitted to the following types of raising systems: Treatment 1-Pure scavenging, Treatment 2-semi-scavenging and Treatment 3 - gradual scavenging. All young chickens and mother hens included in the program were vaccinated against Newcastle Disease. One Treatment was attributed to each farmer. Weigh and mortality were monitored weekly and recorded. Diseases and predators were found to be the factors that cause more mortality. The aim of the study was to compare the mortality and the growth of the young chickens subjected to one of the treatments.
Comparing the villages 1 and 2, treatment 3 resulted in a significantly higher BWG in Village 2, compared with the BWG obtained in village 1 during the 8-week period. A significant (P<0.05) interaction effect was found between village and treatment in all weeks except in week 4, indicating that the effect of treatment was not the same in the two villages. Four different causes of mortality were studied: 1) all causes of mortality (all deaths and disappearances were considered as a death, losses at different known times or losses by ending of the study were considered right censored); 2) mortality due to predators (only deaths identified as caused by predators were considered as a death due to other causes and losses were considered as right censored); 3) disappearances; and 4) mortality due to diseases.
Different responses were obtained from the two villages. In village 1, treatment 2 yielded significantly (P<0.05) lower mortality rates as compared to the mortality rates from treatment 1. The difference between treatment 1 and 3 was not significant. In village 2, the chickens subjected to treatments 2 and 3 presented significantly lower mortality rates relative to treatment 1. However, concerning overall mortality, treatment 1 caused the highest mortality rates in both villages. In relation to predation, the development in cumulative mortality was comparable between the two villages, as mortality was significantly higher (P<0.001) with treatment 1. The mortality curves between the villages differ, however, since the curve for treatment 1 in village 1 increases at a faster rate compared to the same treatment in village 2, indicating that these chickens were taken by predators at a faster rate, compared to village 2. Concerning disease, the development in cumulative mortality over time differs between the villages, as the disease is higher in treatment 3 in villages 3, whereas in village 2, the highest incidence of disease is seen in treatment 1.

Key words – Local chickens, scavenging, supplementation, non-conventional feed, larvae, termites, body gain weight, survivability.

1. Introduction

In developing countries such as Mozambique, the overall standard of husbandry is usually poor because of the low level of inputs and in addition there are a considerable number of constraints to village poultry production (Mavale, 2001). It has been reported by several authors that family poultry represent a very important income for the family (Scones, 1992; Kusina et al., 2004). However, farmers are reluctant to increase their level of inputs into local chicken production due to the high mortality normally encountered in their flocks (Gunaratne et al., 1993; Tadelle, 1996; Permin et al., 1997).

Some studies (GRM International, 2001; Mavale 2001) show that almost all eggs are destined for incubation. The fertility of layers and the hatchability are satisfactory as each hen usually hatch about 8 to 12 chickens, however on average only 2 to 4 chickens from each clutch raised to maturity Mavale (2001). There are some constraints that have to be solved in order to increase survivability and production.

The main causes of mortality in chickens when there is no Newcastle Disease (ND) outbreaks are predators (eagles, snakes and wild cats), chilling in the first day of life and deficient feeding. According to Pandey (1992), Wilson et al. (1987), Matthewman (1977) and Permin et al., (2001), disease prevention measures are rare and high mortality rates are common. Studies in Nicaragua and Mali have shown chicken mortality to be in the range of 30% to 40% within the first three to four months after hatching. In Nigeria, a mortality of more than 80% was reported within one year after hatching. According to Banhare (2001), a mortality rate of 60% of the chickens before 4 weeks of age is common in North Central Region of Namibia. Mwalusany et al. (2001), referred that mortality in early life was very high with only about 60% of the chickens surviving by the age of 10 weeks in a study in Tanzania.

In two Districts in the centre of Mozambique (Tete Province) Harun et al 2001 found the time of highest production in the harvest season from April to July. In this period there is high hatchability (78%, with about 8-9 young chickens hatched) and high chick survival rate (66%). The same authors reported the lowest production occurs from July to December. During this period the hatchability and chicks survival rate are low. The low survivability is due to the winds, rain and predation (the natural protection provided by vegetation is absent).

The variation in chicks survivability may be linked to the availability of the food by scavenging which may influence fertility and the incidence of disease (Mwalusany et al. (2002).

Diseases and predation were the main causes of the high losses in chickens, whereas management factors appear to be more important for survival of the individual bird and for the overall productivity of the flock. Mwalusany et al, 2002 stated that the protection of chickens up the age of 8 weeks should reduce losses due to predators but this will only be possible when there is proper chicken housing and feeding.

Branckaert and Gueye (1999) concluded in their studies that predators such as snakes, rats, dogs, cats, foxes, raccoons and birds of pray represent the main causes of losses, especially in young birds. Human being can also represent another important predator for adult birds when there is the habit of theft. In order to prevent this constraint it was suggested to construct housing using locally available materials. They also recommended that predators should be trapped, hunted or repelled by specific plants. For example, in Nigeria, sliced garlic (*Allium sativum sp*) is placed around poultry houses to keep off snakes.

In terms of nutrition, chickens obtain food predominantly by scavenging in the surrounding environment (Mavale, 2000). Their food consists of worms, insects and greenery that are abundant during the rainy season and scarce during the dry season. Robert (1999) described the available feed resources, which was identified as household waste, materials from the environment, cultivated and wild fodder materials (grasses, herbs and fodder trees and water plants), non traditional feed materials (including sources of animal protein such as cultured snail, earthworms, termites, frogs and unicellular protein and vegetable protein particularly from water plants) and others not important for scavenging condition. In the materials from the environment, it is possible to include: metazoans such as worms, snails and insects, grain products from cultivating, harvesting and processing, green pick and seeds.

Mavale (2001) stated that the general lack of housing is an important factor that favours losses of birds through predation. The lack of housing system has meant that at times of climate extremes such as heavy rains, cyclones and low temperatures many birds especially the younger ones, are often lost. Khieu (1999) supported the idea that housing will provide safe shelter to the chickens during the night, and in addition facilitated vaccination and give farmers better control of their chickens.

Harun and Massango (2001) reported that some farmers in the central part of Mozambique provide housing for their chickens. Houses are built to protect the birds from the predation, to control egg production and to keep the birds away from the fields during the planting season. Chickens are released from their houses during the day and allowed to scavenge, and are enclosed at night. In this area there were basically three types of housing. Houses at ground level are usually made from mud, rocks or baked bricks, with a roof made of straw. The entrance to these houses is only large enough to permit the entry of chickens and prevent the entry of many predators, especially dogs and hyenas. However the interior is generally small and dark, making access for cleaning difficult. A house of this type does conserve heat, which is especially important in the colder seasons. Enclosures are sometimes made for chickens under maize granaries. These protect the birds from predators. Rocks or baked bricks are laid around the perimeter of the granary, leaving a small opening to the interior.

However, in general housing is not always provided according to Mavale (2001) and Wethli (1985). When it does exist, it is constructed of local material and is intended to prevent predation during the night. In some families, chickens are accommodated in the owner's house, particularly during the brooding period. Where there is no provision of housing chickens roost in trees and they make their nests in the bush, which increases the losses due to the predation.

Riise, et al. (2003) recommended for hot climates that the best and cheapest method is the so-called "basket system". When the weather is hot, the chickens often do not need extra heat, but they should be protected against wind and rain. To keep out predators and other poultry, the chickens should be fenced in the basket with access to clean water and feed and gradually be let out during the day.

Kumtakar (1999), found that the maximum mortality occurs in the young chick stage. Simple management skills like covering the bamboo baskets with newspapers or cow dung would be valuable with regard to insulation during brooding and protection in winters. In addition creep feeding, low-cost balanced feed formulations, awareness about hygiene for feeding and watering of birds, burning of a lamp or charcoal burner inside the brooder in winter to give warmth to the chickens are some of the simple low -cost management practices suggested to reduce early chick mortality. As the main causes of mortality in local chickens shown are chilling in the first days, predators and lack of feeding, the aim of the present field experiment was to provide some kind of simple housing (basket system) and starter feed (based on local raw materials) during 8 weeks to determine the possible level of productivity under improved management conditions. As the composition of local feed with the available raw material in the rural area does not provide sufficient nutrients to cover the requirement for growing chickens, production of maggots will be started as a supplement the diets. Further, a description of the farming systems in village chicken production in two villages in Manica Province will be performed.

2. Materials and methods

2.1. Study area

The present study was carried out in two selected villages, Nhambamba and Bairro dos Trabalhadores during a period of 6 months.

Sussudenga District with 92,622 inhabitants (INE, 1999) covers an area of 61,661 square Km and is located in Manica province in the Agro Ecological Zone number IV. The altitude ranges between 200 and 1000 m and the average annual rainfall is 800-1000 mm. There are 2 different seasons, the dry season from April to October and the rainy season is from November to March.

The average annual temperature is approximately 24˚C, however during the study period from August to December 2004 temperatures ranged extremes from 7.5˚C to 36.8.

The Agricultural Research Station of Sussundenga (EAS) was the reference point for both selected villages situated at altitude of 635 m above sea level, latitude 13° 19' 50'' S and longitude 35° 15' 9'' E.

The main activity in both villages is crop production, with cereals such as maize, sorghum, cassava, millet, sweet potato and several types of legumes being the most important products, e.g. cowpea.

Chickens are the most common livestock kept in both villages; however, some farmers owned a small number of cattle used for milk production and for traction in the fields.

2.2. Selection of Farmers

The experiment was conducted under on-farm conditions with 52 Farmers and 52 hens and 535 one-day-old chicks in total. The criteria used to select farmers were based on farmers having one broody hen with the minimum of 8 chickens hatched. In addition, it was very important that the farmers showed considerable interest and sincerity in developing this activity. Prior to selecting farmers and starting the experiment, contacts were made with traditional and local authority. With their support most farmers from both villages were visited to identify local chickens´ owners with broody hen. On those visits, farmers were met individually and together in several meetings to raise awareness about the importance of the experiment. At the beginning it was very difficult to convince farmers to participate and implement the treatments, so considerable effort was made in order to convince them. Those farmers who accepted to be involved in the project were curious about the results and all the inputs were provided.

General information was obtained in relation to the following issues: distance from the crop fields to the house, type of crops grown, both in the fields and in the surroundings close to the house, type of fruit trees grown in the backyard, other domestic animals kept, type of shelter used for adult birds and mother hen and chickens, type of household provided, main constraints for the poultry family, type of predator existent and the most common type of predator in that area. The information was obtained in order to get a better understanding of the existing poultry' management/farming system in the selected villages.

2.3 Birds

After farmer selection, chickens were wing tagged for their individual identification and individually weighed every week, on the same day of the week during the 8-week study period. An electronic scale was used, having a precision of 0.5 g.

Farmers were asked to catch chickens and keep them in cages or pots before the weighting time.

During the weekly visit farmers received some feed to provide chickens during the week, and were asked to explain the reasons of chicken losses or death, during the previous week. All information obtained was recorded for each farmer separately.

All chickens and mother hen included in the program were vaccinated against Newcastle disease.

2.4. Diet, Feeding and housing system
The diet produced for the experiment was based on maize, sorghum and cowpea, the crops most commonly grown in the Districts located in Manica Province. The ingredients were bought by local farmers/producers and at local market, and the diet was produced at a local mill in Sussundenga. Each of the ingredients were milled to pass through a 3mm screen before mixing with the other ingredients. The composition of the diet is shown in table 1. The diet was provided as mash in the 8-week experimental period.

The relatively simple composition of the local diet was done to allow the smallholders themselves to prepare easily the feed, with the products harvested from their own farms. The inclusion level of cowpeas was determined in a pilot study under controlled conditions using facilities for chicken experiments at the Faculty of Veterinary Science in Maputo (Goncalves et al., 2005, unpublished).

Table 1. Composition of the local diet

Ingredients	% Inclusion
Maize	65
Sorghum	15
Cowpea	20
Salt (NaCl)	0.3
Maggots	Uncountable
Cowpea leaves	Ad-libitum

The local diet was analyzed at DIAS for dry matter, protein by the Kjeldahl method (987.02) using a Kjell-Foss 16200 autoanalyser, amino acids (Mason et al., 1980), fat (Stoldt, 1952), ash (AOAC), non-starch polysaccharides (NSP) and dietary fibre (DF) (Bach Knudsen, 1997).

2.4.1. Treatments
Treatments were randomly allocated to the farmers involved in the program and each farmer was attributed one treatment.

Treatment 1 – based on pure scavenging and no housing considered as the control group.

Treatment 2 – based on semi-scavenging and no housing. Supplementary feed was provided in a restricted way early in the morning and late in the evening during approximately one hour in each period. Between the above-mentioned periods chickens were allowed to scavenge. Young chickens received supplementary feed inside the creep feeder. Creep feeder is a kind of bottomless cage made by local material (bamboo) built only for feeding purpose. It allowed chickens from the same clutch receive supplementary feed without being disturbed by other birds (including mother hen).

Treatment 3 - based on young chickens' confinement using the 'basket system' during 4 weeks, followed by gradual scavenging. Feed is provided in the basket.

The basket is a kind of cage, made from local material (bamboo), with a diameter of 80 to 100 cm and a height of about 80 cm.
The main body of the basket is open at the top and in the bottom and two respective covers composed the basket, used as housing. Both covers were built in such way that they could fit/adjusted exactly on the main body of the basket, to avoid the entrance of predators like snakes and rats especially at night.
The top hole was 20 cm diameter and it was useful to change feed and water without disturbing the birds unnecessarily. It was covered at night with the respective cover (lid). The lower cover of the basket served as a floor and allowed the easy transport of chickens inside it. As it was not built connected to the main body of the basket, it was possible to remove and wash when dirty with faeces. Farmers were instructed to avoid putting the basket always in the same place to prevent the adverse temperature, radiation, rain, chilling weather and the concentration of parasites.

During the 1^{st} month of rearing in the confined basket system, all young chickens had access to local feed and water *ad libitum* and were offered maggots (larvae of domestic fly) or termites and fresh green leaves daily. The mother hen was kept with chickens inside the basket during the nights, the 1^{st} full week (morning and night), and in the cold hours in the following weeks.
On the 5^{th} and 6^{th} week, a small stone was placed under the rim of basket and chickens were allowed to scavenge around homestead and in the neighbourhood for approximate a period of 5 hours in afternoon.
From 7^{th} to 8^{th} Week they were allowed to scavenge with mother hen all day.
Supplemented feed and clean fresh water was provided early in the morning before young chickens left for the fields and late in the evening after coming from the fields.
After the 8^{th} week, the Basket system was removed and chickens were allowed to scavenge, and spent night in poultry shelter with other adult birds.

2.4.2. Diets administration
The same local diet B (Table 1) was administrated to chickens in treatment 2 and 3, and the quantity provided for each treatment is represented in Table 2.

Table 2. Feed provided in Treatments 2 and 3

Weeks	Creep Feeder (g)	Basket System (g)
1st week	1260	2100
2nd week	1680	2520
3rd week	2940	3780
4th week	3360	4200
5th week	3780	4620
6th week	4200	5040
7th week	4620	5460
8th week	5040	5880
Total	26880	33600

2.5. Data registration

Bodyweight (g/chick) per chick was taken weekly from day-old until 8 weeks of age.

Bodyweight gain was calculated by subtracting initial bodyweight (Hatched day) from final bodyweight. Feed intake of the chickens was not recorded as the mother hen was eaten together with the chickens: In order to record feed intake accurately enough to calculate feed conversion, each farmer should have used much more time with the hen and chickens each day, which was considered an unrealistic demand at this stage. Therefore, an exact recording of feed intake and calculation of feed conversion was not performed in the present study.

Mortality and different causes of mortality were recorded weekly on the day of the visit.

2.6. Experimental design and Statistical analysis

The experiment was carried out according to a factorial design that comprises factor 1 being housing system (night shelter and basket system) and factor 2, with three feeding strategies (pure scavenging, semi-scavenging and gradual scavenging).

Information is given in Table 3.

Table 3. Farmers' and chicks distributed per village and per treatment

Housing System.	No Farmers No Chicks	Night shelter (non conventional Housing)		Basket System
Treatments		Treatment 1	Treatment 2	Treatment 3
Production System		Scavenging	Not confinement with supplementary feed	Confinement with supplementary feed
Village Nhambamba	No Farmers No Chicks	11 118	6 64	10 102
Village Bairro Dos Trabalhadores	No Farmers No Chicks	9 89	8 83	8 79
Total Number Total Number	Farmers Chickens	20 207	14 147	18 181

To study the effects of nutrition and housing on body weight gain the General Linear Model Procedure was used (SAS Institute Inc., Cary, NC, USA, 2001) based on the following statistical model:

$$Y_{ijlk} = \mu + B_i + A_j + (BA)_{ij} + b\,(D_{ijlk} - D) + \varepsilon_{ijlk}$$

Y_{ijk} - Dependent variable BWG of the n^{th} chickens in the i^{th} nutrition and j^{th} housing;
μ - The overall mean of body weight gain
B_i - The Effect of i^{th} Nutrition, i=1, 2 and 3;
A_j -The Effect of j^{th} Housing, j=1 and 2;
$(BA)_{ij}$ -The Effect of the Interaction between the I^{th} Nutrition j^{th} Housing;
D_{ijlk} - Body Weight at hatch of the i^{th} Nutrition of i^{th} Housing;
D - Average of Body weight at hatch; and
ε_{ijlk} The Effect of Random Error, associated with each observation assumed to be normally and independently distributed with 0 mean and variance $I\sigma^2_e$

The data collected on survivability and cause of mortality per treatment and per village was analysed by Chi-square using SAS.

Further, the observed overall mortality after eight weeks was analysed using a logistic model. The response variable was the number of animals dead after 8 weeks. The discrete

explanatory variables (factors) were: treatment and village. A normal distributed random effect taking common values for the animals coming from the same farmer (and the same clutch) was also introduced in the model to account for the dependency between observations from the same clutch.
An initial model containing effects of treatment, village and the interaction of treatment and village was designed. The cumulative mortality rate curve, i.e. a curve assigning different cumulative mortality rates for each time point, was estimated for each treatment (Kalbfleisch and Prentice, 1980). Then the cumulative mortality rate curve was estimated as one minus the estimated survival function. The cumulative mortality curve is then a curve that relates to each time (age) the probability of dying before this time. Estimates of the cumulative mortality rate curve were calculated separately for each of the three treatments.

3. Results

3.1 General information and description of the study area

This section describes briefly village poultry production as a result of direct interviews and observations to provide a basic knowledge about the family poultry production in the selected villages.
Nhambamba is a village mainly composed of farmers who were refugees during the civil war. The area is mountainous and the soil is very dry. The farmers make their own houses using local material, and their cultivated fields were situated far from the residential/living area. Nhambamba River passes through Nhambamba village, however almost all the population fetched water from the pumps for their own use.
Bairro dos Trabalhadores is situated close to the Agrarian Station of Sussundenga (EAS), and approximately 3.5km from the other village. In most cases farmers are employees of the EAS, and live in cement houses that belong to the Research Station. Farmers fetch water directly from tank or neighborhood houses. The area is also mountainous but not so dry as Nhambamba village. Almost all farmers own cultivated land situated close to their house.

3.1.1. Soil, agriculture and livestock

Both villages depend totally on the rainy season for agriculture and the main kinds of crops produced are maize, cassava, sorghum, millet, sweet potato, groundnuts, and several types of legumes (e.g cowpea) and occasionally rice.
Apart from the general subsistence production, Nhambamba' farmers also produced cotton and tobacco as cash crops. In village there are few fruit trees apart from those which were naturally sprouted or self sown.
At Bairro dos Trabalhadores there horticultural activity was observed and the food crops grown included cabbages, tomatoes, other vegetables and some types of fruit trees, which were planted and not only wild grown species. Banana trees are very common there. The livestock kept include beef cattle, pigs, goats, chickens, ducks and pigeons all in an integrated management.
The soil especially in the Bairro dos Trabalhadores has a tendency for the natural and high formation of termitaries (houses for termites). It is common to see the stem and branches of the nearby trees empty and completely destroyed by termites.
Although In Nhambamba there was a tendency for the natural formation of termitaries, the presence was not so high, compared to Bairro dos Trabalhadores. Chickens are the most common livestock kept and they scavenge everywhere in Nhambamba village and it's difficult to see other small species. However, some farmers also kept cattle.

3.1.2. Socio-economic condition of the farmer

Almost all the selected farmers were illiterate, but their children were attending the primary school. Both male and female farmers in Nhambamba were involved solely with agriculture, which is a seasonal activity. Female farmers were more numerous in Bairro dos Trabalhadores, as most of the men were an employee of the Agricultural Research Station of Sussundenga. Their monthly income source did not only come from the agriculture products sold, but also from the salary received from EAS.

3.1.3. Feeding

Village chickens obtain food by scavenging freely in the surrounding environment. Feed consists of household wastes, worms, insects, termites, and crop wastes.
Some families reported that birds received feed supplementation especially when someone was preparing cereal flour for the family. At this time, all the animals including, chickens, turkeys, ducks and goats were fed in the same place.
Farmers were instructed to produce larvae and collect termites to provide chickens a local and cheap protein source. There was no habit of storing by-products for the dry season.
Water is never provided for chickens probably because woman normally had to transport water for 1 Km or more and carried it on 20 L gallon, on the head.
Birds drink dirty water that had been use for washing up or from the family' washed clothes exposed to the sun to be dried. Chickens scavenge for food and water as soon as there is daylight. Mother hen takes the young chicks early in the morning and arrives with them late in the evening. During the first days mother hen scavenge with chicks around the farmers homestead.

3.1.4. Housing

For adult birds, farmers sometimes build a small poultry house made from local material. Normally farmers opened the poultry house early in the morning and after the return of the birds late in the evening they closed it.
Most hens with chickens stay overnight in the farmers' kitchen or verandah totally or partially open on the lateral side with a simple roof on the top. This type of poultry' shelter considered as control was the most common used in Sussundenga District and in general in the rural areas.

3.1.5. Diseases

Newcastle disease was the most commonly reported disease. Although farmers applied traditional medicines with the purpose of controlling the disease, it is appeared that the results were very poor.
Chickens and mother hen involved in the program received Newcastle Disease vaccination for free, however when asked if they could pay for that service if it was possible, all of them were reluctant to make such a payment.
They supported the idea that they could not waste any money in any input especially because they were not sure if the chickens would survive.
Farmers believed strongly that the chickens' survivability rate depend on the individual luck of the owner. Sometimes chickens 'owners were just children and they received one hen from the grand parents to check if she/he is a lucky person by observing the number of chickens that survive to adulthood. In Nhambamba, as the houses are situated in the same place very close to the others, there was a great possibility to spread a disease more easily than in Bairro dos Trabalhadores where the houses are not so close to the others.

3.1.6. Predators

Nhambamba was a village created recently, and there were many inhabitants living in the same area, but the area is very open with few trees. This makes the environment very

favourable for the presence of the kites, which is a bird raptor. It was very frequent to see kites in the daytime looking for young chickens. Wild cats were also present but in lower numbers.
Bairro dos Trabalhadores is older than Nhambamba village. In certain places of Bairro dos Trabalhadores it can be seen a heavy forest even close to the residential area. The most probable reason for that is the existence of a weed popularly called monkey beans (*Mucuna spp*) that causes a serious allergy if the hair of the beans comes into contact with a person. Probably due to this fact, there is a heavy forest close to the city as people are afraid to clean this area. In this kind of environment the most common predator is the snake, followed by wild cats and dogs.
On the other hand as there is an integrated management of the animals, they eat and drink on the same place, and it was frequently observed that pigs, and goats stepped on chickens by chance.

3.2. Chemical composition of the diet
The chemical composition of the local diet is shown in Table 4. The protein content was 12.8% DM and the amino acid content was 2.32g/kg DM for cystine, 2.33g/kg DM for methionine, 4.84g/kg DM for lysine and 4.43g/kg DM for threonine, which is below requirement for optimal growth for layer chickens (NRC, 1994). Since the local diet was simple and based on local grown ingredient, the low content of protein and amino acid was expected, but still considered valuable as a supplement to scavenged feed. The total content of non-starch polysaccharides (NSP) amounted to 8.1%, where approximately 20% were soluble NSP. The content of dietary fibre was 11.8% DM.

3.3 Chicken performance

3.3.1. Body weight gain
Body weight gain according to the treatments per village is presented in Table 5. In the following, village 1 refers to Nhambamba and village 2 to Bairro dos Trabalhadores
In Village 1, treatment 3 based on young chickens' confinement in a basket system during the first 4 weeks of life and gradual scavenging from 4 to 8 weeks showed significantly lower BWG compared with treatments 1 and 2, during the whole 8 week period. Although there was no significant difference between treatments 1 and 2 in village 1 in the first 6 weeks, chickens in treatment 2 tended to grow better compared to treatment 1, and from week 6 the chickens in treatment 2 grew significantly better than chickens in treatment 1.
In Village 2, no significant difference among the three treatments was found, except for treatment 3, where the chickens had a significantly higher BWG in week 1 and significantly lower in week 3 compared to the other two treatments. However, in the last two weeks of the experiment, chickens subjected to treatment 1 tended to slow their growth rate, compared to chickens from treatment 2 and 3.

Comparing the villages 1 and 2, treatment 3 resulted in a significantly higher BWG in Village 2, compared with the BWG obtained in village 1 during the 8-week period. A significant ($P<0.05$) interaction effect was found between village and treatment in all weeks except in week 4, indicating that the effect of treatment was not the same in the two villages.

3.3.2. Survivability and mortality
The average of mortality (given in percentage) within each treatment per village is given in Table 6. The results showed no significance difference between villages per treatment, although the number of chickens is different in each village. In village 1 no significant

difference between the three treatments was seen, but in village 2 there is significant difference between treatment 1 and treatment 3, but no significant difference between treatments 1 and 2 and treatments 2 and 3.
The possible causes of mortality was recorded and divided into 3 main groups being predators, disappearances (cause of mortality not ascertained), and disease. The distribution in the different groups of the total number of chickens involved in the experiment is shown in Table 7 together with the number of chickens that survived to the end of the experiment at 8 weeks of age. The results contain data from both villages. In order to discuss the effect of the three treatments within village and between villages, the results are presented in percentage in Figures 1-6.

In general, the mortality was highest in treatment 1 (Figures 1-2), reaching 64% in village 1 and 74% in village 2. Predators caused the highest mortality (37%, 50%), followed by disease and chickens disappearance. The incidence of diseases was much higher in village 2 compared to village 1.
In treatment 2 (figure 3-4) mortality was considerably lower reaching a level of 42% in village 1 and 46% in village 2. The survivability increased to an average of 56% compared to an average of 31% in treatment 1. The causes of death were almost equal distributed in the two villages, and in general there was a decrease in all three kinds of death causes. The survivability of chickens subjected to treatments 2 and 3 (Figures 5-6) did not differ in village 1, being 58% and 52%, respectively. Apparently, the use of the basket system in village 1 did not improve survivability compared to treatment 2, where chickens received supplemented feed in the morning and afternoon, but were released to scavenge with mother hen during the day. The results obtained with treatment 3, using the basket in village 2, improved survivability from 54% observed with treatment 2 to 62% with treatment 3. The impact of predators in treatment 3 was decreased to a large extent in both villages being 5% in village 1, and 0% in village 2. The incidence of disease was close, whereas the percentage of chickens disappeared was highest in village 1 in treatment 3.

The development in overall mortality and causes of mortality during the 8 weeks is illustrated in Figures 7a-d and 7e-h. All the analyses regarding mortality rates were performed separately for the two villages, as the two villages were considered very different. Mortality rates due to different causes of mortality were studied by using suitable definitions of censoring (Kalbfleisch and Prentice, 1980 and Hougaard, 2001). For example, when studying the mortality caused by disease, all mortality due to other causes were considered as right censored. Four mortality rates were studied: 1) all causes mortality (all deaths and disappearances were considered as a death, losses at different known times or losses by ending of the study were considered right censored); 2) mortality due to predators (only deaths identified as caused by predators were considered as a death due to other causes and losses were considered as right censored); 3) disappearing; and 4) mortality due to diseases.
Clearly, there are rather different responses for the two villages. In village 1, treatment 2 yields significantly ($P<0.05$) lower mortality rates as compared to the mortality rates from treatment 1 (Figure 7a). The difference between treatment 1 and 3 was not significant. In village 2, the chickens subjected to treatment 2 and 3 presented significantly lower mortality rates relative to treatment 1 (Figure 7b). However, concerning overall mortality, treatment 1 caused the highest mortality rates in both villages. In relation to predation, the development in cumulative mortality was comparable between the two villages, as mortality was significantly higher ($P<0.001$) with treatment 1 (Figures 7c and 7d). The curves between the villages differ, however, since the curve for treatment 1 in village 1 increases at a faster rate compared to the same treatment in village 2, indicating that these chickens will be taken by predators at a

faster rate, compared to village 2. In figure 7e and 7f, the cumulative curves due to disappearances shows that the risk is highest with treatment 3 in both villages. Concerning disease, the development in cumulative mortality over time differs between the villages (Figure 7g and 7h) as the disease is higher in treatment 3 in villages 3, whereas in village 2, the highest incidence of disease is seen in treatment 1.

4. Discussion

The results obtained showed a different response in the implementation of the three treatments in terms of body weight gain (BWG), mortality and causes of mortality in two villages where the experiment was carried out. To explain the results obtained, it is necessary to connect them to direct observations and farmers' information. The two villages were considered very different and were therefore difficult to compare.

These differences might be caused by specific environmental conditions of each village, the socio-economic condition of the farmer and farmers' management.

In village 1, treatment 2 resulted in the best BWG, probably because birds received supplementary feed and also obtained additional feed items from scavenging. Until the 5th week chickens subjected to treatment 1 could probably adequate feed to cover their basal requirements in the scavenging area. After that the chicken requirements were higher than the amount of feed found in the field were able to cover, so the birds on Treatment 2 grew better, because they received supplemented feed. Contrary to what was expected, chickens subjected to treatment 3, being confined with feed *ad libitum* had a lower BWG during the whole study period. One reason for this finding could be lack of necessary farmer management needed to rear chickens in the basket.

In village 2, the growth curve for the three different treatments was almost similar, except for treatment 1, which decreased in the last 2 weeks. The reason for this result with treatment 1 was most likely, that in the beginning of the experiment the chickens were able to find enough feed in the scavenging area to cover their nutrient requirement. As treatment 1 did not receive supplemented feed and that the period coincided with the dry season, the birds probably have not enough to fulfil their requirements at the end of the experiment.

In an on-farm study performed by Lwesya *et al* (2004), chickens and mother hen were enclosed in woven basket during 8 weeks and fed with a 300 g mixed mash diet per day. The diet was formulated to contain 22% protein, 3480 Kcal-kg Metabolizable Energy and 2.47% crude fibre. In the rain season a growth rate of 3.96g was achieved per day. In the present study, the protein content in the diet was 12.8% DM protein and the content of dietary fibre 10.8% DM. In addition to the supplemented diet provided *ad libitum,* the farmers were oriented to give also some amount of termites and fresh green leaves to the chickens, and the growth rate obtained with treatment 3 was 3.7g/day and 4.9g/-day for village 1 and village 2, respectively. It can be concluded that the effect of introducing treatment 2 in the two villages resulted in a much higher average growth per day in village 2, and the different results obtained with the same treatment might be caused by the differences both in environment and farmers management between the villages.

The mortality in treatment 1 (figure 1 and 2), was highest in both villages compared to the other treatments, being 64% and 74% for villages 1 and 2, respectively. The reason for that could be that chickens did not receive water, supplemented feed and in addition had to walk long distances searching for feed. They were more exposed to predators and all the extremes weather climates in the field conditions. In village 1, chickens were more exposed to kites because the area is very open. Although in village 2 there is also action of different predators like snakes, wildcats, dogs and other, predation seems to prevail to a minor extent. In village 1 it can be seen that young chickens disappear in a major frequency probably because they have to walk long distances with mother hen to search for feed, increasing the risk that the chickens becomes weaker and consequently more vulnerable to predators. When chickens were weak they could not follow mother hen and could not receive her protection when attacked by predators or even died on the way, which could explain that in village 1, the young birds' disappear in 13% while there is no chickens disappeared in village 2. However, the percentage of disease in village 2 was high, being 13% compared with village 1. The integrated system of management of livestock in general can be the main reason for that.

Tadelle (2001) reported that in the Central Highlands of Ethiopia the major source of loss in the system, characterized by no or few inputs and a low output level was the high mortality of chicks, indicated as a 61% during an 8 weeks period. Mwalusanya (2001) reported the survival rate of local chickens up to 10 weeks in Mororo district of Tanzania to be 59.7%. In the present study it was found in two different villages 64% and 74% in mortality during the 8-week period.

In a study carried out in a communal area in Zimbabwe, mortality reached a level of 55% until 16 weeks of age, but 69% of most deaths occurred before chickens reached 3 weeks of age (Mcainsh, 2004). According to the same author, the mortality causes of chicken was distributed in the following way: Diseases 28%, Predation 27%, External Parasites 21%, Accidents 12%, Rain 6% and not specified cause 6%.

In the present study carried out until 8 weeks the mortality caused by predators was higher indicated as 50% for village 1 and 37% for village 2, However, considering that Disease include the mortality caused by external parasites in our study, it indicates 1% and 37% for Village 1 and 2 while in Zimbabwe it represents 49%. In both studies mortality caused by diseases and redaction are very high compare with other causes of mortality.

In treatment 2 (figure 3-4), mortality represents less than 50% and it varies from 42-46% respectively for Village 1 and 2. Probably after receiving some supplemented feed young chickens were not so weak and probably could easily follow the mother hen while searching for feed. Being close to the mother it was probably easier to receive some protection from her against the predators. There was a considerable reduction in predation from 50% (Village 1) and 37% (Village 2) to 27% in both Villages.

Concerning disease in village 1, it increased from 1% to 12% between treatment 1 and 2, which was not expected due to the feed supplementation. However, probably mother hen did not take them to scavenge so far as, and as the density of chickens was very high in that area chickens were in more close contact with the others and consequently more exposed to get some diseases. In Village 2 the percentage of Disease decreased by 24% when compared with Treatment 1. The proportion of chickens that disappeared was twice as high in village 2, which probably could be explained to the observation that scavenging activity was often near the houses, and the risk for theft higher.

Roberts (1999) reported that providing household refuse in a creep feeder for a short period twice a day increased the survival rate but did not improve the growth rate. However supplementing the household refuse with protein improved both survival rate and growth rate. It was shown that the control group reached a mortality of approximately 47%, whereas the group fed with 9% of protein presented around 30% of mortality. Finally, the group fed with 15% protein showed about 18% mortality, indicating a direct relation between the protein level containing in the feed and the rate of survivability, and the best survivability rate is achieved with the highest protein content. In the present study birds fed with 13% of protein showed 44% of mortality. As the quality and the quantity of scavenging feed resource base changes over the year and in addition varies from area to area, depending on the season (rainy season or dry season), and also is influenced by the density of birds scavenging in that area, it is difficult to obtain the same results under different conditions (Gunaratne et al.,

1993; Mwalusany et al. (2002).
According to Robert (1999) monogastrics have to obtain protein from animal sources like fishmeal meat meal and metazoans. If the diet is deficient in essential amino acids the utilization of protein is inefficient and expensive. Vitamins are available in diets, which include green feed, but if it has more than 7% of fibre the efficiency of utilization declines. The same authors explained that the low crude protein existent in the SFRB is inadequate for young chickens and growers. When there is a competition for scavenging feed the young chickens and growers become weaker and die from starvation.
In the present study, treatment 3 represented the confined system in the basket and in village 2 the mortality was decreased (38%) in the treatment, which could be explained by the factor farmers' management, following carefully the instructions given for rearing chickens in the basket system and giving not only the feed but also the termites and fresh green leaves. They also were more compliant about moving the basket to promote better environment for chickens. The portion of chickens that disappeared with treatment 3 was relatively higher in village 1, probably because farmers provide less care to the management system introduced, and in the basket young chickens can be easily stolen if not kept under observation, or even be disturbed by children or other animals, which simply wanted to eat. Cases were recorded when another hen, pig or goat entered in the basket to eat and drink feed and water provided *ad libitum* in the basket. During this action all movements caused the overturning of the basket allow the young chickens to escape from the basket and easily got lost and disappeared.

Disease constitutes the largest proportion in treatment 3 in both villages. The disease is always higher in village 2, probably because they have the integrated system of rearing all the animals together. In addition, when using a confinement system as the basket, farmers must be more serious about the management, as young chickens are very sensitive. It is recommended to change the position of the basket because if it is placed always in the same place there is the risk of parasite concentration, and disease contamination. Further, regular cleaning is important. The other problem is related to the weather constraints and because they are confined if the farmer is not careful they are exposed to the wind, rain and climatic differences. Due to the bad management in some cases birds did not have *ad libitum* feed and water as it was supposed to have during the confinement in the basket.
In a field trial carried out over 24 weeks, it was assumed that keeping the young chickens enclosed during the first 3 weeks, would improve the survival rate during the growth period (Pedersen, 2001). However, the same author found that mortality was lower during the first three weeks (23%) but higher in the following weeks reaching the level of 55%. According to the farmers, 27% of these deaths were due to predators, 18% due to diseases, 17% due to external parasites, 9% due to rains and 14% due to unspecified cause (Pedersen et al. 2001). Although all causes of mortality were studied in detail in the present study, the incidence of external parasites was considered an integrated part of disease, however, and it can be concluded that disease and predation are the major causes of mortality, supporting the study by Pedersen et al. (2001).

5. Conclusion

In conclusion, family poultry in Mozambique is raised under a traditional extensive system characterized by poor feeding and housing system. In general smallholders are illiterate and have never have reared chickens under improved conditions. The social and economical differences on farmers´ condition and their respective way of living interfered with chicken management in both villages.

In Nhambamba farmers were more conservative and they kept chickens in a traditional management as they considered agriculture as the most important activity and the main source of income.
In Bairro dos Trabalhadores farmers were open minded, better off and more open to learning and implementing different practices of management as a way to improve the productivity in their flocks.

To develop any poultry activity under the present situation in rural area it is necessary to understand options available to farmers and raise awareness of how chickens can be raised under cost-efficient improved conditions. Basic skills in poultry´ management and health and access to veterinary extension services must be promoted.
To improve the productivity on village poultry and increase the number of chickens per clutch, it will be very important to evaluate the farmer condition before introduction of any treatment.
It seems that simple changes in management practices in village chickens can decrease the high mortality reported in the scavenging system.

Treatment 2 is more recommended to farmers that depend more on agriculture than in other activity for their own subsistence, because they provide little care to the young chickens. The results obtained with treatment 3 revealed to be more dependent on farmer ´management and it is more efficient when farmers are more motivated to implement the management instructions recommended for basket.
There is a considerable reduction in predation action from the use of treatment 1, pure scavenging and to treatment 3, Basket system. In treatment 1 it was observed that mortality caused by predators was 50% and 37% in village 1 and village 2 and in treatment 3 it was reduced to 5% and 0% in the two villages. However, disease is still a great constraint varying from 22% to 25% in treatment 3.
As therapeutic interventions are very expensive, farmers must be aware of this situation and get some management´ basic skills to reduce the mortality.
The interaction of the three constraints: disease, housing and feed, underlines the necessity for a holistic approach to interventions according to Dwinger et al., (2001).
Extension Services packages must include vaccination against Newcastle, introduction of the creep feeding practices and simple housing based on simple structures like in basket system for young chickens up to 8 weeks. Those structures made of local material can be easily improvised and adopted by farmers to improve village chickens productivity without increase in costs.

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Tables and figures

Table 4. Chemical composition of local diet
(% of dry matter. Amino acids: g/kg dry matter)

Nutrients	Diet
Dry matter	88.79
Ash	2.01
Protein (Nx6.25)	12.81
Cysteine	2.32
Lysine	4.84
Methionine	2.33
Threonine	4.43
Fat	4.36
NSP[1]	9.10
S-NSP[1]	1.80
I-NSP[3]	7.30
Cellulose	2.30
Lignin	2.70
DF[4]	11.80

[1]Non-starch polysaccharides, [2]Soluble non-starch polysaccharides,
[3]Insoluble non-starch polysaccharides, [4]Dietary fibre=NSP+lignin

Table 5. Body weight gain[1] (g) in Village 1 and 2

Means ± SD	Treatment	Village 1	Village 2
	T1	12.0^{aA} ± 0.7	11.2^{aA} ± 1.1
Day-old weight	T2	11.2^{aA} ± 1.0	12.9^{aA} ± 0.9
	T3	7.5^{bA} ± 0.8	15.9^{bB} ± 0.9
	T1	29.5^{aA} ± 1.4	28.9^{aA} ± 2.1
Week 0-2	T2	26.4^{aA} ± 1.9	32.8^{aB} ± 1.8
	T3	19.0^{bA} ± 1.5	30.8^{aB} ± 1.7
	T1	51.0^{aA} ± 2.3	58.9^{abA} ± 3.5
Week 0-3	T2	51.1^{aA} ± 3.1	62.8^{aB} ± 3.0
	T3	31.9^{bA} ± 2.5	53.5^{bB} ± 2.9
	T1	77.8^{aA} ± 3.4	93.6^{aB} ± 4.9
Week 0-4	T2	80.9^{aA} ± 4.4	92.6^{aB} ± 4.2
	T3	56.9^{bA} ± 4.0	87.1^{aB} ± 4.1
	T1	116.7^{aA} ± 4.3	131.1^{aB} ± 6.0
Week 0-5	T2	120.4^{aA} ± 5.5	128.2^{aA} ± 4.9
	T3	71.7^{bA} ± 6.2	121.0^{aB} ± 4.8
	T1	159.5^{aA} ± 6.7	173.7^{aA} ± 8.1
Week 0-6	T2	178.2^{aA} ± 7.8	172.4^{aA} ± 6.7
	T3	112.8^{bA} ± 9.2	165.8^{aB} ± 8.1
	T1	205.2^{aA} ± 8.9	197.6^{aA} ± 12.2
Week 0-7	T2	237.4^{bA} ± 10.0	221.1^{aA} ± 9.1
	T3	170.7^{cA} ± 11.9	218.5^{aB} ± 10.8
	T1	236.9^{aA} ± 10.3	258.2^{aA} ± 13.9
Week 0-8	T2	$294.7^{b\,A}$ ± 10.9	266.7^{aA} ± 10.1
	T3	206.8^{aA} ± 13.0	273.7^{aB} ± 12.4

[1] Values are mean of the number of chickens per week per village. Small letter indicates the difference among treatments within each village (columns). Capital letter indicates the difference between villages within each treatment (rows). Means with the same character are not significantly different (P>0.05).

Table 6. Average Mortality per Treatment represented in two villages (%).

	Treatment 1	Treatment 2	Treatment 3
Village 1	64.8^{aA} ± 08.9	43.2^{aA} ± 12.0	48.3^{aA} ± 09.4
Village 2	69.4^{aA} ±10.4	44.7^{abA} ± 10.4	38.9^{bA} ± 10.4

Small letter indicates the difference among Treatments within each village. Capital letter indicates the difference between villages within each Treatment. Means with the same character are not significantly different (P>0.05).

Table 7. Survivability and causes of mortality in each treatment[1] per village[1]

	Treatment 1		Treatment 2		Treatment 3	
	Village 1	Village 2	Village 1	Village 2	Village 1	Village 2
Alive	42	23	37	45	53	49
Predator	59	33	17	22	5	0
Disappeared	16	0	2	5	21	10
Disease	1	33	8	11	23	20
	118	89	64	83	102	79

[1]Number of chickens

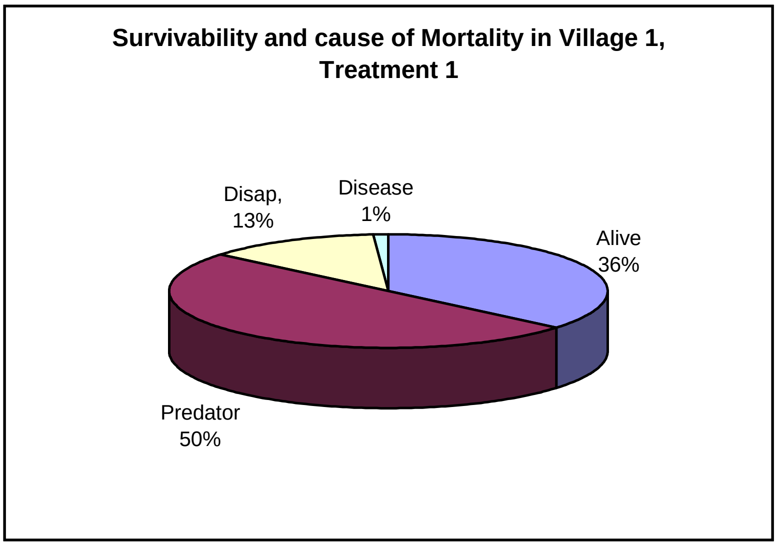


Fig. 1 Survivability and cause of Mortality in Village 1, treatment 1

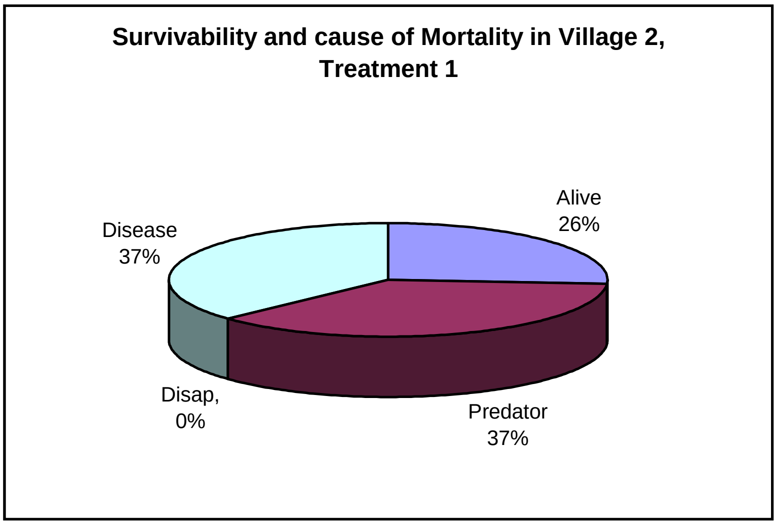


Fig. 2 Survivability and cause of Mortality in Village 2, treatment 1

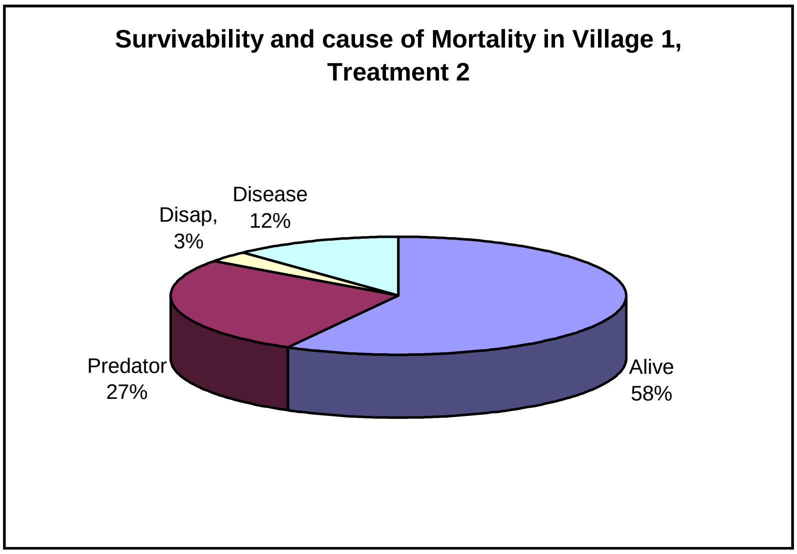


Fig. 3 Survivability and cause of Mortality in Village 1, treatment 2

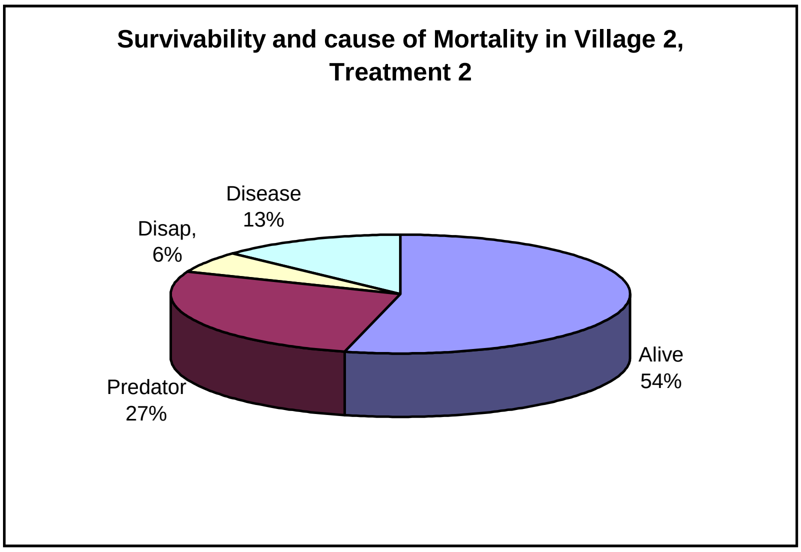


Fig. 4 Survivability and cause of Mortality in Village 2, treatment 2

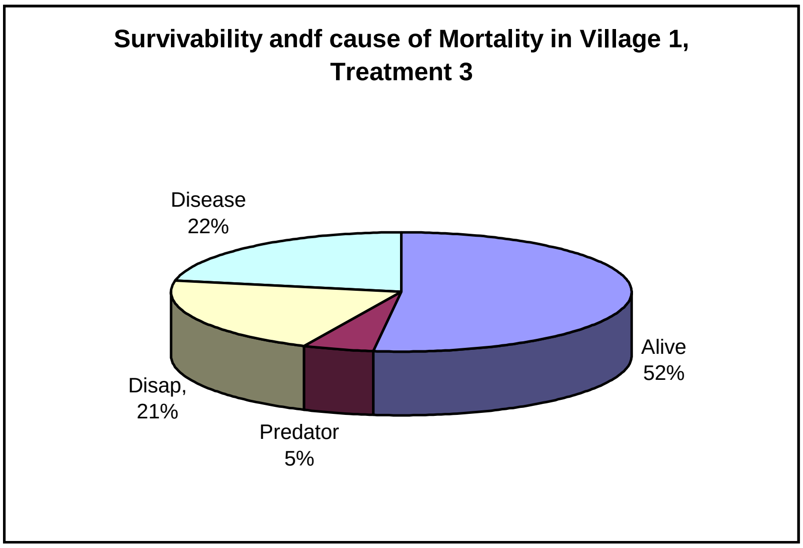


Fig. 5 Survivability and cause of Mortality in Village 1, treatment 3

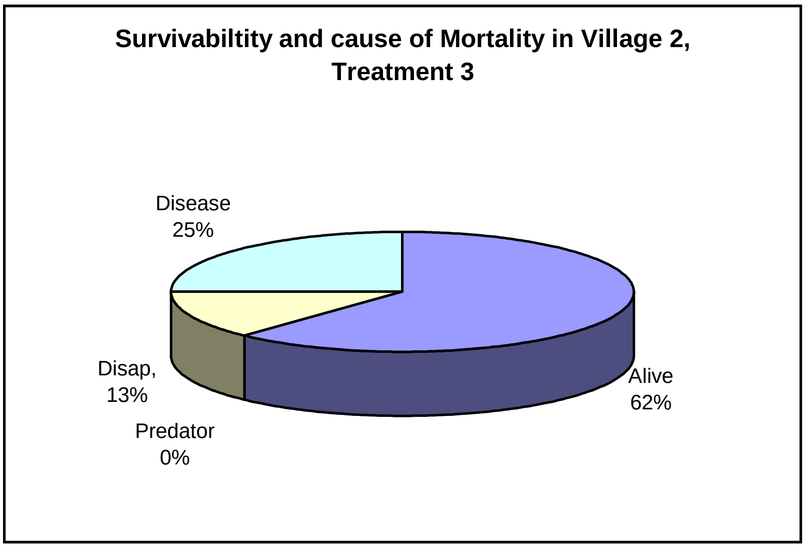


Fig. 6 Survivability and cause of Mortality in Village 2, treatment 3

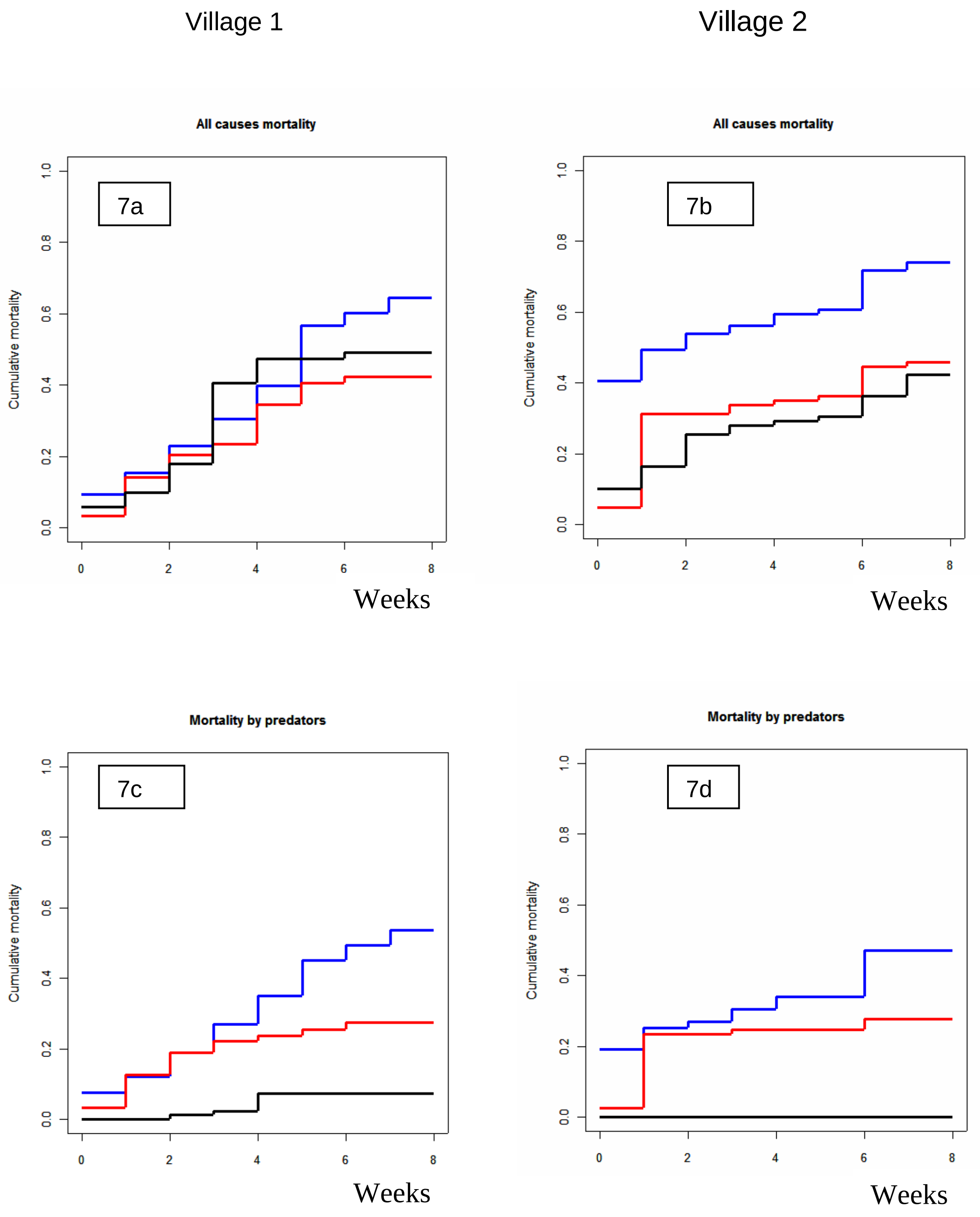
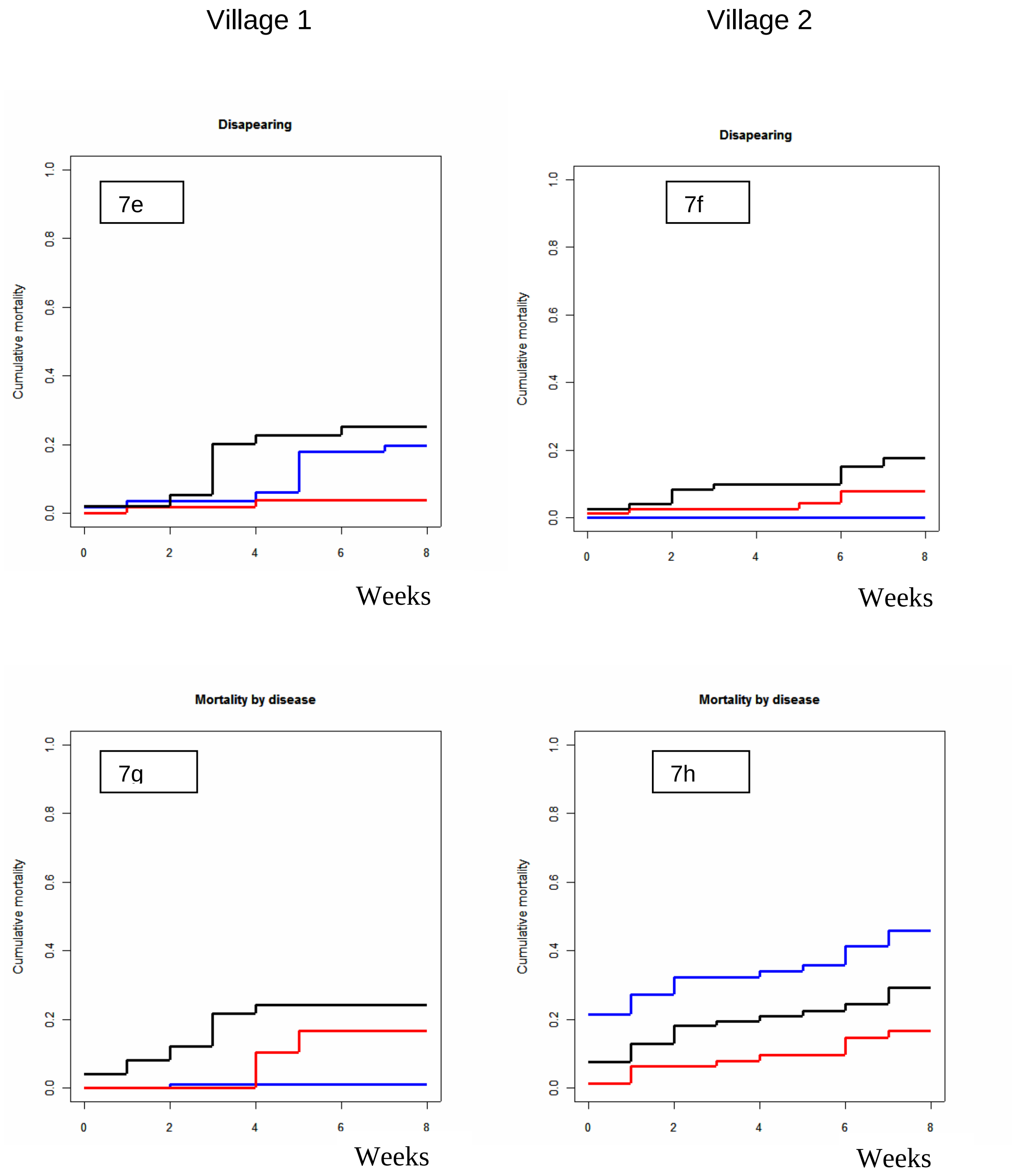


Figure 7 (a-d). Cumulative mortality:
Blue=treatment 1
Red=treatment 2
Black=treatment 3



Figures 7 (e-h). Cumulative mortality:
Blue=treatment 1
Red=treatment 2
Black=treatment 3