

THE EFFECT OF EDUCATION ON SMALLHOLDER PIG FARMERS'
KNOWLEDGE, PRACTICES AND PIG PRODUCTIVITY IN THE ANGÓNIA
DISTRICT, MOZAMBIQUE

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DECLARATION

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ABSTRACT

Smallholder pig production provides an important contribution for farmer livelihoods in many African developing countries. However, there are many constraints that limit pig performance and thus financial outcome. The present on-farm trial was carried out from June 2011 to September 2012 in four villages in the Angónia district, Tete province, Mozambique. The aim was to evaluate the effectiveness of pig health, housing, feeding and reproduction education of smallholders pig farmers on the knowledge uptake, changes in pig management practices and performance of sows and their offspring. All four villages were taught pig health and housing, but information on either feeding, reproduction or feeding and reproduction was also provided to each of three villages. The education was provided through an initial focussed group discussion followed by a collective and participatory training session. In addition, construction of a good quality pig pen was demonstrated in each village and throughout the study farmers received on-farm knowledge reinforcement. For evaluation of knowledge and practices, pig farmers (total across the villages: n=179) were tested using a semi-closed questionnaire and on-farm observation pre-education (baseline, month zero) and post-education (month thirteen). Reproduction data from sows (n=125) and production data from their progeny (from birth until 8 months age, n=461) were collected from June 2011 to June 2012. Overall, 58% of the sows could be monitored to the end of the study. Overall high and significant proportions of farmers demonstrated knowledge uptake but the changes in practices were more modest except for pig pen quality, which improved substantially. The only significant change in pig productivity was an increase in the number of litters per sow in only one of the two villages taught reproduction. Unfortunately, this was countered by high piglet mortality so the number of weaned piglets was the same as in the other villages. It is concluded that, though education can induce substantial knowledge uptake by smallholder farmers, it is more difficult to change their practices. This was probably in part due to lack of resources, but overall with just a little change there is a potential for improving pig performance.

CHAPTER 1

GENERAL INTRODUCTION

Livestock production is an important agricultural activity because it contributes substantially to global food security for a large proportion of the human population. Combined with a worldwide increase in demand for meat it is therefore becoming more and more important to focus on producing livestock species with a fast growth rate that are likely to meet these needs. Pigs are very prolific, precocious and have a very efficient feed conversion rate, and can thus contribute substantially to the overall production and output of the livestock subsector. “Pork is the world’s most consumed meat from terrestrial animals” (FAO, 2012). In Mozambique, the demand for pork is high and the local farmers cannot produce enough to supply the needs so that the market tries to cover the deficit by importing pork and pork products from the neighbouring countries such as South Africa and Swaziland (Direcção Nacional de Pecuária, 2014). In the last decade (from 2000 to 2011) Mozambique registered a drop of 2% in pork production (FAOSTAT, 2014) so that, approximately 532 tons of pork were imported in 2012 alone (Direcção Nacional de Pecuária, 2014).

In contrast to the developed world, where highly commercial and intensive pig production systems are dominant, developing countries mainly produce pigs in traditional small-scale subsistence-driven production systems (FAO, 2012). In Mozambique particularly, the commercial intensive sector almost does not exist and more than 80% of pig farms of the country are smallholder farming units (Instituto Nacional de Estatística, 2010). In the smallholder pig farming systems, pig keeping is very often one component of a mixed food and cash crop production system (Wabacha *et al.*, 2004a), but they still play a very important role for the farmers’ livelihood. Pigs provide meat mainly at special occasions like wedding festivals and other ceremonies, but fundamentally they represent a fast source of money in the case of money shortage or urgent family needs (Ocampo *et al.*, 2005) such as school fees for the children (Wabacha *et al.*, 2004a) or medical treatment (DANIDA, 2006).

However, smallholder pig farming has an overall low productivity and consequently low financial output. In this low input-output system, sow performance is crucial because it determines the overall herd performance. For example, compared to the commercial industry, smallholder pig farming produces fewer weaned piglets per sow per year as a consequence of small litters (Lanãda *et al.*, 1999), longer weaning to conception interval and high level of pre-weaning mortality (Lanãda *et al.*, 2005). Studies specifically evaluating sow performance on smallholder farms in tropical regions have shown that the low performance levels are especially due to diseases (Wabacha *et al.*, 2004a) and poor management such as poor breeding schemes (Ocampo *et al.*, 2005; Mutua *et al.*, 2011), poor hygiene and poor nutrition

(Gatenby & Chemjong, 1992; Lanãda *et al.*, 1999; Mutua *et al.*, 2011; 2012). In addition, piglet performance also depends on maternal management and subsequent performance, particularly the feed supplementation to suckling piglets and the length of the lactation period (Taveros & More, 2001).

Despite all the constraints, there are opportunities to develop subsistence pig farming systems (Wabacha *et al.*, 2004b). The reproductive performance of sows could thus be improved through farmer mentoring programs that directly target management strategies by providing knowledge especially on feeding, breeding and general management (Ocampo *et al.*, 2005). However, there is still a large gap between the published scientific management tools that could potentially improve long-term profitability on smallholder pig farming and the farmers' application of these tools.

Farmers' education could be a valuable strategy to improve smallholder pig farming. In Mozambique, studies assessing the effects of providing technical education to farmers on the performance of their livestock are scarce. The aim of the current study was to assess if education of smallholder pig farmers could improve their knowledge improvement and whether such improvement could result in better pig management practices and ultimately improve sow and progeny productivity.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The process of globalisation results in changes in trade and investment patterns, pushing agricultural producers and rural communities in developing countries to try to adapt to the changing scenario. The most important challenges are to identify and implement tools that can increase food security and economic return in order to increase public health and reduce poverty.

Pig production in particular can make an important contribution to the global livestock productivity and outcome because pigs are generally very prolific and precocious when compared to other livestock species. However, the small subsistence production systems (smallholder farms), which are very common in African developing countries, generally do not use the valuable local resources efficiently. Therefore, to better contribute to farmers' livelihoods through pig production is essential to study and implement pig management tools that could improve the productivity and profitability of the low input-output pig production systems.

With the main focus on developing countries, this review describes the main characteristics, constraints and challenges of smallholder pig farming systems. The review also shows the potential for development of systems based on locally available resources, improving sustainability. Further, the importance of education and the most recommended methods are described, including the many complex factors to be taken in account when understanding the dynamics of the process of learning and adopting new technologies.

2.2 CLASSIFICATION OF PIG PRODUCTION SYSTEMS

Globally, many different pig production systems have been described and each specific system had a considerable heterogeneity. It is therefore important to know the main characteristics of the individual systems in order to identify and address interventions to improve performance and sustainability of a given system (FAO, 2001).

The great diversity in pig production is reflected in the many ways different authors classify pig production systems. Devendra & Fuller (1979) thus described three main production systems, which included 1) small-scale subsistence systems, 2) semi-intensive systems and 3) intensive systems. In addition, they added an integrated production system, combining

livestock production with other agricultural activities such as crop production. Eusebio (1980) on the other hand, described four major systems of rearing pigs in tropical developing countries in Asia, South America and Africa, grouping them in 1) scavenging systems, 2) backyard systems, 3) medium-sized pig units and 4) large-scale commercial pig production systems. Holness (1991) more simply used two overall systems 1) small-scale systems (incl. scavenging pigs, semi-intensive production and intensive production) and 2) large-scale systems (incl. intensive or extensive production), but also described separately, the integrated system similar to that of Devendra & Fuller (1979).

Analysing the descriptions of the various authors there are many coincidences in system and sub-system characterisation. For Devendra & Fuller (1979) the subsistence production system was characterised by rearing animals in complete freedom and self-sustenance or confined in very rustic pens with provision of feed. Eusebio (1980) preferred to further sub-divide this group and designated pigs in complete freedom as “scavenging pigs” while “backyard pigs” when reared under confinement in rustic pens or tied by a rope in the yard or elsewhere and thus dependent on the kitchen waste and occasionally agricultural by-products for their survival. Half the pig population in developing countries is typically maintained in these traditional small-scale subsistence systems (FAO, 2014). These have generally been shown to be low-input systems (Kagira, 2010) commonly using indigenous breeds (Eusebio, 1980; Ocampo *et al.*, 2005; Phengsavanh *et al.*, 2010) but also exotic-indigenous crossbreeds (Kagira, 2010) that were kept in small herds (Ocampo *et al.*, 2005; Kagira, 2010; Mutua *et al.*, 2011). The indigenous breeds were preferred because they tend to be tolerant to more adverse rearing conditions as low feed quality, high temperatures and diseases (Eusebio, 1980; Madzimure *et al.*, 2012).

The opposite is observed in intensive systems, which according to Devendra & Fuller (1979) demand a very high investment in buildings and equipment, skilled labour and in order to return the invested capital they depend on a high demand for meat of good quality by consumers. This system was classified as large-scale commercial production by Eusebio (1980) who added as part of the system, the integration of activities ranging from the production of grains (including transformation into feed rations) and pork processing. On the other hand, Holness (1991) named this system as large-scale intensive production systems and added that they use modern breeds of high-performance or their hybrids and that the conditions of housing, feeding and husbandry should be optimal. These systems are typically found in Europe and North America where pig production is mainly a large-scale business, carried out as an industry, which in most cases is very specialised (Eusebio, 1980). The use of improved breeds and progress in feeding technology, husbandry practices and disease control (Holness, 1991), reinforced by the fact that the consumers are increasingly demanding quality

and to know the origin of the products (Honeyman, 2005) have been important factors in developing the industry in these regions. Due to the emerging concern for animal welfare, alternative production systems such as free-range and organic system (Sundrum, 2001) have been re-introduced and optimised in many developed countries. These systems are improved welfare systems that are often more expensive to manage than the intensive indoor systems, thus making the meat more expensive and a niche product (Bornett *et al.*, 2003).

Between the subsistence and intensive systems, Devendra & Fuller (1979) allocated an intermediate sub-system of pig production, the semi-intensive system. In this system, besides the relative low financial investment compared to the intensive system, pigs are kept in small fields, as part of mixed agricultural activities with access to pasture and crop residues. Pregnant females generally have pens or refuges for farrowing and as a shelter. In contrast, this type of system was designated as an extensive system by Holness (1991) and considered as a component of large-scale systems (outdoor systems) and later defined by Honeyman *et al.* (2001) as being a system, which enables pigs access to open fields.

2.3 PIG PRODUCTION IN AFRICA

Africa holds only 3.1% of the world's pig population and contributes with 2% of the world pork production (FAOSTAT, 2011). As presented in Figure 2.1, on the African continent the pig production is concentrated in the Sub-Saharan region while in northern Africa is insipient. Nigeria is the leader in terms of pig population in the continent while South Africa, Tanzania, Mozambique and Madagascar Island are the most representative in the southern Africa (Figure 2.1) (FAOSTAT, 2010). The main production system in most of the African countries is traditional systems where indigenous pigs or their crosses are the most used (Lekule & Kyvsgaard, 2003), as reported for example in Kenya by Wabacha *et al.* (2004a) and Kagira (2010) and in Mozambique by Pondja *et al.* (2010).

In relation to pork production, overall the continent registered an increase of 5.8% from 2000 to 2011, corresponding to an increase of 1,282,900 tonnes. The largest pork production occurred in Southern Africa (660,300 tonnes), where the South Africa was leading the pork production (320,000 tonnes) and pork production was growing compared to the rest of the continent (10,8% from 2000 to 2011) (FAOSTAT, 2014). While the trend of pork production in Africa is of growing, in Mozambique the opposite scenario was happening, where for 2000 to 2011 was registered a drop of 2%.

In Mozambique the pig population dropped from 1,677,000 animals in 1999 to 1,266,000 in 2008 (FAOSTAT, 2010). About 98.2% of the pig production units in the country are

smallholder units (Instituto Nacional de Estatística, 2010). Tete province (where the Angónia district is located) is the second major holder of pig units in the country (with 16.6% of units) while Inhambane province holds the major proportion (39% of the units).

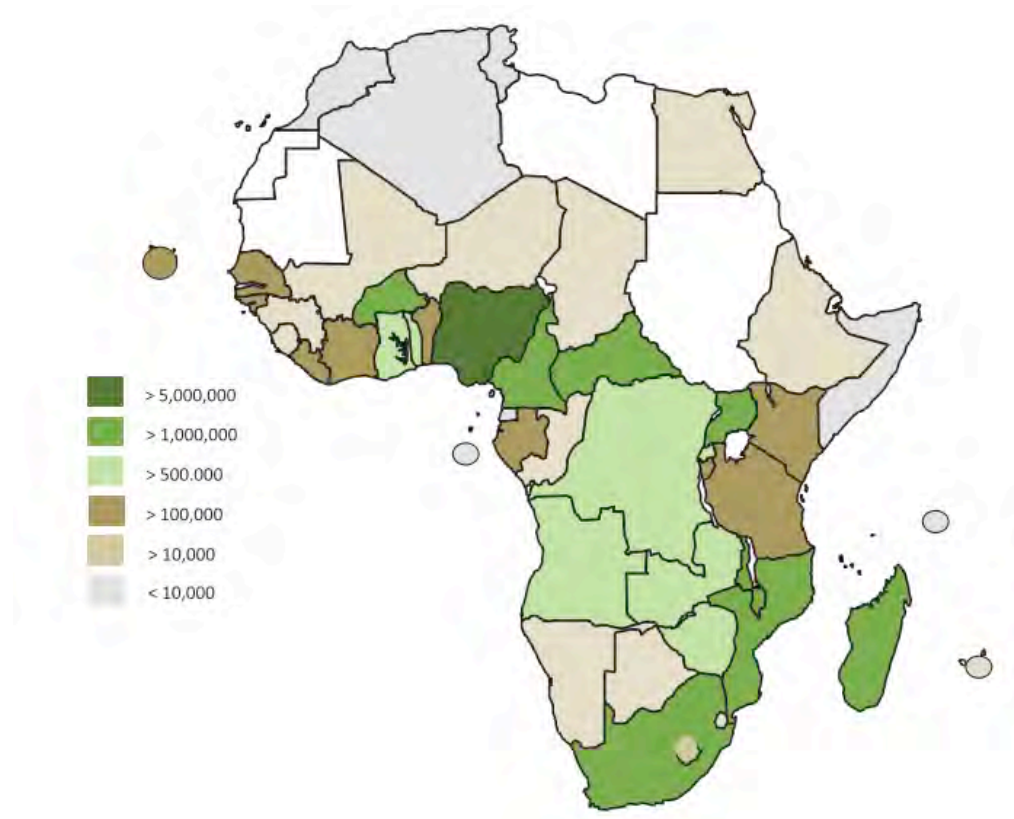


Figure 2.1 Pig population in African countries. The unshaded countries and the Comoros Islands have been reported to having no pigs (FAOSTAT, 2011).

2.4. CHARACTERISATION OF SMALLHOLDER PIG PRODUCTION SYSTEMS

2.4.1 General characterisation

Smallholder pig farming systems have been characterized by low inputs though it is still carried out with the purpose of supplementing a household income (Eusebio, 1980; Kagira, 2010) rather than for family consumption (Pondja *et al.*, 2010). The pigs are commonly kept in traditional free- and semi-scavenging systems (Ocampo *et al.*, 2005; Phengsavanh *et al.*, 2010), the herd size per farmer generally small, each farmer keeping 2-3 sows (Ocampo *et al.*, 2005) or an average of 1.3 sows (Mutua *et al.*, 2011). Most of the pigs reared in these systems are of indigenous breeds (Ocampo *et al.*, 2005; Phengsavanh *et al.*, 2010) and the investments in breeding, feed and disease control are minimal (Lanāda *et al.*, 2005).

Consequently, management practices are poor, where pigs have limited access to water and veterinary care such as deworming and vaccination (Lee *et al.*, 2005; Lanāda *et al.*, 2005), and to a high level of inbreeding (Phengsavanh *et al.*, 2010). This system can be affected by many constraints that may impact animal performance and welfare. Studies recommended education of farmers as a strategy for improvement (Ngowi *et al.*, 2008; Thomas *et al.*, 2013). The low priority given to pig production compared to other agricultural activities is also a constraint (Wabacha *et al.*, 2004a; Kagira, 2010). There are reports indicating that farmers spent less than 1 hour a day for pig management (Chittavong *et al.*, 2012a). This is because smallholder pig production is part of more complex agricultural production systems (Taveros & More, 2001) and for many farmers it is not the primary activity, but often supplements crop production (food and cash crops) which is the basic source of income (Wabacha *et al.*, 2004a). The most important limitations for smallholder pig productivity include reproductive performance of sows (Gatemby & Chemjong, 1992; Lañada *et al.*, 1999; Wabacha *et al.*, 2004b), the high mortality rate (Lañada *et al.*, 1999; 2005) and the low growth rate of pre-weaning piglets (Wabacha *et al.*, 2004b). The scarcity of feed resources (Kagira, 2010; Chimonyo *et al.*, 2010), the low feed quality (Ocampo *et al.*, 2005; Ajala *et al.*, 2007; Tu *et al.*, 2010) and diseases (Gatenby & Chemjong, 1992; Lanāda *et al.*, 1999; Kagira, 2010; Mutua *et al.*, 2011) were also important constraints.

2.4.2 Housing conditions and confinement practices

Pigs in smallholder systems can be provided pens or not. Some of the reasons mentioned by farmers for not building pig pens include limitations on providing feed to the pigs, fear that pens would be damaged by the pigs, the muddy environment generated during the rainy season and the lack of time to take care of confined pigs (Mutua *et al.*, 2012). Lack of money to buy building materials, time and knowledge on how to build pig pens were also considered as limiting factors (Mutua *et al.*, 2012).

The type of pen adopted varied widely in terms of materials used, design and dimensions (Figure 2.2). In western Kenya for example, 87% of the farmers did not have a pig house but used simple pig pens built on locally available materials (Mutua *et al.*, 2012). Similar structures are found in Kenya (Lemke *et al.*, 2006). In Vietnam, these materials included wood, bamboo and straw (Lemke *et al.*, 2006). On the other hand, it has also been possible to find conventional pig pens under smallholder farming conditions, which were fully roofed (More *et al.*, 2005a; Lanāda *et al.*, 2005), with cement flooring (Lanāda *et al.*, 2005) or with a mix of cement on the floor, concrete or bamboo for the walls and straw, tiles or asbestos for the roof (Lemke *et al.*, 2006).

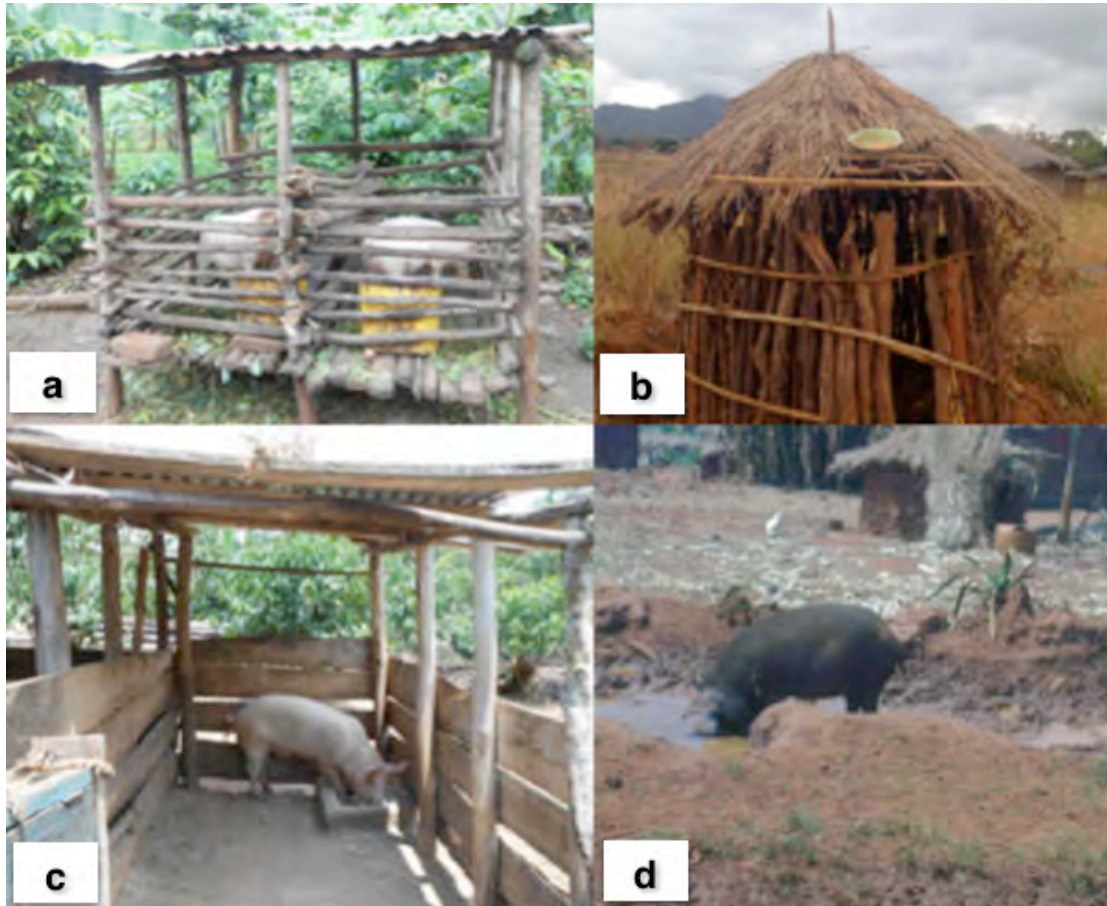


Figure 2.2 a. raised pig pen with timber floor in Uganda (Ouma *et al.*, 2014); b. non-raised pig pen with earth floor in Mozambique (Angónia district); c. non-raised pig pen with cemented floor in Uganda (Ouma *et al.*, 2014); d. Pig in free range in Mozambique (Angónia district, Zeiss Alfredo).

Permanent confinement was reported in Vietnam for breeding pigs and fatteners whereas the piglets had access to the external area of the pen (Lemke *et al.*, 2006). The pig houses can be positioned on stilts or at ground level (Lemke *et al.*, 2006). The pig house with elevated floor are considered to be very hygienic because the urine is easily drained (Ouma *et al.*, 2014).

The area (m^2) of the pen varies but generally they are small and the vital space (m^2/pig) did not follow technical recommendations. Lanãda *et al.* (2005) reported $3,5 \text{ m}^2/\text{boar}$ (range $0.7 - 8.1 \text{ m}^2/\text{boar}$), whereas More *et al.* (2005a) reported a range of 0.3 to $5.1 \text{ m}^2/\text{pig}$ and a median of $1.7 \text{ m}^2/\text{growing pig}$. For sows a median of $3.7 \text{ m}^2/\text{sow}$ (range $0.8 - 15.7 \text{ m}^2/\text{sow}$) was reported at the northern part of the Philippines (More *et al.*, 2005a).

The presence of pig houses does not necessarily mean permanent confinement. Before the end of harvest in Colombia, pigs were generally kept confined to avoid crop damage and after the harvest pigs were released to have free access to crop residues in the fields and to other feed sources (Ocampo *et al.*, 2005). Contrarily, in western Kenya, during the planting, growing and harvesting seasons most of the pigs were prevented from roaming by being tethered

rather than confined inside pens (Mutua *et al.*, 2012). Although not common, tethered pigs were also seen in the Philippines (More *et al.*, 2005a). There were reports that pigs were also confined in cases of large herds (more than 5 sows) and the sows were confined when they were about to farrow (Ocampo *et al.*, 2005). Where crop protection was not an important issue pigs were confined during the night and then allowed to roam freely during the day (Chittavong *et al.*, 2012a; Mutua *et al.*, 2012).

2.4.3 Breeds

Breed is the term given to a livestock group that have similar phenotypic characteristics which distinguishes them from other members of the same species (Barker, 2001). Within a given geographic area pig breeds are generally described as indigenous, crossbreeds and sometimes improved. The most common breeds reared under subsistence or smallholder pig farming have previously been shown to be indigenous breeds (Lanāda *et al.*, 2005; Ocampo *et al.*, 2005; Kagira, 2010; Madzimure *et al.*, 2012) and they were generally small (60-70kg) and completely black (Ocampo *et al.*, 2005; Kagira, 2010) or sometimes black with white markings (Kagira, 2010; Phengsavanh *et al.*, 2010) (Figure 2.3). Farmers with limited resources preferred to keep local breeds because, compared to the improved breeds, they were anatomically better adapted to extensive rearing systems and to the tropical climate (Ocampo *et al.*, 2005; Phengsavanh *et al.*, 2010). Indigenous breeds were also preferred because they are perceived to be more tolerant to limited and poor quality feed resources and to diseases (Ocampo *et al.*, 2005; Herold *et al.*, 2010). In Northern Lao PDR farmers also claimed that pigs of indigenous breeds are in higher demand in local markets and that the meat tasted better (Phengsavanh *et al.*, 2010) whereas in Colombia the carcass quality was also an important criteria (Herold *et al.*, 2010).

However, crossbreeds may also be common in the smallholder pig farming systems in some regions. In the Philippines, native/exotic crossbreeds were the most common (Lanāda *et al.*, 2005; More *et al.*, 2005). In central Kenya, all the pigs were commercial crossbreeds mostly of large white or landrace (Wabacha *et al.*, 2004a), whereas most pigs in western Kenya were commercial and/or native crossbreeds (Kagira, 2010). According to Phengsavanh *et al.* (2010) mature crossbreeds can reach between 80 to 120Kg.



Figure 2.3 Varieties of pigs kept by smallholder farmers in Busia District. **a.** White boar, **b.** Black and white sow, **c.** Black boar, **d.** Black and white grower (Kagira, 2010).

Though rare under smallholder pig farming systems, commercial breeds were reported in the Philippines (Lanāda *et al.*, 2005) and also in the Rain Forest of the Pacific Coast of Colombia (Ocampo *et al.*, 2005).

2.4.4 Breeding

Commonly, under the smallholder farming system farmers keep a low number of sows (2-3 sows) and reproduction is not controlled (Ocampo *et al.*, 2005). Most sows are raised at the farm or come from a neighbouring farm (Lanāda *et al.*, 2005). Farmers also keep their own boars (Lanāda *et al.*, 2005; Ajala *et al.*, 2007; Mutua *et al.*, 2011) or use boars owned by a group of farmers (Mutua *et al.*, 2011). In regions where most of the farmers did not keep breeding boars (Wabacha *et al.*, 2004a), the sources of breeding boars included borrowed boars from the other farmers or free roaming boars (Lanāda *et al.*, 2005; Ajala *et al.*, 2007). In one study, natural mating was the most practiced (Wabacha *et al.*, 2004a). Overall, inbreeding was found to be common in smallholder systems (Ocampo *et al.*, 2005; Ajala *et al.*, 2007).

Indigenous gilts tend to be precocious, being mated for the first time at an average of 7.5 months age and the sows reproductive life has been found to last until 9 farrowings, though 5 was the most common (Ocampo *et al.*, 2005). However, it may also be restricted to only one

farrowing because farmers believe that sows do not come into oestrous after the first farrowing (Ocampo *et al.*, 2005). Boars may be kept for a long reproductive period and culled mainly due to old age rather than to reproductive disorders (Ocampo *et al.*, 2005). In most cases piglets are weaned naturally (Ocampo *et al.*, 2005) but there were cases of artificial weaning at two or more months of age and less commonly between one and two months or even less than a month old (Kagira, 2010). Kugonza & Mutetikka (2005) tested different strategies of artificial weaning for commercial piglets bred under smallholder farming conditions and concluded that restriction to suckling two times a day and split weaning (each piglet was weaned when it reached 6Kg live weight) did improve sow productivity without reducing piglet survival and growth. Conversely, early weaning associated with lack of feed supplementation to suckling piglets were reported as compromising factors for smallholder sow productivity (Taveros & More, 2001). Although early weaning can reduce production costs, it can also generate higher disease and mortality rates (Galanopoulos & Aggelopoulos, 2006).

2.4.5 Feeding

Feeding has been reported as one of the main constraints for smallholder pig production in African countries (Ajala *et al.*, 2007; Mutua *et al.*, 2010; Ouma *et al.*, 2014) and also in non-African countries (Tu *et al.*, 2010; Chittavong *et al.*, 2012b) where the feeding regime is overall based on the availability of feed resources rather on the needs for good pig performance (Lemke *et al.*, 2006). Feed resources can be scarce and even if available, the prices may be prohibitive (Chimonyo *et al.*, 2010). Feedstuffs availability is also dependent on seasonality, main agricultural practices in the region and different farmer's experience on pig production (Phengsavanh *et al.*, 2010).

Overall, in smallholder farming systems, pigs are left to roam freely in order to search for their own food and only in some cases they have access to supplementation but very irregularly in frequency and quantity (Ocampo *et al.*, 2005; Phengsavanh *et al.*, 2010). Confined pigs are mostly fed two times a day with the basic feed (Chittavong *et al.*, 2012a; Mutua *et al.*, 2012), once in the morning and once in the evening but rarely three times a day (Chittavong *et al.*, 2012a). The limitations on feedstuffs are not only in quantity but also in quality, specially concerning the supply of protein (Ocampo *et al.*, 2005; Chittavong *et al.*, 2012b) and minerals like Calcium (Ca), Sodium (Na) and Phosphorus (P) (Chittavong *et al.*, 2012b). The basic food provided for the pigs varies largely in different regions, according to availability and accessibility. For example banana and maize were the most common feedstuffs in Colombia (Ocampo *et al.*, 2005), whereas household leftover food (peels of

yams, potatoes, cocoyam, bran and cereal crops) and brewers' wastes were used in Nigeria (Ajala *et al.*, 2007). In Kenya, household wastes, vines of vegetables, sweet potatoes and swills were frequent (Kagira, 2010). Farmers in Lao PDR used rice bran, broken rice, maize, brewers' grains, taro, thick head and fresh cassava roots (Chittavong *et al.*, 2012a). As presented before, the most used feedstuffs are mainly energy rich, resulting in diets nutritionally imbalanced (Phengsavanh *et al.*, 2010) and even assuming that overall, the nutritional requirements of indigenous pigs, which are most commonly utilised in this system (Ocampo *et al.*, 2005; Lanāda *et al.*, 2005; Kagira, 2010; Madzimure *et al.*, 2012) are lower than those of commercial breeds, the protein needs of indigenous pigs varies between pig categories and cannot be completely satisfied by forages only (Ocampo *et al.*, 2005). This was confirmed in a field study on pig supplementation in Lao PDR as local pigs in a smallholder farming system were affected by poor nutrition (Chittavong *et al.*, 2012b). Although commercially produced feeds could be an alternative for farmers but they are not commonly used. In some countries such as the Philippines (Lee *et al.*, 2005) and Kenya (Wabacha *et al.*, 2004a) there are reports of areas where the smallholder pig farmers used mostly commercial pig feeds. However, in many other countries most of the smallholder pig farmers do not know anything about using commercial feeds for pigs (Ajala *et al.*, 2007) or only very few farmers use commercial feeds (Ocampo *et al.*, 2005; Ajala *et al.*, 2007; Kagira, 2010). According to Chimonyo *et al.* (2010), in smallholder pig farming conditions it is better to use feed sources that are local and readily available because it promotes efficient resource utilisation and sustainability. In fact, the use of commercial feeds is reported in regions where pigs of commercial breeds (Wabacha *et al.*, 2004a) and/or crossbreeds (More *et al.*, 2005a; Lanāda *et al.*, 2005) are commonly reared.

Water access is also of concern. A very low proportion of pigs reared in this system has access to *ad libitum* drinking water (Lee *et al.*, 2005; Lanāda *et al.*, 2005) and the quality of the water used is poor (Wabacha *et al.*, 2004a). Some farmers use kitchen waste water (Mutua *et al.*, 2012) whereas others use over and underground water (Chittavong *et al.*, 2012a). Pigs are provided water in varied ways according to the region, e.g., farmers in western Kenya provide water mixed with the main feed whilst others provide it separated from the feed (Mutua *et al.*, 2012).

2.4.6 Productivity

The most important economic measure of productivity for breeding herds is the number of piglets weaned per sow per year (Radostits *et al.*, 1994). Productivity of the smallholder farming systems can be low as reported by Lanāda *et al.* (1999; 2005) in the Philippines.

Generally, one of the most important limiting factors may be the reproductive performance of the sow (Gatenby & Chemjong 1992; Lanāda *et al.*, 1999; Wabacha *et al.*, 2004b). Nevertheless studies on performance of sows on smallholders farms in tropical regions are scarce, it has been shown that the low sow reproductive performance is generally due to diseases, poor management and low food quality (Gatenby & Chemjong, 1992; Lanāda *et al.*, 1999; Mutua *et al.*, 2011).

2.4.6.1 Number of piglets weaned per sow per year

The number of piglets weaned per sow per year was negatively influenced by a prolonged period from weaning to conception (non-productive sow days), high level of pre-weaning piglet mortality (Lanāda *et al.*, 1999; 2005) and the litter size at birth (Lanāda *et al.*, 1999). In Kenya, the median for weaning to service interval was found to be 3 months and the farrowing-to-farrowing interval to be 6.4 months (Wabacha *et al.*, 2004b). In the Philippines the average farrowing-to-farrowing interval was 9.7 and 6.7 months in Northern and Southern sites, respectively (Lanāda *et al.*, 1999). In the South Western China the average was 11.4 months (Riedel *et al.*, 2014). The high number of non-reproductive days can be caused by malnutrition of the sow and also by a low availability of boars (Wabacha *et al.*, 2004b). Some smallholder farmers castrate and fatten most male pigs leading to subsequent problems such as lack of boars for service leading ultimately to inbreeding (Lanāda *et al.*, 2005). In Kenya, the long inter-farrowing interval commonly resulted in only 1 litter/sow/year. However, cases of 2.0 litters/sow/year were also reported (Wabacha *et al.*, 2004b).

2.4.6.2 Litter size

Productivity can also be affected by the litter size as this parameter associated with the pre-weaning piglet mortality, defines the number of piglets a sow can wean. An average litter size of 7.8 was reported in western Kenya (Mutua *et al.*, 2011) whereas 12.0 live-born piglets/litter was reported in central Kenya (Wabacha *et al.*, 2004b). Cases of more than 9.0 piglets per farrowing were also observed in Colombia and Kenya (Ocampo *et al.*, 2005; Mutua *et al.*, 2011). In northern and southern sites of the Philippines one study registered 8.5 and 8.4 live-born piglets, respectively (Lanāda *et al.*, 2005), and in South Western China an average litter size of 5.8 piglets was recorded (Riedel *et al.*, 2014).

2.4.6.3 Lactation period and weaning

The lactation period of the sows under smallholder farming conditions is variable and also a determinant for the farrowing-to-farrowing interval. Generally, in smallholder systems the lactation period is long (Wabacha *et al.*, 2004b; Riedel *et al.*, 2014). Weaning is often natural, happening when the sow will no longer feed the piglets (Ocampo *et al.*, 2005). For example, pigs were 4.1 to 10.5 months old at weaning in central Kenya (Wabacha *et al.*, 2004b), 5.4 months in Western Kenya and 4.3 months old in South Western China (Riedel *et al.*, 2014).

However, artificial weaning may also take place. It has been reported in western Kenya where piglets were weaned at ≥ 2 months of age and less commonly 1-2 months or even < 1 month old (Kagira, 2010). Although in situations of feed scarcity, artificial weaning has been pointed out as being responsible for high diseases occurrence and mortality (Taveros & More, 2001), there are strategies (e.g. restricted suckling and split weaning) that could lead to good results, (Kugonza & Mutetikka, 2005). Nath *et al.*, (2013) reported that 30% of the Indian farmers practiced artificial weaning for crossbreeds before 2 months of age and 50% of farmers weaned them when piglets were 2 to 3 months old.

2.4.6.4 Piglet mortality

Pre-weaning piglet mortality is also major determinant for the number of piglets weaned and under smallholder pig herds has been reported to be high (Lanãda *et al.*, 1999; 2005) so that piglet management is a critical factor for the smallholder sow productivity (Taveros & More, 2001). The number of piglet weaned tends to be low. In Kenya, one study registered 7.5 weaned piglets per farrowing (Wabacha *et al.*, 2004b). One study documented a 17% mortality within the first 24 hours after farrowing due to crushing or health problems (Ocampo *et al.*, 2005). Similarly, a 29% pre-weaning piglet mortality was reported in Kenya (Wabacha *et al.*, 2004b) whereas it was 19.0% and 12.8% in the northern and southern regions of the Philippines, respectively.

2.4.6.5 Average daily weight gain

The average daily weight gain (ADG) varies according to the breed used. In Kenya it was found that crossbreeds (0.15 kg/day) grew better than the local breeds (0.12 kg/day) (Carter *et al.*, 2013). According to the same authors, the causes for the overall low ADG in smallholder systems were malnutrition but also the high loss of energy due to a free-range regime, high parasite prevalence, disease and/or low genetic potential. Similar results were found in Kenya, with a median ADG of 0.13 kg/day both for pre-weaned and post-weaned piglets

(Wabacha *et al.*, 2004b). The genetic potential and sex of post-weaning pigs were shown to influence growth by Chimonyo *et al.*, (2010) in Zimbabwe, where indigenous/exotic crossbreeds showed a significantly higher ADG (0.41kg/day) compared to indigenous breeds (0.31 kg/day). In this study, males had better ADG than females. The authors associated the effect of sex with the positive influence of testosterone on growth.

Despite all the productivity constraints, there is a potential for sustainable improvements indicated by the presence of some highly productive sows under smallholder pig farming (Lanāda *et al.*, 1999; 2005).

2.4.7 Health/diseases

Diseases have been reported in many studies as important concerns in smallholder pig farming systems (Ajala *et al.*, 2007; Kagira, 2010; Kambashi *et al.*, 2014). Pig diseases can have a negative effect on pig performance (Carter *et al.*, 2013), financial outcome (Chah *et al.*, 2014) and also on public health (Mahanty & Garcia, 2010). Under this system the biosecurity measures are very poor (Alawneh *et al.*, 2014) and access to health and veterinary assistance lacking (Costard *et al.*, 2009; Kagira, 2010; Alawneh *et al.*, 2014). Prophylactic measures such as vaccination may be ignored (Wabacha *et al.*, 2004a) which may lead to disease outbreaks (Costard *et al.*, 2009). When disease does occur, smallholder farmers may respond very differently either seeking veterinary assistance, treatment with traditional remedies, do nothing or slaughter and eat or sell the affected pigs (Ajala *et al.*, 2007). In some cases, depending on the diseases and regions, commercial medicines or drugs are used by the farmers, for example anthelmintics and acaricides to control worm and mange infections, respectively (Wabacha *et al.*, 2004a). However, local treatment alternatives, such as engine oil to control mange (Wabacha *et al.*, 2004a) have been found to be more common in these systems (Ajala *et al.*, 2007).

There are many health problems in a smallholder setting and although the importance of different diseases varies from region to region there are some common problems. The most important health problems reported in many studies are related to parasites (both endo- and ectoparasite), infectious diseases and other non-identified diseases. Gastrointestinal parasites have been widely reported (Wabacha *et al.*, 2004a; Ajala *et al.*, 2007; Nganga *et al.*, 2008; Kagira, 2010; Matos *et al.*, 2011; Nonga, 2011; Nissen *et al.*, 2011; Nath *et al.*, 2013), but also extra-intestinal parasites such as Porcine Cysticercosis (PC) (Matos *et al.*, 2011; Nonga, 2011). Among the ectoparasites, especially sarcoptic mange (Wabacha *et al.*, 2004a; Ajala *et al.*, 2007; Kagira, 2010; Matos *et al.*, 2011; Nath *et al.*, 2013) and lice have been reported to be common (Kagira, 2010; Matos *et al.*, 2011). Infectious diseases have not always been

properly identified but African Swine Fever (ASF) has been diagnosed and documented (Kagira, 2010; Matos *et al.*, 2011). Other common health problems reported are diarrhoea (Wabacha *et al.*, 2004a; More *et al.*, 2005b; Lemke *et al.*, 2006; Ajala *et al.*, 2007; Nath *et al.*, 2013; Kambashi *et al.*, 2014) and pneumonia (Wabacha *et al.*, 2004a; Ajala *et al.*, 2007; Nath *et al.*, 2013).

Amongst all the diseases reported under this system, ASF is the most fatal for pigs (Kambashi *et al.*, 2014; Swai & Lyimo, 2014) and PC is an important public health risk associated with human epilepsy (Mahanty & Garcia, 2010). African Swine Fever is caused by a virus and the result is a devastating viral haemorrhagic fever with a morbidity and mortality up to 100% depending on the virus strain, the host, exposure level and the route of exposure to the virus (Costard *et al.*, 2013) and some pigs can fully recover from the disease (Penrith *et al.*, 2004). An outbreak results in considerable economic losses and food security decreases in the affected areas (Edelsten & Chinombo, 1995; Fasina *et al.*, 2012b). There is no vaccine and/or treatment against the ASF virus (ASFV) making it difficult to control the disease (Costard *et al.*, 2009), however, eradication is possible (Lyra *et al.*, 1986). In addition to high mortality rates, ASF outbreaks may block international trade and may induce implementation of drastic and costly control strategies to eradicate the disease (Costard *et al.*, 2009). In Africa, ASF has been reported to cause great losses for smallholders farmers (Swai & Lyimo, 2014; Kambashi *et al.*, 2014) especially where the biosecurity measures are very poor (Alawneh *et al.*, 2014). The epidemiology of the disease include the sylvatic cycle (between wild pigs and soft tick vectors), the domestic-sylvatic cycle (between soft ticks and domestic pigs) and the domestic cycle (between domestic pigs) (Costard *et al.*, 2013). The involvement of wild pigs and soft ticks in the transmission of ASF were demonstrated by Anderson *et al.* (1998). The domestic cycle occur through contact with infected pigs or fomites. Poor hygiene, shared implements, movement of workers, the use of the neighbouring farms as a source of new animals have been mentioned as responsible for the transmission of the disease in Nigeria (Saka *et al.*, 2010). Free-range pig farming has also been also reported as one of the most important risk factor for spreading ASF in Malawi (Allaway *et al.*, 1995) and Nigeria (Olugasa & Ijagbone, 2007). Other associated factors for spreading of the disease include the previous occurrence of the disease on the farm (Randriamparany *et al.*, 2005), the occurrence of the disease in the neighbourhood, the existence of an abattoir in the community (Fasina *et al.*, 2012a) and the omission to report disease outbreaks (Etter *et al.*, 2011). In Malawi, Allaway *et al.* (1995) also found that the slaughter and sale of infected animals was on major risk factor for ASF. The emergency sale of apparently ASFV free pigs, which is common in smallholders systems when an ASF outbreak is suspected, has thus contributed to spreading the disease (Randriamparany *et al.*, 2005; Fasina *et al.*, 2012a). The virus is highly resistant to

inactivation and can remain viable for long periods in blood, tissues and in the environment, thus the access of pigs to improperly disposed-of carcasses, frozen, insufficiently cooked or cured pork products represents a risk (Costard *et al.*, 2013).

Prevention and control of ASF are based on the implementation of biosecurity measures which include limiting access of people and vehicles to the production unit (Costard *et al.*, 2013). When access is needed by workers and veterinarians, they should be disinfected and supplied with protective clothes before entering the facilities (Penrith & Vosloo, 2009). Although not that effective, foot baths should still be part of the biosecurity protocol (Penrith & Vosloo, 2009). Prevention involve quarantine policy, zoning (establishment of diseased and disease-free zones), stamping out, compensation for culled animals (to encourage early reporting and avoid the emergency slaughter by the farmers for home consumption, for sale and inappropriate disposal of the carcasses), cleaning/disinfection, tick control, sentinel animals, restocking and wildlife control are important measures to prevent and control ASF (FAO, 2012).

The disease is endemic in Mozambique including the Angónia district, with a prevalence of ASF in the district of about 14,3% (indirect ELISA) (Matos *et al.*, 2011).. Although surviving pigs are only carriers of ASFV for a short period (Penrith *et al.*, 2004), a high proportion of these pigs may still spread the virus to the environment for 70 days or more, thus representing a risk for the transmission of ASF (Ferreira *et al.*, 2012). Circulation of the virus is dependent on naive pigs, which may often be easily accessible within the traditional free-ranging pig farming systems (Penrith *et al.*, 2007). As presented in Figure 2.4a, before 1994 the disease was restricted to the Centre and North of Mozambique. In 1994 the first outbreak of ASF occurred in the Southern region, in Maputo province, at the Veterinary Faculty of the Eduardo Mondlane University (DINAP, 1994), and then the provinces of Gaza, Inhambane were also affected, but the greatest impact was in Maputo, which held the largest number of pigs of the country (DINAP, 1994). The distribution of ASF outbreaks in Mozambique from 1994 to 2006 is presented in the Figure 2.4b.

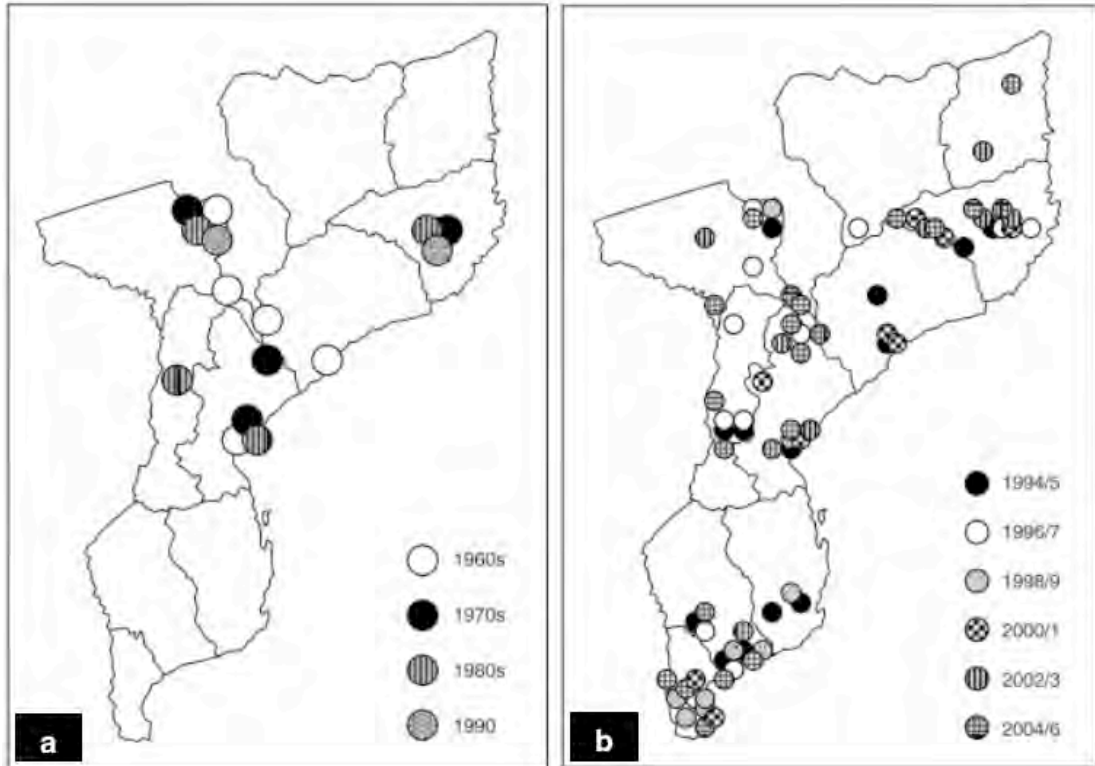


Figure 2.4 a. Distribution of African swine fever outbreaks in Mozambique from 1954 to 1994; **b.** Distribution of African swine fever outbreaks in Mozambique from 1994 to 2006 (Penrith *et al.*, 2007).

As presented in Figure 2.4, AFS has also been diagnosed in almost all countries surrounding Mozambique such as Tanzania, Malawi, Zambia, Zimbabwe and Madagascar Island. In South Africa only sporadic outbreaks have been reported to occur via a sylvatic cycle.

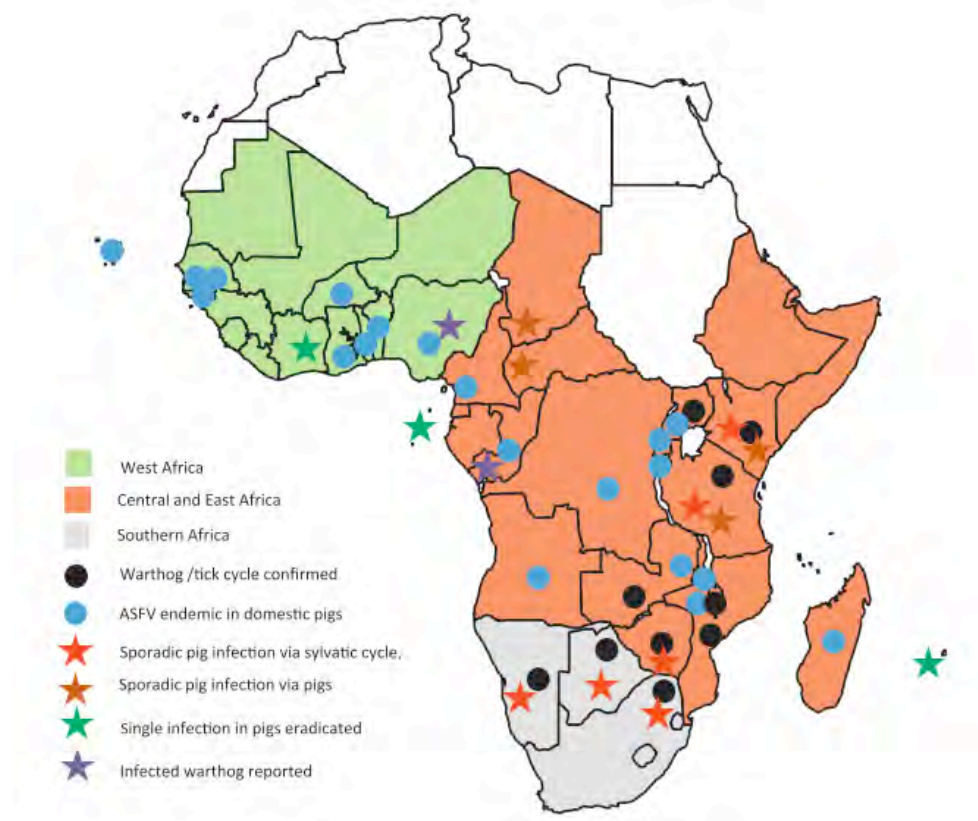


Figure 2.5 Distribution of African swine fever in Africa (Penrith *et al.*, 2013).

PC is caused by the tapeworm *Taenia solium* (García *et al.*, 2003). As presented in Figure 2.6, the parasite has a life cycle that needs two hosts, the human being the only definitive host of the adult tapeworm whereas both humans and pigs can serve as the intermediate host of the *T. solium* larvae (*Cysticercus cellulosae*), so that the parasite needs both hosts to complete its life cycle (García *et al.*, 2003). Infestation occurs by ingestion of eggs each containing a single *T. solium* larva. In the pig the larva leaves the egg and migrates to all types of tissues and organs and is encysted causing PC which is prevalent in many African countries (Phiri *et al.*, 2003). If a human (final host) eats undercooked infected pork, the larva is released in the intestinal tract growing into an adult tapeworm in the intestine (taeniosis) (Boa *et al.*, 2006). The adult parasites, as a way of reproduction, release body segments (proglottids) containing infective eggs. The eggs are then passed to the environment with the human faeces and may be spread to vegetables, water and other human foods. Humans can then be directly exposed to the eggs by autoinfection when they ingest eggs or proglottids from their own faecal material or indirectly by ingestion of contaminated food or water. This causes the parasite to behave as if the human is the intermediate host and causes human cysticercosis (HC) or if the cysts lodge in the central nervous systems, neurocysticercosis (NCC).

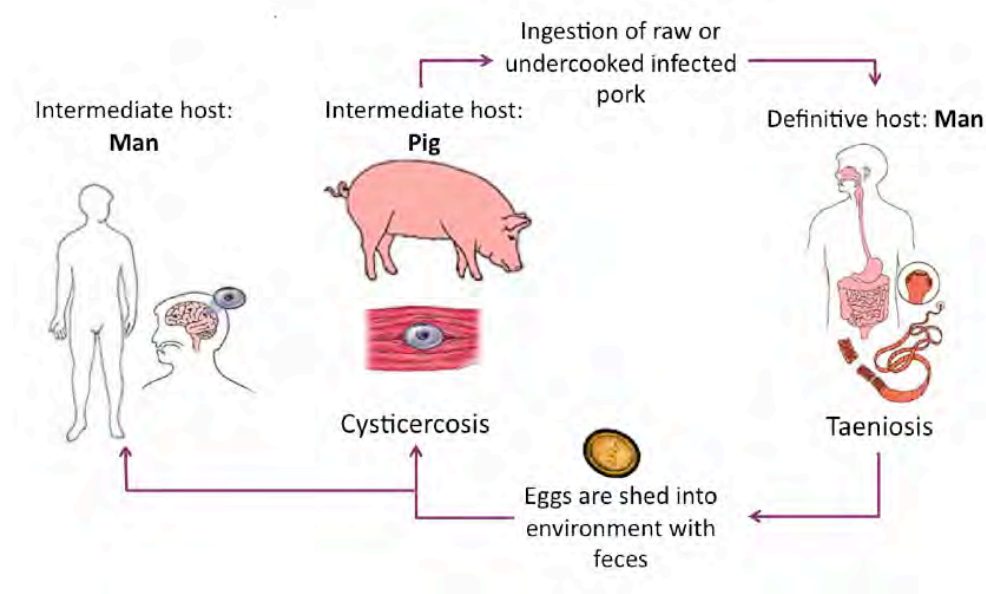


Figure 2.6 Life cycle of *Taenia solium* (Deckers, 2007).

Human cysticercosis have also been reported in many African countries (reviewed by Mafojane *et al.*, 2003). Pigs may ingest eggs by eating human faeces due to coprophagic behaviour or through rooting and foraging in a contaminated area. In Angónia, Mozambique approx. 40% of the pigs are infected with PC (Pondja *et al.*, 2010). There is little evidence of clinical and subclinical symptoms in pigs, but it is likely that they are affected to some degree. However, it is the zoonotic potential that has a serious impact on the pork trade because infected carcasses officially have to be rejected for human consumption, not being officially marketed (Nonga, 2011). Unfortunately, in resource poor communities it is likely that infected meat is not condemned but sold on the black market at a low price, thus having a negative effect on farmers' livelihoods and potentially their health. To control cysticercosis and taeniasis it is necessary to change human behaviour and practices by preventing open defecation (use of latrines), inspection of pig carcasses at the abattoirs, improving pig husbandry (complete confinement of pigs), properly cooking pork (Boa *et al.*, 2006), improving hygiene/sanitation (Nonga, 2011), treating against cysticercosis PC/HC (Mkupasi *et al.*, 2013) and improving health education (Ngowi *et al.*, 2008a; Pondja *et al.*, 2010). Figure 2.7 shows the worldwide distribution of *T. solium* taeniosis/cysticercosis.

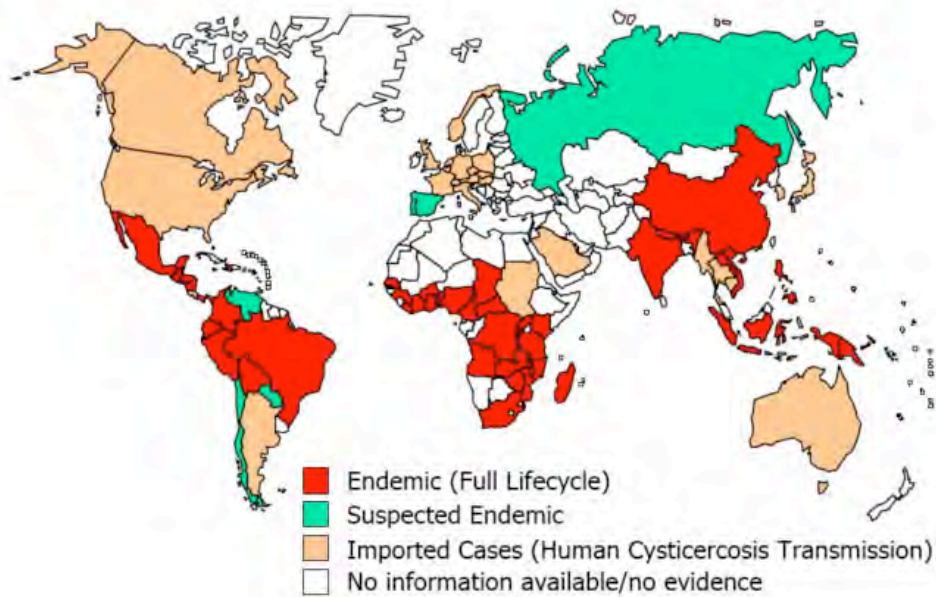


Figure 2.7 Worldwide distribution of *Taenia solium* taeniosis/cysticercosis (Source: <http://www.bvsde.paho.org/bvsacd/cd65/cysticercosis.pdf>)

2.5. IMPORTANCE OF PIGS FOR SMALLHOLDER FARMER'S LIVELIHOODS

Pigs are a very important livestock species for smallholder farmers in developing countries. They efficiently convert food waste and agricultural by-products into high quality protein, have a relatively short production cycle (Costard *et al.*, 2009) and they are very prolific (DANIDA, 2006; Mutua *et al.*, 2010). Pigs are not reared primarily for household consumption (Lanāda *et al.*, 2005) but commonly farmers consume pork during festivals and celebrations (Ocampo *et al.*, 2005). Pigs thus make an important contribution to food security because they are an important protein source at the community level (DANIDA, 2006).

Pigs, under subsistence farming provide much more than meat to the farmers. Although smallholder pig farming cannot be considered a business venture (Ocampo *et al.*, 2005), pigs are generally reared with an income objective (Kagira, 2010; Mutua *et al.*, 2010). They may thus be sold (Lanāda *et al.*, 2005) at any age or size (Lemke *et al.*, 2007) depending on the financial demands of the family (Wabacha *et al.*, 2004a), such as the need for funds to pay for food and field labour (Lemke *et al.*, 2007) or even school fees, medical treatments or small investments (FAO, 2014). Even the manure of pigs are used as fertilizer for crop production (Mutua *et al.*, 2010). Because there is little or no initial financial input to rear pigs (Taveros & More, 2001) and because they are generally kept in small herds and most of the time left to scavenge their own food (Lee *et al.*, 2005; More *et al.*, 2005a), any monetary income from

these systems is of great value for the overall household income (Taveros & More, 2001). Pigs therefore constitute an important source of income for many families (Lee *et al.*, 2005; More *et al.*, 2005a). In the remote areas of Northern Lao PDR, income from pigs accounts for more than 50% of the total family income (Phengsavanh *et al.*, 2010). Pigs are important for farmer's poverty alleviation (DANIDA, 2006).

2.6 EDUCATION

2.6.1 Education in the agricultural sector

Education can be an important tool to improve technical skills, farm productivity and income. A reduction in consumption of infected pork and on the incidence of PC were observed as a result of pig health and management education campaigns for farmers (Ngowi *et al.*, 2008). Further, a sustainable financial gain for farmers has also been demonstrated following education (Ngowi *et al.*, 2007). However, knowledge uptake itself does not necessarily guaranty an improvement in the everyday practices (Bonger, 2001; Ngowi *et al.*, 2008b).

Education can be basic schooling (formal education), transmission of knowledge through extension services, adult literacy, organised apprenticeship (non-formal education) and learning by doing or by direct experience to a specific set of circumstances (Coombs & Ahmed, 1974; Figueroa, 1985). FAO (2001) referenced the Farmer Field School (FFS) as an interactive way of disseminating information, learning and to induce to adoption. Training methods that involve demonstration, especially at farmer level, have been reported to be one of the most relevant training methods (Bonger, 2001). Amongst these methods, many agricultural studies have stated that extension services may be the most effective way to change farmers knowledge uptake and practices (Emenyeonu, 1987; Bonger, 2001; Cavane, 2009; Rezvanfar *et al.*, 2009). This should include a demonstration centre (Model Farming Training: MTF) (Bonger, 2001), because of the possibility to integrate both information and demonstration, and also because of the easy accessibility for farmers (Emenyeonu, 1987).

Information may be crucial inducing adoption of agricultural innovation. Farmers that have access to information about technologies are more likely to change their behaviour (Genius & Pantzios, 2006) and the more aware farmers were about a technology, the higher the adoption rate (Rezvanfar *et al.*, 2009). However, adoption can vary greatly among farmers as it may be influenced both by farmers characteristics (structural and behavioural characteristics) and innovation characteristics (Diederer *et al.*, 2003). The agro-ecological characteristics may similarly be important for whether or not the adoption of a technology takes place because they can determine not only the production potential but also the availability of resources

(Doss, 2003). How and by whom the information is delivered can also be important. When using the extension services, the more the extension agents were accepted by farmers, the higher the adoption level, and acceptability was related to the capability of the agent to communicate and create credibility and confidence, so that extension agents should be prepared before they start working with the communities (Rezvanfar *et al.*, 2009).

The appropriateness of information delivered to the target group can also increase adoption levels (Rezvanfar *et al.*, 2009). For example, labour-demanding technologies can have a limited adoption due to labour scarcity (Maheswari *et al.*, 2008). The availability and prices of technology as well as the potential improvement in results compared to the traditional methods also played an important role. Consequently, the adoption of a new technology was not only based on willingness and awareness (Ani *et al.*, 2004). Higher levels of adoption have been reported for practices that did not need cash investment compared to practises that could provide a fast return if money was invested (Bonger, 2001). Overall, resource limitations, including financial and credit limitations, reduced the adoption of technologies (Maheswari *et al.*, 2008). Its is important to select technologies that are affordable even to resource poor households (Marenya & Barrett, 2007). Credit access can also improve access and utilisation of new technologies (Maheswari *et al.*, 2008; Liverpool & Winter-Nelson, 2010).

Larger farms showed higher net profit when new technologies were adopted, according to a study on farmers adoption of precision technology in resource-poor environments (Maheswari *et al.*, 2008). Smaller farms may be more likely to be resource limited and thus have less capacity to invest in new technologies (Maheswari *et al.*, 2008). Especially for livestock production, small land size appears to be a limiting factor, as for instance in most Eastern African countries slow growing breeds are used in combination with free range feeding regimens that demand large areas for foraging (Davis *et al.*, 2012). This can mean that having less land may indicate poverty, and the poorest farmers may not gain the full benefit of training (Davis *et al.*, 2012).

Farmers are also risk sensitive. Whereas the researchers may be focussed on the potential benefits of using new technologies without fully understanding the context and constraints, farmers may be conservative and mainly focus on avoiding changes in outputs that could be harmful to the security of their family and the preservation of their socio-cultural habits (Koppel, 1985). This can have a negative impact on adoption if farmers do not understand the exact benefit of a technology and are simultaneously influenced by opposing traditional beliefs (Maheswari *et al.*, 2008).

The channels used to present information are of particular importance. There are different sources of information on farming education. One study has indicated that the more sources and channels of information farmers have access to, the higher the level of adoption (Rezvanfar *et al.*, 2009). Exposing farmers to different information sources may have a positive influence, because it increases the possibility of getting the information but not all sources of information may have the same positive influence (Genius & Pantzios, 2006). According to a study conducted by Bonger (2001), the impact of printed and audio-visual means of diffusing information did not have any perceptible impact whereas Rezvanfar *et al.* (2009) recommended the use of “mass media” as television and radio broadcasting to address technical information to farmers. Emenyeonu (1987) preferred the use of radio, as the limitation of other mass media is that generally they may be poorly accessible in a rural context, limiting their capacity of reaching farmers.

Behavioural and societal characteristics of farmers also have an influence on knowledge uptake and adoption process. In relation to gender, studies have indicated that households headed by females tended to adopt new knowledge and practices more than households headed by a male (Bonger, 2001; Davis *et al.*, 2012). Age may also have an influence as older farmers have been shown to participate less in training (Bonger, 2001) whereas younger farmers appeared to adopt more readily (Diederer *et al.*, 2003). Age can be related to farming experience and it has been shown that the extent of adoption may span from no adoption, partial adoption and full adoption from older to younger farmers (Genius & Pantzios, 2006). Similarly, it has been shown that less experienced farmers may be more receptive to new technologies than more experienced farmers because they are generally older, with a low level of education and willingness to change (Ani *et al.*, 2004). For older household heads participative experimentation and demonstrations are therefore very important tools to address new technologies (Davis *et al.*, 2012).

Literacy also plays an important role for adoption. Low education levels inhibit the farmers’ understanding of and attitude to new practices so that more educated farmers tend to better adopt new technologies (Bonger, 2001; Ani *et al.*, 2004; Kavia *et al.*, 2007). The acquisition of farming information is more easy for farmers with a good level of education as they are able to decode information from a range sources (Genius & Pantzios, 2006; Maheswari *et al.*, 2008). The higher the socio-economic situation of the farmer the higher the access to information and the better the adoption (Emenyeonu, 1987). Farmers with the highest off-farm income, were more likely to become full adopters of a technology (Genius & Pantzios, 2006). However, it has also been argued that farmers with more financial resources or better solvency may not be earlier adopters because they may be more likely to be afraid of taking risks (Diederer *et al.*, 2003).

The livestock value also has a positive influence on adoption (Marenya & Barrett, 2007). Good access to markets may also positively influence adoption behaviour. If a farmer has differentiated markets to deliver the products to, he is more likely to become an earlier adopter of innovation (Diederer *et al.*, 2003). Agro-ecological characteristics are also important for certain technologies. For example, a study on organic farming showed that farmers located in areas with unfavourable climatic conditions were less likely to adopt organic farming practices than if the climate was more beneficial (Genius & Pantzios, 2006). The same situation was shown by Maheswari *et al.* (2008) where scarcity of water limited the adoption of precision farming in resource-poor regions.

Overall, the adoption of new practices depend on a very complex set of factors, so that knowledge, willingness and experimentation with the technology is not enough to secure its successful adoption (Ani *et al.*, 2004).

2.7 CONCLUSIONS

According to the reviewed literature, pig production is carried out under different production systems and for the developing countries smallholder pig farming is largely practiced and is a very important supplement for farmer's livelihoods. This is because pigs represent a source of readily available income mainly in cases emergency, but pigs also contribute to food security as they help meet the protein needs of resource-limited communities. Although important, smallholder systems face many constraints, mainly related to poor management, poor nutrition of the animals and a high occurrence of diseases, leading to a poor pig performance and thus financial outcome. Beside these constraints, studies have showed that there is a potential for the development of smallholder pig production using the locally available resources to ensure sustainability.

Education, especially based on extension services has been proven in many educational studies to be an important way to address technical information to farmers in order to improve their knowledge and thereby improve the management practices and take advantage of available resources. Although the adoption process depends on a complex of factors, and thus not exclusively on the farmers' awareness, it has been shown that overall education can lead to improvement in the practices and in agricultural performance in a sustainable way.

CHAPTER 3

THE EFFECT OF EDUCATION ON SMALLHOLDER PIG FARMERS' KNOWLEDGE, PRACTICES AND PIG PRODUCTIVITY IN THE ANGÓNIA DISTRICT, MOZAMBIQUE

3.1 INTRODUCTION

Livestock production is essential to the livelihoods of poor people in many developing countries. Although pigs are considered as important livestock species by smallholder farmers (Lanãda *et al.*, 2005), pig keeping may often not be the primary income source, but often supplements crop production (food-and-cash crops) which is their main source of income (Wabacha *et al.*, 2004a). Pigs are mostly reared to be sold in situations of financial need (Lanãda *et al.*, 1999 ; Lee *et al.*, 1999; Wabacha *et al.*, 2004a; Lanãda *et al.*, 2005), and only occasionally for home consumption during festivals and ceremonies (Ocampo *et al.*, 2005). Generally, pig keeping appears to not be approached as a business venture (Ocampo *et al.*, 2005), but because of the overall minimal financial input required for food, breeding and disease control if pigs are kept free range (Lanãda *et al.*, 2005), it can still be of great value to increase overall household income (Taveros & More, 2001).

Despite pig production being important, productivity in smallholder systems may generally be low (Riedel *et al.*, 2014). A few available studies on sow performance in smallholders' farms in tropical regions have demonstrated that low performance levels are specially a result of diseases, poor management and low food quality (Gatenby & Chemjong, 1992; Lanãda *et al.*, 1999; Mutua *et al.*, 2011). Sow productivity is negatively influenced by poor sow nutrition, genetics, facilities and the competence of the person(s) rearing the pigs (Taveros & More, 2001). High consanguinity can also be a very important constraint to reproduction performance (Ocampo *et al.*, 2005). Additionally, in smallholder production system, piglet mortality can be high and the average daily weight low (Lemke *et al.*, 2006; Phengsavanh *et al.*, 2011; Carter *et al.*, 2013; Riedel *et al.*, 2014). Pig diseases have also been reported as important constraints. The most reported health problems appear to be ASF, prevalent in 26 African countries in 2011 (Penrith *et al.*, 2013), which is a highly lethal viral disease (Swai & Lyimo, 2014), endoparasitosis (Kagira, 2010; Matos *et al.*, 2011) and ectoparasitosis (Nonga *et al.*, 2011; Matos *et al.*, 2011). Of the parasitosis, the *T. solium* cysticercosis is an important public health issue (García *et al.*, 2003; Montresor & Palmer, 2006).

The potential for the developing smallholder pig production systems has been demonstrated in several studies (Madzimure *et al.*, 2012; Carter *et al.*, 2013; Riedel *et al.*, 2014). In addition, it has been shown that education can positively change the farmers knowledge and behaviour (Ngowi *et al.*, 2008) which is important as overall awareness regarding proper pig management is scarcely available in the smallholder scenarios (Taveros & More, 2001; Kugonza & Mutetikka, 2005; Kagira, 2010; Chittavong *et al.*, 2012b; Madzimure *et al.*, 2012; Mkupasi *et al.*, 2013).

Education could therefore be an essential tool to increase knowledge and elicit sustainable changes in management practices thereby improving their technical skills and pig productivity. There are very few studies in Mozambique assessing the efficacy and/or effectiveness of farmers' education programmes and their effects on agricultural performance. Further, no study has documented the effect of education programmes on smallholder pig farming. The aim of the current study was therefore to assess if education of pig farmers could improve their technical knowledge and if this could in turn have a positive effect on their day-to-day management of pigs and thereby improve sow and offspring productivity.

3.2 MATERIALS AND METHODS

3.2.1 Study area

The study was conducted in the Angónia district, Tete province in Mozambique (Figure 3.1). The district has two administrative areas (Ulóngoè and Dómuè). The district headquarters is situated in Ulóngoè (Ministerio da Administracao Estatal, 2005). Angónia is located in north-western Mozambique (14°47'S, 34°29'E) in the Tete province, occupying an area of 3,277 km² and it is bordered in the north and northeast by Malawi, in the west by the Macanga district and in the south and east by the Tsangano district of the Tete province (Figure 3.1). According to the 1997 National census, the Angónia district had a population of 247,999 people, corresponding to 72.2 people per km². In the entire district there were 81,980 families with an average of 3 to 5 members each.

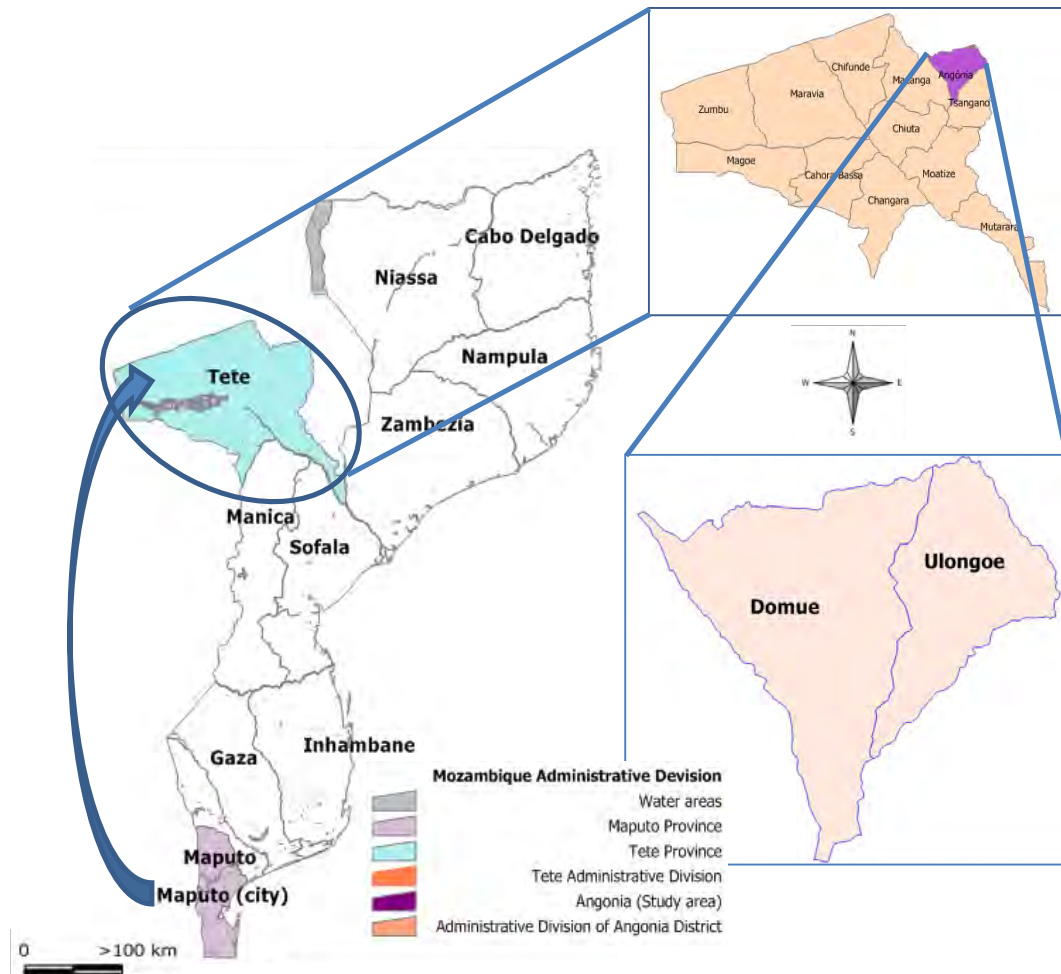


Figure 3.1 Mozambique map with the location of the study area

In the district there are State legitimized traditional leaders that represent local communities. They have an important role as mediators with State entities, mobilisers of local communities for various activities and conflict mediators (Ministério da Administração Estatal, 2005).

The population in the district belongs to the Chewa ethnic group and people mainly speak Chichewa (native language). Only 11.4% of the inhabitants of the district speak Portuguese and 81% of them are illiterate (Ministério da Administração Estatal, 2005). Only 4% of the total active population received a regular contracted salary (Ministério da Administração Estatal, 2005). Agriculture is therefore the economic backbone of the district, covering up to 150,000 hectares of arable land and it is practiced almost by all families (Ministério da Administração Estatal, 2005). The most commonly cultivated crops are maize, beans, peanuts, tobacco, potatoes, cassava and vegetables. Farmers produce crops for subsistence (mainly maize, beans, peanuts, cassava, potatoes and vegetables), where the surplus is sold at the local markets, and cash crops (such as tobacco and soya beans).

The overall climate of the Angónia district is temperate humid. The rainfall varies from 725mm to 1,149mm per year, with most of the rainfall (90%) occurring between late

November and early April. The temperature is strongly influenced by altitude, which ranges from 700m to 1,655m above sea level. The overall average temperature was previously calculated to be 20.9 °C for Ulóngoè (Ministério da Administração Estatal, 2005).

The most important livestock species are cattle, goats, pigs, sheep, chickens and ducks (Ministério da Administração Estatal, 2005). Pig production is carried out in extensive production systems integrated as an important part of the agricultural system of the district. Pigs are confined during the nights and also during the rainy season and crop growing seasons whereas they roam freely during other times of the year. The pigs are fed mainly by maize bran and sometimes kitchen leftovers (Pondja *et al.*, 2010).

African swine fever is endemic in Angónia district, outbreaks frequently occur and it was demonstrated that local pigs have some degree of resistance/tolerance towards ASF and some do survive the infection (Penrith *et al.*, 2004). Nevertheless mortalities are high and as a strategy to protect their herds from dying due to ASF outbreaks farmers may separate their herd by lending females to different neighbouring farmers. The borrowed females are then returned to the original owners after the first farrowing with their litters, except for one piglet per litter. Porcine cysticercosis is also endemic in the district (Pondja *et al.*, 2010) and only negative animals (by tongue examination) can be purchased by local traders and transported on bicycles, usually one animal at a time (Gule, 2008).

Proper facilities for slaughter and butchery are only present at the district headquarter (Ulóngoè) so that slaughtering occurred mostly at the trader's home without meat inspection and pork is sold at local markets directly by pig traders or farmers (Gule, 2008). According to Pondja *et al.* (2010) 18.6% of farmers in the Angónia district slaughter pigs at home and 99% of the farmers do not have the meat inspected.

The district had a poor road network and public transport and during the rainy season, many villages are not accessible. Bicycles are the main means of transport used while motorcycles and cars are few.

The district had 277 water sources installed by the government, though only 200 of them remained functional in 2004 together with 23 traditional water holes originally built by the community (Ministério da Administração Estatal, 2005). Only 1% of families had electricity and piped water in their houses (Ministério da Administração Estatal, 2005).

The current on-farm educational trial was carried out at smallholder pig farms in four villages in the administrative areas of Ulóngoè and Dómuè (Figure 3.2). The district has 17 localities, 11 in Dómuè and 6 in Ulóngoè. The villages were selected purposively based on a known history of good cooperation and a high number of farmers keeping pigs. In Dómuè the

localities of Liranga (Liranga village) and Kamphessa (Muiaua village) were included and in Ulóngoè, the locality of Kalómwè (Chabualo and Massoco villages) was selected.



Figure 3.2 Map of the Angónia district with the study villages (Liranga, Muiaua, Chabwalo and Massoco) in their respective administrative areas (Dómue and Ulóngoè).

According to Pondja *et al.* (2010), all pigs reared in the Angónia district were of indigenous breeds (black pigs), most of them (75%) less than 12 months of age and only 18% of farmers practiced total confinement while the majority left pigs to roam during the day and confined them during the night and during the raining season. The same authors reported that most of farmers (92,5%) kept pigs both for sale and consumption while a small percentage of farmers kept pigs only for consumption (5.9%).

3.2.2 Study design

The study was a controlled randomised on-farm educational intervention trial based on a production-problem-oriented approach. The education program consisted of four packages, i.e. health (Hth), housing (H), feeding (F) and reproduction (R). The packages were applied in four combinations and each of the villages was randomly allocated to one of the combinations. All four villages received basic training on health and housing. Three of the

villages were provided with additional training on feeding and/or reproduction and they were designated as treatment villages, while the fourth village, which only received education on health and housing was designated as the control village (Table 1). The education packages were provided to all interested farmers in a given village to monitor knowledge uptake and subsequent change in management practices (study farmers). From this group, a sub-group of farmers having female pigs was selected and one female pig per farmer was included to evaluate performance parameters (including progeny performance) as an effect of the education programme (performance study). For the purpose of this study, female pigs were selected within the range of two months age until the first farrowing as study animals.

3.2.3 Sampling and selection of study subjects (farmers and animals)

At the beginning of the study there was no available official information about the number of smallholder pig farms and/or the number of pigs in each village. The first step before sampling was to obtain a list of current farmers, which was made during the study establishment (June to August 2011). That was possible with the support of the local governmental extension officers who worked together with local leaders for each of the selected villages. Leaders also advised that information on pig populations was very dynamic and could suddenly change due to ASF outbreaks. A smallholder pig farmer was considered as someone who had in his/her backyard at least one pig in traditional housing facilities or free range and with at least one year experience at the time of the first visit.

3.2.3.1 Sampling and selection of farmers

For the assessment of smallholders pig farmer's knowledge and practices on pig health and production the sampling unit of interest and analysis was the smallholder pig production farmer. Simple random sampling approach was adopted for the study areas and the sample size was calculated according to "Sampling and Surveying Handbook," (2002) using the formula $n = (NZ^2 \times 0.25) / ([d^2 \times (N - 1)] + (Z^2 \times 0.25))$, where n = sample size required; N = total population size (in this case 239 farmers); d = precision level (0.05 for the present study) and Z = the standard deviation of the sampling distribution (1.96) corresponding to the confidence level chosen. A confidence level of 95% was considered. A sample size of 148 farmers was computed and then adjusted in relation with the expected response proportion. The adjustment was made dividing the sample size by the expected response proportion (90%) and an output of 165 farmers was the sample size obtained. This sample size was then screened in order to distribute the sampling units for the corresponding study area. A total of

179 farmers were actually interviewed, because of their willingness to participate, 30 in Liranga, 75 in Muiaua, 38 in Chabualo and 36 in Massoco.

3.2.3.2 Selection of study animals for the performance study

The animal unit of interest were gilts and first parity sows (hereafter all categorised as sows) and the minimum sample size (number of gilts/sows) needed was calculated using the equation recommended by Dell *et al.* (2002):

$$n = 1 + 2C \left(\frac{s}{d} \right)^2$$

To calculate the minimum sample size, ‘the expected average number of litters per sow during the study period’ was used as reference variable. The reference result considered for this variable was 1.0, with a standard deviation (*s*) of 0.2 and needed a difference (*d*) of 0.4 with a power (1-β) of 90% and a significance level (*α*) of 5%. Then, the minimum number of sows needed for each treatment was 12. However, because of the risk of ASF outbreaks and consequent potential loss of animals, the sample size was increased according to the willingness of the farmers, in order to include more animals where possible. In total, 125 sows were selected, corresponding to one per farm, based on the likelihood of that animal

Table 3.1 Distribution of education packages and initial number study subjects among the study villages.

Villages	Initial no. of study subjects		Implemented packages			
	Study farmers	Study sows	Health	Housing	Feeding	Reproduction
Liranga	30	24	+	+	-	-
Muiaua	75	42	+	+	+	-
Chabualo	38	35	+	+	-	+
Massoco	36	24	+	+	+	+
Total	179	125				

+: applied; -: not applied

farrowing during the study. The initial number of farmers is presented on the Table 3.1.

3.2.5 Intervention protocol

3.2.5.1 Education packages

The intervention consisted of training of smallholder pig keepers on pig health (ASF transmission and prevention and, PC transmission) and pig management (housing, feeding and reproduction).

For each education package 2-5 themes were selected and a set of measures of knowledge (topics) and the corresponding indicators of changed practices were defined (Table 3.2). The philosophy was to address very simple technical information that could be easily understood by the farmers and, monitored and measured by the researcher.

3.2.5.2 Duration of the intervention

The present study was carried out during 15 months, from June 2011 to September 2012. Initially, the principal investigator (PI) stayed in the field for 3 months (June 2011 to August 2011) to establish the study. During this period the cooperation of the local government agricultural services was sought and an agricultural extension officer was identified to facilitate the fieldwork, recruit the study villages and potential participants in collaboration with local village leaders. The extension officer also served as a translator for the local language (Chichewa). Questionnaires, record cards and education materials were pre-tested and optimised as the extension officer was trained on how to teach farmers in their local language.

During September 2011, the study farmers were tested on-farm for initial knowledge on pig health and management topics as well as their management practices (Appendix 1 and 2). During the following 12 months the educational intervention was implemented and data collected to assess the impact of education on sow and piglet performance. In September 2012, farmer's knowledge and practices were tested once more.

Table 3.2 Description of the specific education themes, knowledge topics addressed and the indicators of changed practices.

Education package	Education themes	Measures used (before and after education)	
		Knowledge topics	Changed practices indicator
Health	ASF	ASF transmission	-
		ASF prevention	-
	PC	PC transmission	-
Housing	Pig pen	Pig pen design	Improved pig pen
	Confinement	Confinement regiment	Full confinement
Feeding	Feed container	Where to provide feed	Use of feeder
	Feeding frequency	When to provide feed	Feeding 2 times a day
	Supplementation	How to supplement	Use of vegetables
	Water container	Where to provide water	Use of drinker
	Drinking frequency	When to provide water	<i>Ad libitum</i> drinking
Reproduction	Breeding	Inbreeding	No inbreeding
	Weaning	Artificial weaning	Artificial weaning

ASF: African swine fever; PC: Porcine cysticercosis, -: not applicable

3.2.5.3 Training methods

The intervention was preceded by focussed group discussions (FGD) followed by a) collective and participatory training session; b) on-farm demonstration of how to build a suitable pig pen and c) on-farm reinforcement training of farmers. These FGD were conducted at the site for normal community meetings in each village at the beginning of the study. The FGD were undertaken with a previous consent of the village leader who negotiated with the farmers and informed about their willingness, the date, place and time for the

meeting according to their agreement. The process in connection with the FGD consisted of five basic steps, (i) Introduction, where the research group was introduced to the participants by the leader, farmers were welcomed and explained who the research group was and what they were trying to accomplish, what would be done with the information collected, why they were chosen to participate and the purpose of the FGD; (ii) Explanation of the FGD process and the logistics for the process including the duration, the refreshments available and the allowance to leave the meeting when needed; (iii) Clarifications of possible farmers questions; (iv) Conduction of the FGD based on previously prepared education packages and topics (Table 3.2) and; (v) Closing remarks where the farmers were informed that they would be visited regularly for on-farm training and data collection. Immediately after the FGD, training material was provided to the farmers and a demonstration pig pen was built by farmers (on-farm training) with the support of the research group in a household chosen by the farmers. This had been planned beforehand so that the farmer had time to collect the needed materials.

Subsequent reinforcement training was made by visiting each farmer and addressing topics focused on specific problems of each particular farmer. This was done on 5 occasions (December 2011, March, April, June and July 2012). The data collection consisted of on-farm observation and questioning about practices using a sow-progeny and management record card (Appendix 3). Based on the outcomes, farmers were once more instructed according to the relevant education packages to specifically reinforce areas of knowledge that were lacking or poorly implemented. The reinforcement was addressed to the household head or another household member that was the primary pig keeper. This person was over 18 years old and it was always the same person for a given farm, though on some occasions data could not be collected, as the person was not available despite having forewarned the person of the visit.

3.2.5.4 Education material

To help ensure consistency of the technical information addressed during education sessions, illustrative training leaflets were produced purposively for the study, one feeding leaflet (Appendix 4) and one reproduction leaflet (Appendix 5), and information about health and housing were re-used from a previous project implemented in Angónia. The topics of the teaching materials are described in Table 3.2. All materials were in Portuguese and the extension officer was trained to translate them verbally. The materials were then used as a guide during the training sessions and also provided to each farmer during the FGD and if absent, during the first on-farm visit.

3.2.6 Measurement of knowledge practices

For measuring knowledge (initial and uptake) a questionnaire was prepared and used in a face-to-face interview with each study farmer before and after the education intervention and collection of production data (Appendix 1). The questionnaire had specific questions closed or semi-closed questions for each package (2-5 questions) with the corresponding right answer registered, so that the farmers answer was compared to the right answer and marked accordingly as right or wrong. The questions were in Portuguese and read out loud by the PI to the extension officer who then translated it into Chichewa for the farmer and the farmer's answer was then translated into Portuguese back to the PI.

Similarly, pig management practices were assessed at the beginning and at the end of the study using a Portuguese verification card that was designed with a combination of observation points and confirming questions for the farmers (Appendix 2). There were 2-5 predefined practices to be verified for 3 of the packages (pig housing, feeding and reproduction). For each practice there was a specific indicator of practice (initial or changed) and/or the corresponding right answer was applied. The verification of the practice combined with the right answer (if applicable) was then marked on the card as present or absent by the PI and extension officer at each farm. Both the questionnaire and the verification card were pre-tested on smallholder pig keepers in a non-study village, during the establishment of the study (June to August 2011) and optimised accordingly in order to ensure relevance and clarity of the questions and indicators. They did not include the identification of the farmer, only the indication of the village name and the assessment moment (before or after the educational intervention).

3.2.7 Measurement of sow and piglet performance

At each farm visit data were collected on changed practices and sow and piglet performance. For that purpose a record card (sow-progeny and management record card) was kept for each farm and updated at each farm visit by interviewing the primary pig keeper in the household.

Data on sow and piglet performance included: mating date (first and/or second mating), origin of the boar, farrowing date, litter size (live and still born piglets), monthly piglet weight, weaning date, pre-weaning piglet mortality and number of piglets weaned. Weaning date was only accurate where the farmers artificially weaned the piglets. Where the weaning was natural the approximate week was registered. During the visits, the progeny of the study sows was weighed using a handheld portable scale (50Kg), where the piglets (one at a time) were placed into a sack and weighed.

3.2.8 Statistical analysis

Data were initially entered in an Excel spread sheet and a descriptive analysis was made. To compare knowledge and practices within each village, before and after the intervention, the proportion of correct responses and observations for each question was computed and the difference in knowledge (% knowledge uptake) and practices (% change in practice) calculated. Knowledge level and practices were compared before and after intervention using the Chi-square test in each village to determine if a given change was significant. Measures of reproductive performance of sows were calculated as the average number of litters per sow during the study period; the average number of piglets born per litter; the average number of piglets born alive per litter; the average number of piglets weaned per litter and the average number of piglets weaned per sow during the study period. The measures of productivity of the progeny were the pre-weaning piglet mortality (%) and the average daily weight gain in kg/day. Analysis of variance was used to compare the performance parameters of sows and piglets among the study villages. A significance level of 5% was used. Analyses were done using Prism 6 (GraphPad Software, Inc.).

3.2.9 Ethical considerations

Prior to the implementation of the project, it was approved by the scientific board at the Eduardo Mondlane University, Maputo, Mozambique (Reference number 02/FV/2009).

3.3 RESULTS

3.3.1 Compliance

Initially the study included a total of 125 sows each belonging to a single farmer from the four study villages (Table 3.5). However, during 12 months study period the number of sows was reduced to 72 corresponding to 58% of the original study population. Farmers in Muiaua and Liranga had the highest compliance whereas those in Massoco and Chabualo were the least compliant. This was also reflected in a reduction in the number of farmers that participated in the questionnaire survey on knowledge and practices (Table 3.6 and 3.7).

The main reasons for the reduction in animals were that sows died (14.4%), due to diseases reported as ASF, or that sows were returned to their owner (13.6%). This occurred in situations when the farmer had borrowed a sow from another farmer with the purpose of beginning or restarting pig production. Other reasons for the drop on the initial number of sows were that some farmers' withdrew completely from the study (9.6%), often without a clear reason. Lastly some sows were sold (4.8%).

3.3.2 Knowledge and perceptions among farmers before the intervention

At the initial assessment before the educational intervention, it became clear that farmers in the four study villages had very little knowledge about pig health and production (Table 3.6). The existing knowledge among farmers was mostly related to the feeding package, followed by the health package. Knowledge about pig housing was almost non-existent before the intervention, and the evaluated reproduction topics were completely new to the farmers.

Concerning the health package, the average proportion of farmers (irrespective of village) who had knowledge on some of the topics evaluated was low (average 7%). Knowledge levels were slightly higher in Chabualo, Muiaua and Liranga than in Massoco. Regarding the three individual topics of the health package, there was no knowledge on how ASF is transmitted in any of the four villages. However, there were a number of farmers that had knowledge about how to prevent ASF. Most of them were concentrated in Liranga and Chabualo whereas hardly anyone knew about ASF prevention in Muiaua. Despite the overall low knowledge (15%) this topic was still the most well-known health topic among the farmers in all four villages. Farmers with knowledge about PC prevention before the educational intervention were only found in Muiaua (10.7%) and Chabualo (10.5%) villages.

The average number of farmers with knowledge about the evaluated topics relating to the housing package before the educational intervention was found to be non-existent or very

low. Between the two housing topics evaluated before the intervention, there were more farmers with knowledge about total confinement of pigs (2%) than how to construct a suitable pig pen. Only one farmer from Chabualo had more advanced knowledge on pen construction.

Table 3.3 Reasons for reduction in the initial number of farmers and sows included in the study of pig performance during the twelve months study period.

Village	Initial no. of study sows	Reasons for reduction of initial no. of sows				Final no. of sows	Compliance (%)
		Dead	Sold	Returned*	Withdrawn		
Liranga	24	0	1	8	0	15	63
Muiaua	42	6	3	3	0	30	71
Chabualo	35	9	0	1	10	15	43
Massoco	24	3	2	5	2	12	50

* Borrowed sows that were included in the study and had to be returned to the original owners after farrowing

Overall, farmers had some knowledge about how to feed pigs before the educational intervention (37%), this was higher for supplementation with vegetables (94%) and use of a feeder (81%). The village with the highest proportion of farmers with previous knowledge about pig feeding was Massoco but the level was almost similar with the other villages.

The reproduction package was completely new to all the study villages before the education intervention.

3.3.3 Knowledge uptake among farmers following education

After 12 months of the education intervention, an overall high proportion of farmers (over 63%) demonstrated knowledge about 2 to 3 health topics in each study village. The highest and significant ($p<0.0001$) proportion of uptake (89%) was related to ASF transmission and the improvement was most evident in Chabualo and Massoco. The least and overall non-significant uptake was related to PC transmission (17%), for which Liranga and Massoco did not show any improvement while Chabualo showed significant improvement ($p<0.0001$). Overall, the greatest improvement for the health package occurred in Chabualo and the lowest in Muiaua and Liranga.

After the educational intervention period, there was a very high level of improvement in the number of the farmers with knowledge about construction of good quality pig housing. On average 84% of the farmers knew that they should totally confine pigs. Despite a pronounced knowledge uptake on housing after the intervention, the control village had the lowest level of improvement for the housing package, impaired by a low level but significant ($p<0.001$) knowledge uptake about total confinement of pigs.

Generally, education led to an increase in knowledge about the various feeding topics. Unexpectedly, the overall knowledge uptake in the non-feeding treatment village (Chabualo) was significant and at the same level as that in one of the feeding treatment villages (Massoco). The other feeding treatment village (Muiaua) showed less but significant knowledge uptake and it was at the same level as the control village (Liranga).

At the end of the twelve months study period, the evaluation showed that villages taught reproduction registered an overall high and significant ($p<0.05$) corresponding knowledge uptake. This was most pronounced in Massoco for artificial weaning, and the average uptake for this topic for the two reproduction treatment villages was 86%. Surprisingly, one of the non-reproduction treatment villages (Muiaua) showed some level of knowledge uptake related to the inbreeding topic but non-significant ($p<0.001$).

3.3.4 Change in farmer's pig production practices following the educational trial

The results of the changed practices related to the knowledge addressed to the farmers are shown in Table 3.5. Three of the four knowledge packages were evaluated for the changes in management practices.

Concerning the housing package, a highly significant ($p<0.01$) change in practices was registered among farmers in all study villages (58%), with the highest level in Chabualo and Massoco and the lowest in Muiaua. Between the two topics addressed (housing and confinement), the improved pig pen was the most frequently implemented in all villages (62%). Massoco village registered the highest level of implementation of improved pig pen whereas for the permanent confinement, Chabualo registered the highest degree of implementation. It is important to notice that before the intervention the application of the housing topics was not practiced in Liranga and Chabualo villages although it was practiced at low levels on the other 2 villages.

In the case of the feeding package, the use of feeders was already a well-established practice in all the villages, followed by the supplementation of pigs with vegetables. In contrast, farmers did not know that pigs have to be fed at least two times a day but after the

intervention the feeding treatment villages evidenced a significantly higher ($p<0.01$) change in practices (Table 3.7) as compared to the non-feeding villages. None of the farmers had any concept of neither using drinkers to provide water to the pigs nor the use of *ad libitum* access to it. After the intervention, the use of drinkers and *ad libitum* drinking had significantly increased ($p<0.01$) in Massoco (except for *ad libitum* drinking practice at $p>0.05$) and Muiaua (feeding treatment villages) whereas no changes were observed in the control village after the intervention. The highest level of changed practices for the feeding package was found in one of the two feeding treatment villages (Massoco), unexpectedly followed by a village that was not taught how to feed the pigs (Chabualo) whereas the control village showed very little change feeding practices.

The reproduction technologies were completely new to all farmers. Avoidance of inbreeding practice showed significant ($p<0.01$) changes only in the reproduction treatment villages, more so in Massoco than in Chabualo. For the artificial weaning practice, a significant change ($p<0.0001$) was registered but only in Massoco.

Table 3.4 Proportion of farmers (%) with knowledge before (baseline) and after (uptake) and a twelve months education intervention among the farmers about twelve topics relating to pig health and production.

Packages	Knowledge	Control village		Treatment villages					
		Liranga ^{Hth, H}		Muiaua ^{Hth, H, F}		Chabualo ^{Hth, H, R}		Massoco ^{Hth, H, F, R}	
		% Before	% After	% Before	% After	% Before	% After	% Before	% After
		(n=30)	(n=14)	(n=75)	(n=24)	(n=38)	(n=14)	(n=36)	(n=13)
		Baseline	Uptake	Baseline	Uptake	Baseline	Uptake	Baseline	Uptake
HEALTH (Hth)	ASF transmission	0.0	85.7 ^{****}	0.0	70.8 ^{****}	0.0	100.0 ^{****}	0.0	100.0 ^{****}
	ASF prevention	20.0	80.0 ^{****}	12.0	88.0 ^{****}	15.8	84.2 ^{****}	11.1	88.9 ^{****}
	PC transmission	0.0	0.0	10.7	6.0	10.5	60.9 ^{****}	0.0	0.0
HOUSING (H)	Improved pig pen	0.0	100.0 ^{****}	0.0	100.0 ^{****}	2.6	97.4 ^{****}	0.0	100.0 ^{****}
	Total confinement	0.0	42.9 ^{**}	2.7	97.3 ^{****}	2.6	97.4 ^{****}	2.8	97.2 ^{****}
FEEDING (F)	Use of feeder	73.3	26.7 [*]	80.0	20.0 [*]	81.6	18.4 [*]	88.9	11.1
	Feeding	10.0	90.0 ^{****}	10.7	89.3 ^{****}	7.9	92.1 ^{****}	5.6	94.4 ^{****}
	Supplements	100.0	0.0	92.0	8.0	89.5	10.5	94.4	5.6
	Use of drinker	0.0	28.6 ^{**}	2.7	43.1 ^{***}	2.6	97.4 ^{****}	0.0	100.0 ^{***}
	<i>Ad libitum</i> water	0.0	57.1 ^{****}	0.0	29.2 ^{***}	0.0	100.0 ^{****}	0.0	100.0 ^{****}
REPRODUC-TION (R)	Inbreeding	0.0	0.0	0.0	29.2 ^{***}	0.0	57.1 ^{****}	0.0	15.4 [*]
	Artificial weaning	0.0	0.0	0.0	0.0	0.0	71.4 ^{****}	0.0	100.0 ^{****}

****: Significantly different at $p < 0.0001$; ***: significantly different at $p = 0.0001$ to 0.001 ; **: significantly different at $p < 0.01$; *: significantly different at $p < 0.05$

Table 3.5 Proportion of farmers (%) who applied technologies before (baseline) and after (improvement) at twelve months education intervention among farmers applying technologies related to nine topics on pig production.

Packages	Technologies	Control village		Treatment villages					
		Liranga ^{Hth, H}		Muiaua ^{Hth, H, F}		Chabualo ^{Hth, H, R}		Massoco ^{Hth, H, F, R}	
		% Before (n=30)	% After (n=14)	% Before (n=75)	% After (n=24)	% Before (n=38)	% After (n=14)	% Before (n=36)	% After (n=13)
		Baseline	Improve- ment	Baseline	Improve- ment	Baseline	Improve- ment	Baseline	Improve- ment
HOUSING (H)	Improved pig pen	0.0	71.4 ^{****}	1.3	48.7 ^{****}	0.0	50.0 ^{****}	0.0	76.9 ^{****}
	Total confinement	0.0	21.4 ^{**}	0.0	25.0 ^{****}	0.0	100.0 ^{****}	5.6	71.3 ^{****}
FEEDING (F)	Feeder	73.3	5.3	97.3	2.7	92.1	7.9	63.9	13.0
	Feeding frequency	10.0	4.3	0.0	8.3d	2.6	26.0 ^{**}	0.0	38.5 ^{***}
	Supplementation	13.3	1.0	93.3	6.7	100.0	0.0	8.3	53.2 ^{****}
	Drinker	0.0	0.0	0.0	12.5 ^{**}	0.0	7.1	0.0	23.1 ^{**}
	<i>Ad libitum</i> drinking	0.0	0.0	0.0	8.3 ^{**}	0.0	7.1	0.0	7.7
REPRODUC- TION (R)	No inbreeding	0.0	0.0	0.0	0.0	0.0	21.4 ^{**}	0.0	38.5 ^{****}
	Artificial weaning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.5 ^{****}

Hth: Health; ****: Significantly different at $p < 0.0001$; ***: significantly different at $p = 0.0001$ to 0.001 ; **: significantly different at $p < 0.01$

3.3.5 Relation between the improvement of knowledge and the improvement of knowledge application

Figure 3.1 illustrates the combined relationship between knowledge uptake and changed practices. The trend of this relation twelve months after the initial training and regular training reinforcement was generally that the farmers evidenced more knowledge uptake than the corresponding changes in practices.

In all four villages, the housing packages generated the clearest picture of a potential relationship between knowledge uptake and the corresponding practice change, in that training resulted in a strong improvement in practice, which was significantly higher than for all other topics. This pattern was most marked in Massoco (Fig. 3.1D).

Generally, there was a significantly substantial knowledge uptake about several of the topics included in the feeding package in all four villages even if they did not all receive training on feeding. However, the change in awareness was not reflected in the corresponding practices even in the two villages receiving the training. In Massoco (Fig. 3.1D), there were three scenarios: (1) high knowledge uptake and almost comparable level of change in the corresponding practices; (2) high knowledge uptake with a low corresponding change in practice and (3) changes in practices above the level of knowledge uptake.

For the reproduction topics, the increase in knowledge also increased the corresponding change in practices although in different proportions. This was most marked in Massoco, where the increase in knowledge led to a substantial increase in the corresponding practices while in villages not taught reproduction no improvement was seen in either knowledge uptake or changed practices (Fig. 3.1A).

3.3.6 Performance parameters of sows and piglets

The results of sow's reproductive parameters are shown in the Table 3.8. The only parameter that showed significant difference within the villages was the average number of litter per sow during the study period. The only village with a significant difference was Massoco (reproduction treatment village). The other evaluated parameters did not differ significantly between the villages although numerically, the control village appeared to have the best performance results. No significant differences were found for piglet performance parameters but numerically the control village also showed better results (Table 3.6).

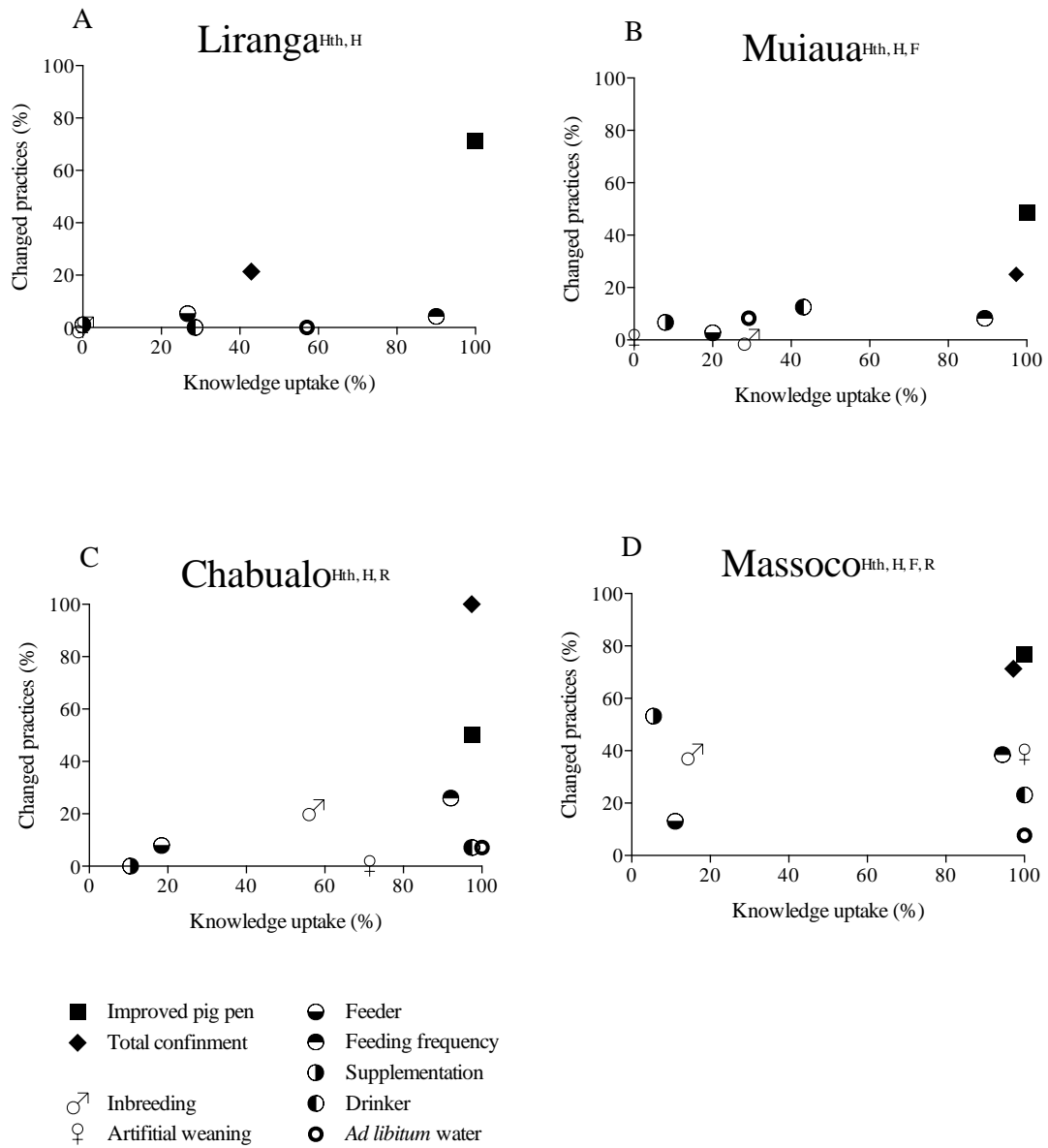


Figure 3.1 Relationship between improvement in knowledge and the level of the corresponding changes in practices in four rural villages following a twelve months education intervention. Hth: health package; H: housing package; F: feeding package; R: reproduction package.

Table 3.6 Mean performance (SD) of sows and piglets in the control and treatment villages at the end of twelve months of an education intervention

	Control village			Treatment villages								
	Liranga ^{Hth, H}			Muiaua ^{Hth, H, F}			Chabualo ^{Hth, H, R}			Massoco ^{Hth, H, F, R}		
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD
<i>Sow performance</i>												
Litters per sow	15	1.0 ^a	0.00	30	1.0 ^a	0.00	15	1.0 ^a	0.00	12	1.4 ^b	0.69
Piglets born per litter	15	6.9	2.02	30	6.2	1.90	15	6.8	3.00	17	5.8	2.26
Piglets born alive per litter	15	6.8	2.14	30	6.2	1.90	15	6.0	2.14	17	5.2	1.97
Piglets weaned per litter	15	5.5	2.42	30	4.4	2.58	15	4.1	2.97	13	4.1	2.82
Piglets weaned per sow	15	5.5	2.42	30	4.4	2.58	15	4.1	2.97	12	4.4	3.79
<i>Piglet performance</i>												
Pre-weaning piglet mortality (%)	104	20.2	2.52	185	29.2	2.62	102	39.2	1.64	70	24.3	1.76
Average daily weight gain (kg/day)*	10	0.14	0.88	22	0.10	0.06	6	0.09	0.03	9	0.10	0.07

Hth: health package; H: housing package; F: feeding package; R: reproduction package

* Calculated for the age of 0-8 months

^{a,b}: Different superscripts for a given parameter denotes a significant difference from the other villages ($p < 0.05$).

3.4 DISCUSSION

The present study showed that exposure to new knowledge did increase the knowledge levels of smallholder pig farmers though the level varied substantially depending on the topic. In addition, farmers were more likely to acquire new knowledge than they were to implement it and thus change their management practices. This may be why there was no substantial improvement on the performance of sows and their progeny.

Before the current project very few smallholder farmers had previous knowledge on the selected health topics. At the end of the study this had changed significantly for both aspects of ASF in all four villages, while it was only in one village that the farmers had really taken notice of how PC is transmitted. How both diseases were transmitted were new topics to the large majority of farmers, but they appeared to be more motivated to learn about and understand ASF. For a given “package” of knowledge, farmers tend to develop a selective behaviour for each single component of it (Koppel, 1985) and, the developed interest for ASF may be because ASF is a fatal disease (Penrith *et al.*, 2004; 2013) that is endemic in the Angónia district and occurs on a regular basis, making farmers experience the loss of their animals (Matos *et al.*, 2011).

Porcine cysticercosis is not perceived as an important clinical issue for pigs and HC, although important for public health, as it has chronic reactions (García *et al.*, 2003; Mahanty & Garcia, 2010; Elliott *et al.*, 2013). The absence of knowledge uptake about PC transmission in two villages (Liranga and Massoco) could be associated with the fact that the life cycle of *T. solium* is relatively complex to understand. When the information is not appropriate the adoption levels can be reduced (Rezvanfar *et al.*, 2009). It was only in Muiaua and Chabualo that the smallholders had knowledge on PC prior to the study and showed any knowledge uptake afterwards. Even then it was only in Chabualo that a significantly large proportion of farmers responded well to the PC information and this could be associated with the fact that they were in the habit of selling and consuming pork at the local market. This may have raised discussions during their meetings at the market about the role of people that eat infected pork in relation to the life cycle of *T. solium* thus reinforcing the information. Ngowi *et al.* (2008) showed that increasing the knowledge about PC transmission and prevention did change Tanzanian farmers’ practices, reducing the consumption of infected pork, thereby reducing the incidence rate of PC. This indicates that although the *T. solium* life cycle is complex it is not beyond the understanding of smallholder pig farmers. However, the study took place in an area with an overall higher baseline level of knowledge among farmers compared to the current study area and this may have influenced learning ability.

Before the intervention farmers did build primitive pig houses that were inappropriate to house animals due to poor understanding of the pigs' needs. Education changed this substantially and though implementation of knowledge gained varied between villages, improvement in pen construction represented, by far, the most substantial change in the smallholder management practices during the study. This may be largely due to the fact that model pig pens were built in all the villages as a demonstration to reinforce the general information given to farmers. Farmers were thus provided with instructions and they themselves helped erect the basic pen structure. Through this they became aware that they could easily improve their existing pens using almost the same kind and amount of local materials with hardly any additional costs, and therefore the new design was adopted. Demonstration of a given technology has previously been shown to be an important method for disseminating information to farmers (Bonger, 2001). Additionally, farmers do not adopt a technology only based on willingness and awareness but also depending on availability, prices and the expected satisfaction with the results also play an important role (Ani *et al.*, 2004).

Although almost all farmers in the four villages knew that ideally pigs should be fully confined by the end of the study, it was primarily implemented in Chabualo and Massoco. People in Liranga were the least knowledgeable and together with the people in Muiaua the least inclined to alter their practices. Liranga is located on top of a small mountain while most of the crops are grown further down on the slopes. Keeping pigs fully penned could therefore mean a higher demand of time and effort to find feedstuffs and transport them to the animals. Some farmers may therefore have opted to let pigs roam to look for feed themselves and this may also be reflected in the very low proportion of farmers providing the pigs with supplements to the basic diet of maize bran. In contrast, Muiaua is situated in a lush valley, with vegetables grown around the houses and easy access to crop by-products. Farmers might therefore have preferred to leave the animals to run free in order to let them take advantage of the available feedstuffs and perhaps also to reduce the amount of maize bran given to the pigs. Nevertheless, farmers did provide vegetable supplements to their pigs prior to the study and with some additional effort it is possible that they could have been willing to combine this with full confinement.

For the feeding education intervention villages (Muiaua and Massoco) there were highly significant increases in knowledge about feeding pigs at least two times a day with the basic feed (maize bran) and the corresponding application. The overall significant improvement on awareness and behaviour in relation to the three feeding topics could mean that the feeding issue was also important and crucial for farmers so that they readily accepted the new approaches and tried to implement them. There was almost no prior knowledge about the use

of a drinker and to provide water to the pigs in *ad libitum* regime. Excluding Massoco, which did not register significant changes in practices for *ad libitum* drinking, other villages showed significant improvements. For *ad libitum* drinking in Massoco there was no significant improvement on implementation maybe because the village is located in a rocky area where availability of water even for human consumption was most limited. Maheswari *et al.* (2008) demonstrated that scarcity of water limited the adoption of precision farming in resource-poor regions. Surprisingly, knowledge about feeding frequency, use of drinker and *ad libitum* water significantly increased in Liranga (control village) and Chabualo (non-feeding treatment village) but the application of this knowledge only happened in Chabualo, and at a significant level exclusively for feeding frequency.

None of the villagers had prior knowledge on how best to manage the reproduction of their pigs. Nevertheless education had positive impact on knowledge levels and it is therefore assumed that especially the concept of having more than one litter per year due to artificial weaning was a great motivator for farmers. However it was only in Massoco that some farmers started to wean their piglets artificially. The reasons could be that artificial weaning would imply additional costs and efforts to feed piglets in order to guarantee their survival, once they stopped suckling. Often, researchers focus on the fact that farmers are cost-benefit and risk sensitive to make adoption decisions, but it is also important to notice that farmers mainly need to avoid changes in agricultural outputs that would become harmful for their family security and to the preservation of the socio-cultural habits (Koppel, 1985).

The increase in knowledge for feeding and breeding topics as well as implementation of feeding practices in those villages not taught these topics could be attributed to (i) errors in the implementation of educational treatments (i.e. topics were accidentally addressed once in the non-feeding treatment villages at the start of the study); (ii) a possible spill over effect from farmers in the treatment villages; (iii) the intrinsic evolution of farmers pig management practices due increased awareness of practices and new challenges due the full confinement of pigs which automatically implies the increase on feeding practices.

Education did not have a significant effect on sow and piglet performance parameters apart from the increase in the average number of litters per sow in Massoco. This positive result may be because Massoco was the only village that applied artificial weaning so that some sows farrowed twice and one of them 3 times during the study. Farmers that adopt improved technologies have been shown to obtain higher productivity and income than non-adopters (Ding *et al.*, 2011), however, this depends on the circumstances. Numerically, Massoco and Chabualo (reproduction treatment villages) and also Muiaua village weaned fewer piglets per sow than Liranga (control village) and this was due to the relatively high level of pre-weaning piglet mortality. For Muiaua and Chabualo this may be associated with the potential exposure

to frequent ASF outbreaks whereas for Massoco it could be attributed to the weakened capacity of the sows to sustain more than one litter in a year, due to feed limitations. Early weaning can reduce the production costs but may at the same time be associated with higher disease and mortality rates (Galanopoulos and Aggelopoulos, 2006). The control village demonstrated that for the conditions already prevailing in the villages, with one litter per year, the sows potentially weaned more piglets, probably because in this village full confinement was less common and artificial weaning did not happen, so that the sows had time enough to feed the piglets and to recover their body condition after farrowing. Though there was no significant difference in the average daily weight gain between the villages, Liranga tended to have the best gain, supporting the notion that perhaps smallholder farmers in the region were already making the best of their situation. Overall, the findings lead to assume that feeding and watering are crucial tools to ensure sustainability for full confinement and artificial weaning. Based on the results observed concerning to the level of mortality and weight gain of piglets, further studies should associate early weaning to feed supplementation for sows and piglets, based on local available feedstuffs in order to improve viability and sustainability of early weaning.

The results of this study indicate that farmers were at a very basic stage of pig production. The most important measures to be implemented were to provide a pig pen to confine pigs in the seasons before harvesting and during the nights, to provide them food (maize bran and vegetables supplements) and protect them from ASF. In this situation the provision of simple management measures could be of a great value.

Overall, in the present study there was a high decrease in the number of study subjects (farmers and sows) from 125 subjects so that only 58% of the initial number remained at the end of the study. A similar situation was reported by Wabacha *et al.* (2004a) as 48% of pigs were withdrawn. However, the low level of compliance in the current study was addressed when designing the study so that the sample size was increased to accommodate a potential reduction. The causes registered during the study period for the drop out of study subjects (i.e. death of sows, farmers withdrawal and sales of sows) were also reported by Wabacha *et al.* (2004a). Death of sows happened in all the current villages except in the control village and farmers reported it to be caused by ASF. The same cause of pig mortalities was reported in southern Malawi by Allaway *et al.* (1995). Considering other causes of pig deaths, ASF should be the most probable so that it might explain why all the villages were highly motivated to learn about ASF transmission and prevention as how to build improved pig pens. Full confinement of pigs has been reported as important to reduce the frequency of ASF outbreaks in a study in Malawi (Allaway *et al.*, 1995). In spite of the endemic presence of ASF in the Angónia district and its frequent outbreaks (Matos *et al.*, 2011), it has been

demonstrated that pigs in the district may survive the infection which could explain the relatively high number of sows surviving as seen in a previous study (Penrith *et al.*, 2004). Compared to other villages, Liranga (control village) is the most isolated and it could explain that no study sows died and the same could be the case for Massoco where the mortality was low. In contrast, Chabualo (village with the highest mortality) is located close to the main road of the district, that connects Mozambique to Malawi and similarly Muiaua is situated between the main district road and other important roads that connect the district headquarter to the main commercial locality. This geographical location of the villages could be a confounding factor influencing the village exposure to ASF. In a study from 2011, Gulenkin also found a correlation between numbers of roads and the risk of ASF outbreaks (Gulenkin *et al.*, 2011). Additionally, these two villages (Chabualo and Muiaua) tended to sell and consume pork at local markets. This is also a risk factor because the virus persists for months in tissues like muscles, fat and bone marrow (McKercher *et al.*, 1987; Mebus *et al.*, 1993, 1997; Farez & Morley, 1997) and also in insufficiently cooked pork (Costard *et al.*, 2013) that can facilitate transmission via fomites such as contaminated clothes, shoes, vehicles and other materials (Mur *et al.*, 2012d).

The return of sows to the original owners (13.6%) was the second main reason for reduced compliance. Farmers reported that it happened because it was a way to protect their animals from dying from ASF. They lent their pigs to different farmers, mainly to those who had lost all the animals from an ASF outbreak and after the first farrowing the sow and all the piglets were returned to the original owner, except one piglet. At the beginning of the study this was not known to the investigator, which resulted in selection of farmers who did not own the pigs enrolled in the study. This type of movement of animals, although it may to some extent potentially protect the herd of a single farmer, has been reported as an important risk factor for ASF transmission and outbreaks at the local level (Costard *et al.*, 2009; Costard *et al.*, 2013).

Refusal to continue within the project and subsequent withdrawal of the sows from the study (9.6%) occurred almost exclusively in Chabualo. In this village, the leader for some unknown reason was not willing to cooperate, which could have influenced the other farmers' willingness to continue with the study. Another reason could have been misinformation in the village that ASF had a cure and that the research project would provide to the farmers. However, this was not further explored.

Finally, some sows (4.8%) were sold during the study period in all the villages, except Chabualo. This can be explained by the fact that farmers may keep pigs to convert into money in cases of household emergencies (Wabacha *et al.*, 2004a), and most probably the sows were sold to address the demand for money to solve immediate issues. A previous study in the

Angónia district evidenced that most farmers (92.5%) kept pig both for sale and household consumption (Pondja *et al.*, 2010).

For this study, individual farmers characteristics and socio-economic conditions were not analysed in relation to changes in practices and adoption behaviour as it has been done in many other studies (Bonger, 2001; Diederer *et al.*, 2003; Doss, 2003; Ani *et al.*, 2004; Maheswari *et al.*, 2008; Rezvanfar *et al.*, 2009). The result may be that some of the reasons for the observed knowledge uptake and adoption behaviour may not be well understood so that for further studies it is recommended to also address these issues. On the other hand, on the education protocol, although the use of leaflets was important as a guide for the PI and the extension officer, they might not be useful as well for the farmers because their level of literacy was poor and they were written in Portuguese and scarce in illustrations. Printed media has been reported to not be effective to address information to farmers (Bonger, 2001). These limitations were minimised by the on-farm visits done for reinforcement and all training sessions were in local language. Bonger, (2001) reported that farmers prefer to have training sessions in local language. In the future, for similar studies, the materials should be more illustrative and written in the local language. This would also help to avoid possible inaccuracies when translating to another language. Radio broadcasting was also referred to be effective for addressing information to farmers (Emenyeonu, 1987; Rezvanfar *et al.*, 2009). For the present study, the use of “mass-media” for disseminating information would not be advisable because different topics were addressed in each village.

The study had other limitations, related to the fact that the villages were not accessible by car during the rainy season so that it was not possible the visit the farmers monthly as scheduled, the farmers were very busy in the field during this season and on the dry season most of the pigs were left out of the pig pens. As a result, access to the animals was difficult. The fact that ASF was endemic in the district was also a constraint because visiting each farmer would become a disease disseminating factor, although the PI and the Extension officer made use of preventive measures such as disinfection (shoes, hands and equipment) before moving from one household to another one. The effectiveness of health education on pig’s health status was not measured, but awareness about ASF and Cysticercosis transmission and prevention could be reflected on the level of adoption pig confinement practice, which implied to build better pig pens.

The present study revealed that increasing the number of litters per sow reduced the piglets’ viability probably due to feeding limitations. Supporting this is the fact that the control village showed better results concerning to number of piglets weaned per sow and the pig confinement was not widely practiced. This could also mean that access to feed resources when roaming freely was greater than when confined. Based on these findings it important to

study alternative feeding systems and resources based on local feedstuffs to make total confinement viable under smallholder pig farming systems.

Confinement is important both for disease prevention and to improve pig management but perhaps not realistic under the smallholder farming systems. To study communication platforms to monitor free ranging animals to prevent diseases such as ASF and Cysticercosis should be investigated, drawn and implemented. For instance, the use of Short Message Service or other mobile phone communication platforms to report on time an outbreak of ASF to a central of message management, followed by on time implementation of control measures designed for the local context, associated with “mass-media” (radio) outbreak and control measures broadcasting could probably reduce ASF outbreaks and dissemination and at the same time taking the advantage of free ranging systems.

3.5 CONCLUSIONS

Farmers were willing to learn, but appeared to do so more efficiently when they already had prior knowledge on the importance of a topic (ASF). However, changes in knowledge and practices may also lead farmers to discover new knowledge on their own, simply because they are faced by new challenges as a direct consequence of the changes.

Farmers mainly changed their practices when they could do it by simply making better use of their current resources, for example by simply reconfiguring housing facilities to be more appropriate for keeping pigs. However, management practices such as artificial weaning that needed an increase in resource input (feed and water) were more difficult to implement and when it was done led to wasteful practices that likely cost the farmers more than they gained. Education alone was therefore not sustainable for all topics, but it may ultimately empower people to seek and be willing to receive more knowledge as well as drive them towards improving farm productivity.

Because of the modest change in practices compared to the knowledge uptake, the level of performance of pigs, in the case of sows and piglets did not change significantly but the study demonstrated that there is a potential to improve performance. If farmers do not apply what they learn, no changes can be registered in pig performance.

CHAPTER 4

GENERAL DISCUSSION AND CONCLUSION

Smallholder pig farming is an important livestock production system in Mozambique as well as in many other developing countries. These systems face many limitations and constraints mainly related to management and optimisation of available resources. The most reported constraints are related to feeding, reproduction and diseases, leading to overall poor pig performance and low financial outcome. Many studies have indicated that there is potential for sustainable improvement but the lack of knowledge about pig management among smallholders pig farmers greatly hinders this process. The present study intended to improve sow and offspring performance in the Angónia district through education of smallholder farmers on pig feeding, reproduction as well as on pig housing and health.

The study demonstrated that there was potential for increasing smallholder pig performance through education as seen by the significant increase in the number of litters produced per sow during the 12 month study period in one of the villages. However, the success of the education strategy on pig performance depended on changes in the management practices as the result of knowledge uptake. Unfortunately, it appeared that the adoption of new practices did not only depend on exposure to new knowledge and uptake but also on other complex factors that were not monitored in this study. It was evident that overall the knowledge uptake for the extension training method (including demonstration) was high but this did not translate into corresponding high changes in related practices. Exposure to knowledge certainly increased the level of awareness but the application of knowledge depends on a complex set of circumstances and implementation is not guaranteed. Further studies should explore the factors that interfere with and affect farmers' adoption behaviour.

Based on this study, it seems that resource availability in the smallholder farming setting influenced the adoption results evidenced by the fact that for the advised *ad libitum* water provision the adoption was almost nil, which could be explained by the fact that water was scarce even for human consumption. It also became clear how farmers are risk-sensitive, as they did not widely apply weaning at 8 weeks of age in order to obtain more litters per sow. The study showed that weaning at 8 weeks might in fact be harmful for the piglets as evidenced by the high mortality level and poor growth performance compared to the control village. This can probably be associated with an increased need for feedstuffs both for sows and piglets when the inter-farrowing interval is reduced. This issue cannot be properly addressed in resource poor pig production systems if the communities cannot at the same time increase access to water and crop productivity, thereby ensuring sufficient and better quality feed stuffs.

The results of the present study suggest that education can significantly increase knowledge uptake and to some extent, produce changes in the related practices, meaning that the adoption process does not depend exclusively on awareness. It is overall crucial to take into account that any change in the smallholder pig farming system can also have unexpected and undesirable effects. Before any intervention implemented it is therefore imperative to understand the different dimensions of potential positive and negative effects especially related to the resource demand to make sure that the implemented measures can be sustained under the available and accessible resources.

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APPENDIXES

APPENDIX 1 Questionnaire for evaluation of smallholder pig farmer's knowledge (baseline and knowledge uptake after intervention).

Questionnaire for evaluation of smallholder pig farmers' knowledge (before and after education intervention)

Questionnaire No.: ____ Selected Y N; Date: ____/____/ 2011 Before intervention: After intervention:

Location of the unit. Administrative area: _____ Locality: _____

Village: _____

Treatment: _____ CODE: _____

Knowledge evaluation				
No	Question	Right answer	Farmers' answer	
			RIGHT	WRONG
Hth1	How do pigs acquire African swine fever (ASF)?	Contact with infected animals or contaminated materials		
Hth2	How can pigs be protected from acquiring ASF?	Avoid contact with infected animals or contaminated materials/Full confinement.		
Hth3	How do pigs acquire porcine cysticercosis?	Ingestion of eggs released with faeces of a human infected with <i>T. solium</i> .		
H1	How should good pig pen be constructed?	Bigger enough to allow a human to go inside and with at least 2 compartments (roofed and unroofed).		
H2	Do your pigs always stay inside the pig pen?	Yes		
F1	Where do you put the feed for the pigs when feed them?	Food container		
F2	How many times a day you provide feed for the pigs?	At least 2 times a day		
F3	What else do you provide to the pigs to eat?	Vegetables		
F4	Where do you put water for your pigs to drink?	Water container/ feeder after giving the food		
F5	How many times a day do you provide water for the pigs?	Always available		
R1	Can you mate a boar with a related sow (from the same family)?	No		
R2	Do you separate the piglets from their mothers to stop suckling or they do it by themselves?	I do		

APPENDIX 2 Verification card for evaluation of smallholder pig farmer's practices (baseline and changed practices after intervention).

Verification card for evaluation of smallholder pig farmers' practices (before and after education intervention)

Questionnaire No.: ____ Selected Y N; Date: ____/____/ 2011 Before intervention: After intervention:
 Location of the unit. Administrative area: _____ Locality: _____
 Village: _____
 Treatment: _____ CODE: _____

Practices evaluation (validate if indicator is observed)						
No	Practices or questions to verify	Validation	Right answer	Indicator of practices	Applied practices	
					YES	NO
H1	How is the pig pen constructed?	Observation	-	Improved pig pen built (big with at least 2 compartments)		
H2	Did the pigs leave the pig pen during the study (except pre-weaning piglets)?	Observation + answer	No	Pigs penned		
F1	Is there a food container inside the pig pen?	Observation	-	Food container in the pig pen		
F2	How many times a day do you provide food for the pigs?	Observation + answer	At least 2 times a day	Traces of maize bran in the pig pen		
F3	Do you provide vegetables to the pigs?	Observation + answer	Yes	Traces of fresh vegetables in the pig pen		
F4	Where do you put water for your pigs to drink?	Observation + answer	Water container/ feeder after giving the food	Water container/ feeder in the pig pen		
F5	How many times a day do you provide water for the pigs?	Observation + answer	Always available	Water in the pig pen		
R1	Who is the father of the piglets you had this year?	Observation + answer	From outside the farm	No boar in the pig pen		
R2	For how long did the sow suckle the litter?	Observation + answer	2 months	Piglets above 2 months age not suckling		

APPENDIX 3 Sow-progeny and management record card – Translated from Portuguese

Farmer's name: _____
 Administrative Area: _____
 Village: _____ GPS: _____

SLIPP

LEGEND: CM-improved pig pen; C-feeder; B-drinker
 R-feed; A-water; V-vegetables; L-confined; P-individual pig weight

PROGENY DATA

SOW No.	
Mating date	
Boar provenience	
Farrowing date	
Litter size	
No. of piglets born alive	
Average weight at birth (kg)	
Weaning date	
Average weight at weaning (kg)	
No. of preweaning piglets dead	
No. of piglets weaned	

MANAGEMENT								
Date	CM	C	B	R	A	V	L	

Date	No. of animals		Pesos (kg)						No. pigs weighed
	Piglets	Weaned	P1	P2	P3	P4	P5	P6	

Cicle 2	
Mating date	
Boar provenience	
Farrowing date	
Litter size	
No. of piglets born alive	
Average weight at birth (kg)	
Weaning date	
Average weight at weaning (kg)	
No. of preweaning piglets dead	
No. of piglets weaned	

MANAGEMENT								
Date	CM	C	B	R	A	V	F	

OBSERVATIONS: _____

OBSERVATIONS: _____

How to feed the pigs?

Young or baby pigs are called **PIGLETS**
Adult female pigs are called **SOWS**
Adult uncastrated male pigs are called **BOARS**

The pigs need to drink **WATER.**

- Pigs must always have clean and fresh water to drink;
- Put the water in an appropriate container (drinker);
- One pig needs at least 5 – 10 liters of water every day;
- The sows needs to drink more water when are feeding piglets, because they need to produce milk;
- Put the water in the shade to stop it from getting hot and being lost due to evaporation;
- It's very important to make sure that the pigs can't push the water container over. Tie it to a post or pole in the ground.

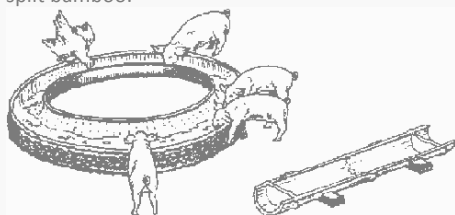
And how to **FEED** the pigs?

Good feed is necessary for growth, body maintenance and the production of meat and milk.

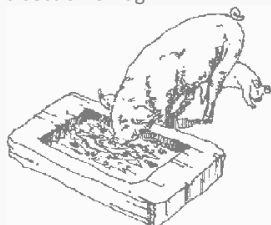
- Pigs need to eat two or three meals a day;
- Divide the food into two or three portions and feed the pigs in the morning, in the mid day and in the evening;
- **DON'T** give all portions of food at the same time because once they have eaten and are full, they will play with the rest of the food, stand in it and make it dirty. This food is then wasted and the pigs will be hungry;
- Pigs must not be fed rubbish or plastic;
- Pigs can eat mixtures of scraps, or leftover food like bread, vegetables, fruit, corn bran and maze bran;
- **DON'T** only feed one vegetable. Pigs need a mixed diet to stay healthy;
- Cutting grass (especially green grass) and feeding this in small amounts will help to supplement the pig's diet;
- It's important that small or weak pigs are fed separately from the bigger pigs or else the bigger, stronger pigs will eat all the food;
- If you have more than four adult pigs then food should be divided into two containers, so that every animal can have a share.

Different models of feed containers

A piglet-feeding trough can be made by cutting a car tire in half along his circumference or from split bamboo.



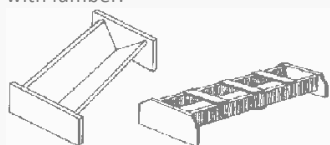
A good pig trough can be made by hollowing out a section of log.



Old cooking pots make a good feeding troughs.



A variety of feeding trough can be made easily with lumber.



2

Low-cost, locally available Feeds

The pigs need Water, Carbohydrates, fats, proteins, vitamins and minerals. These components are founded in different feed sources at different levels.

The young pigs and lactating sows need more water, proteins, vitamins and minerals.

The adult pigs need more water, carbohydrates and fats.

Where can we find these components?

Protein-rich feeds: help an animal grow faster, give more milk.

Plant sources:

- *Leucaena Leucocephala* leaves;
- *Gliricidia septum* leaves;
- Beans;
- *Moringa oleifera* leaves;
- *Cajanus cajan*;
- Waste of soybean;
- Seed skins of mung bean sprouts.

Animal sources:

- Fish rejects;
- Frogs;
- Shrimps;
- Snails;
- Heartworms

Carbohydrates sources:

- *Ipomea batatas* (Sweet potato);
- *Manihot esculenta* (Cassava);
- *Maranta arudinacea* (Arrowroot);
- *Oryza sativa* (Rice);
- *Zea mays* (Maize).

Vitamin and mineral sources:

- Pounded bones;
- Leaves of *Moringa oleifera*;
- Salt;
- Molasses;
- Fruit rejects/peelings;
- Water hyacinth;
- Green and leaf; vegetables stables.

How to have more and health piglets?

Young or baby pigs are called **PIGLETS**
Adult female pigs are called **SOWS**
Adult uncastrated male pigs are called **BOARS**

There is a specific moment where the sow needs the male to be pregnant. That moment is called **heat**. Out of this period the female can not get pregnant.

It's important to the farmer to know how to detect the right moment to join the boar to the sow.

How to detect heat?

The common signs of heat are:

- The sow is restless;
- The sow mount other pigs or allow other pigs to mount her;
- The sow stands still when she feels pressure on her back;
- There is a vaginal discharge that is watery.

Heat lasts about 24 hours. After that, the sow will not stand still for the boar. So it's important to detect the right moment!

Mating. How it can be done?

If you see heat signals, join the boar to the sow during one day for the **mating** process.

A sow should be mated two times at approximately 12-hour intervals. Mate the animals during the fresh time of the day: early in the morning and late in the afternoon. After mating record the date to help you to know if the sow gets pregnant and when the sow will have babies.

Young boars may need assistance in lining up their mate.

Pigs mate slowly. The boar may take a minute or more to reach the point of ejaculation.

Note: *NEVER mate animals that come from the same family because their piglets will be not health and will not grow.*

How to know that the sow is already pregnant?

If a sow does not show signs of heat three weeks after mating, then it is very likely that she is pregnant.

How to care about the pregnant sows?

- Pigs are pregnant for about 4 months and can have as many as 10 piglets at one time;
- Separate pregnant sows from other animals;
- Protect pregnant sows from high temperatures;
- Do not transport a pregnant sow;
- Until the final stages of pregnancy, exercise is good for pregnant sows. Give the sow space to walk in;
- A sow must be kept in a separate area when she is going to have babies. This area must be clean, dry and warm;



- A farrowing pen should be 2 meters by 2.5 meters in size. The pen should have piglet guard rails along the sides. These can be planks or poles 20 to 25 cm of the floor, reaching about 30 cm from the walls. Guard rails will help prevent piglets from being crushed by the sow;
- Put some grass on the floor so that the sow can make a nest. This will help keep the babies warm and close to their mother;
- A sow with babies must have clean water all the time and a lot of good and fresh food at least twice a day.
- It is best to keep pigs of the same size together. If big and small pigs are mixed, there will be fighting and bullying of the smaller or weaker ones;

The birth

Birth in a normal birth, piglets begin arriving within 30 minutes of the first labor signs. Normally, there are born at intervals of 10 to 15 minutes. All piglets are usually born within 3 hours. The placenta (afterbirth) should follow within 20 to 30 minutes.

How to take care of the piglets?

At birth, piglets are wet and covered in a thin mucous membrane. This membrane will dry and disappear very quickly. Most piglets will not need special attention from you.

When the piglet is born, the umbilical cord will hang from the animal. Within 2-3 days, it will dry and fall off.

It is important to keep the piglets warm.

The piglets should be weighed when born and again at weaning.

Newborn piglets can easily be crushed by their mother, until they learn to get out from

under her when she lies down. The farrowing areas should have barriers to prevent the sow from crushing the piglets. After the first two weeks, the barriers can be removed.

If you want more pigs per year what you have to do is...

- Don't let the piglets more than 2 months in lactation. A sow doesn't get into heat when she is lactating;
- Wean the piglets when they are 8 weeks age;
- At the weaning, remove the sow and let the piglets in the farrowing crate for more 7 days;
- After 7 days, transfer the piglets to the weaner pen that has been previously cleaned, left vacant for 10 days and equipped with a fresh supply of feed and water;
- Weigh the piglets when placed in the pen and again when moved out.
- Be attempt to the heat after the farrowing. The sow will be in the heat at 3-5 days after the weaning and again 24-28 days after the weaning. Don't loose the second heat, be attempt!

