Improvement of village chicken production in a mixed (chicken-ram) farming system in Burkina Faso

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Improvement of village chicken production in a mixed (chicken-ram) farming system in Burkina Faso

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Abstract

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Animal production in general and chickens and small ruminants in particular play important socio-economic roles in developing countries. Production of village chickens is a source of easy and regular income for rural farmers in developing countries in general and in Burkina Faso in particular. Unfortunally efforts to improve this production system were not very effective and village chickens still have low productivity. Due to the roles of village chickens, the Strategic Research Plan of Burkina Faso recommended to invest in gathering knowledge on this production and in conducting research for the improvement of the system. The current study started with surveys and literature reviews to analyse the existing production systems at farm level. Special attention was given to farmers' practices and to identification of local feed resources and their use. Secondly studies were designed in order to improve the most common village chicken production systems based on scavenging. On-station studies were undertaken in 2 research stations in the Central and the East Regions of Burkina Faso and on-farm trials were undertaken in 6 villages in the same regions. System analyses showed that both village chicken and sheep fattening could be used for improvement of livestock production and subsequent income generation at rural farm level. Furthermore, an integrated village chicken and ram-fattening farming system appeared to be a promising possibility for village chicken improvement. It allows to control village chicken scavenging and to reduce the high risks related to the free-range system. The studies demonstrated that regular supplementation with locally available feedstuffs as sorghum or local beer by-product can be used as feeding strategies to improve village chicken production. Commercial complete chicken diets may also be used but only as supplement to scavenging because village chickens did not perform well with complete diets in confinement conditions. Further, crop residues can be valorised in sheep fattening with incorporation of 30% of concentrate feed. The results of these studies are used to integrate village chickens and ram fattening production in an Integrated Production System (IPS). The results of this IPS indicate that with adequate supplementation the IPS allows to achieve a daily growth of village cockerels up to 10.4 g/d/bird. Such a level was not found in other conditions of feeding tested so far. Taking the case of Burkina Faso, the study demonstrated that the IPS can serve to obtain an annual income that is above the low poverty line. The tested IPS is an integrated farming system in which rams are fattened and village chickens are allowed to scavenge on the refusals of these rams. In this IPS chickens and rams are reared in a limited area. These controlled conditions give the opportunity to invest with low risks in village chicken production by improving feeding, health care, housing and management, making village chicken rearing more profitable. IPS appears to be a framework within which most activities for improvement of village chicken production can be implemented. IPS fits to farmers' conditions and strategies of keeping multiple species and using essentially locally available resoruces. IPS can be used for poverty alleviation in developing countries in General and in Burkina Faso in particular.

Keywords: Village chickens, sheep, production system, feeding, fattening, Integration, Burkina Faso.

To

- my father Pousga Kondombo and my mother Simandé Bonkoungou,
- my wife Salamata, my son Ghislain Arouna,
  my daughters Acha Gisèle and Djimila Rosine,
- my sister Mme Kafando/Kondombo Solange.

Contents

GENERAL INTRODUCTION

General introduction

Strategic role of livestock in Sahelian traditional livelihood systems

The role of livestock in developing countries in general and in Sahelian regions in particular is already well reviewed by many authors (Ayantunde, 1998; Nianogo and Somda, 1999; Guèye, 2000; Slingerland, 2000). In Sahelian countries animal production is after crop production, the second activity of the population. The level of industrialisation is low and employment in the modern sector (public services and private business) is practically negligible (Slingerland, 2000). About 65 to 80% of the human population live in rural areas (Guèye, 2000; Ndegwa *et al.*, 2001) and their life is strongly linked to crop and livestock production.

Livestock sustains agriculture in Sahelian regions by supplying food, draught power, and manure, and thus direct (by off-takes) or indirect income for the rural households. For example, in Burkina Faso, livestock represents the second resource after cotton and constitutes the second exportation product. It participates to 13% of the Gross Domestic Product (DREE, 1999) and in 1997 livestock represented 28% of total agriculture production. In the following section we will demonstrate the strategic role of livestock in Sahelian traditional livelihood.

Social, cultural and religious roles of livestock

Livestock is known to play an important role in social and cultural life in developing countries in general and in Sahelian countries in particular (Tadelle and Ogle, 1996; Sonaiya *et al.*, 1999; Slingerland, 2000). Cattle is considered as an object of prestige and a sign of richness in crop production farming systems, whereas for the Fulani who practice the livestock farming system, life is organised in direct relation to cattle breeding. Small ruminants (sheep and goat), and family poultry are frequently used as gifts for relatives, sacrifice, marriage or religious ceremonies (Sonaiya *et al.*, 1999; Slingerland, 2000).

In Senegal, Guèye (2000) indicated that poultry has a mystical function and farmers believe that bad spirits which target the family can be diverted to chicken. As a result of this, the chosen birds often show neurological symptoms. The author indicated that this might explain partly the fact that in each Senegalese village household, there is a strong wish to keep at least a chicken flock. Furthermore, he noted that poultry have an important hygiene function, as they feed on household refuse, earthworm, insects, etc. They therefore reduce or even remove household waste and pests.

Mourad *et al*. (1997) studied the destination of village chickens at farm level. They showed that these are mainly used for commercialisation for 45% and reproduction for 28% (Figure 1). The uses of village chickens for socio-cultural roles (sacrifice and gift) are important (5 to 10%) but, appear to be significantly lower than the use for income generation (45%).

Conversion of natural vegetation and crop residues into animal protein and manure

Livestock contributes significantly to improve Sahelian livelihood, through conversion of natural vegetation and crop residues into animal protein and manure. Traditional livestock production is based mainly on grazing systems (Slingerland, 2000). Integration of crop and livestock production is mutually beneficial through manure, crop residues and animal traction.

In general, only a little part of natural vegetation and crop residues is converted to animal protein. An important part is burned in the dry season by bush fires and another part is left in

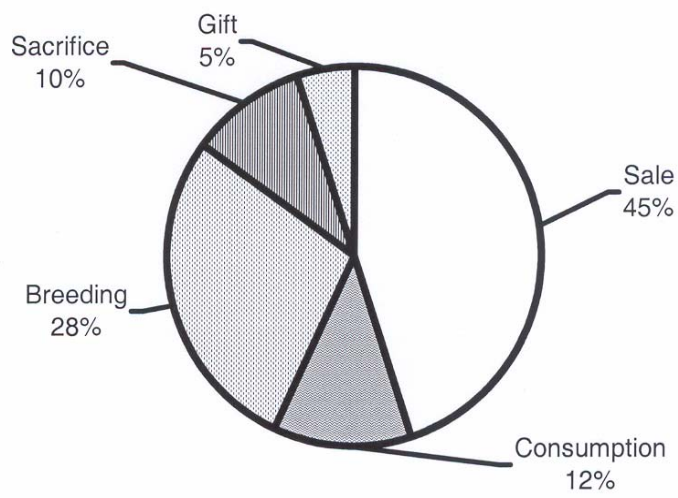

Figure 1. Village chicken use at farm level
(After Mourad *et al.*, 1997)

the field. Competition with stubble grazing, labour availability and lack of a cart are factors limiting the quantities of crop residues collected (Savadogo, 2000). Efficient use of crop residues can help to increase production of milk and meat. Savadogo (2000) demonstrated that without external inputs, 149 kg total livestock weight gain, 2.2 t organic matter (OM) outflow from animal manure and refusals and a balanced OM budget can be obtained in a sustainable crop-sheep farming system based on 5.1 ha of crop land and 26 sheep.

Many studies worldwide show the possibility to use natural vegetation and crop residues in livestock production (Ayantunde, 1998; Muia, 2000; Savadogo, 2000). However, natural vegetation and crop residues as major ingredients in livestock diets may lead to marginal performances. Inclusion of agro-industrial by-products or cereals may increase performance per animal. According to Dembélé (1995) and Kaboré (1996) cited by Savadogo (2000), industrial by-products are not available in Burkina Faso, or so expensive that farmers cannot afford them.

Soil fertility management

Livestock contributes in soil fertilisation through the production of manure. In fact, traditionally livestock herders have for centuries offered manure against crop residues through manure contracts (CTA, 1986; Savadogo, 2000). While feeding on crop residues in the fields, cattle release important amounts of urine and dung that will help to fertilise the crop field. Every farmer in any Sahelian country knows the importance of animal manure in soil fertility improvement. For small ruminants kept in enclosures near the houses, cumulated manure can be transported to the field.

Furthermore, in Sahelian countries, farmers are encouraged to make compost pits that increase the capacity of organic fertiliser production. Compost is the product obtained after aerobic biotransformation of wastes by micro-organisms naturally present in the residues or externally added (Vargas-Garcia *et al.*, 2005). In Burkina Faso for example, the ministry of agriculture launched an operation of 200,000 compost pits in the year 2003 in addition to the other 250,000 that were already realised before that year (Observateur Paalga, 2003). Technologies designed to improve the quality of the compost are being promoted through research (Bonzi, 1989; Lompo, 1993) and extension.

Relative importance of various livestock species with regard to income generation, food security and sustainability at farm level

Livestock represents an important component of the agricultural economy in developing countries. Livestock provides meat, milk, skins, draught power, transport or manure (Ayantunde, 1998; Guèye, 2000) and, as a consequence, plays a key role in food security strategies (Ayantunde, 1998). Furthermore, the increase of the population, the urbanisation and the increase in income in developing countries lead to an important increase of the demand of livestock products (Delgado *et al*., 1999; Gillin, 2002). Such demand can give the opportunity to increase the income of large numbers of poor farmers in rural areas when they succeed to produce and sell livestock products. However, some contradictions are noted in the role of livestock in food security (Delgado *et al*., 1999). The important demand of livestock products in developing countries, the quick increase of the demand and the production of these products may require cereals and concentrate feeds. This will reduce the quantities of cereals available for human consumption (Delgado *et al.*, 1999).

Livestock allows poor landless farmers to have access to income using common resources. It consumes many agricultural by-product which otherwise may be lost. Livestock are often reared on land that might be non-appropriate for crop production and can offer work during the period that other agricultural activities can not be done. In particular poor women have sometimes as source of income, one cow or a few chickens reared at home.

Livestock has more impact at farm level than at regional level, because intermediate products, such as manure and draught power are important benefits (Udo and Cornelissen, 1998). It plays an important role in food security issues at household level. Slingerland (2000) described the role of livestock in food security extensively. In situations with unreliable and erratic rainfall conditions, crop harvests show high variation between years. In years of surpluses, grains are sold and livestock is bought for the revenues. In years of cereal shortages, livestock is sold to buy grains for food. In this way livestock serves as a buffer providing food security.

The sustainability of rural farmer systems seems to be strongly related to animal production through income generation. For separate livestock species, different contributions to income, food security and sustainability can be distinguished.

Guèye (2000) suggested that rural family poultry could be considered as sustainable as they are socially and culturally accepted at one hand and ecologically, economically and financially sound at the other hand. Family poultry are kept for many reasons (Guèye, 2000) and mainly village chicken can be kept by any rural household. They are considered as a strategic mean in income generation and food security for developing countries (Kazi, 1999; Sonaiya *et al*., 1999; Guèye, 2000). Strategies to establish family poultry rearing in general and village chicken in particular as a mean of poverty eradication are now implemented in Bangladesh (Kazi, 1999).

Cattle contribute mainly to milk production and draught power. In a study in Burkina Faso, Savadogo (2000) indicated that most cattle were entrusted to herdsmen in the dry season and used as draught animal by crop farmers in the rainy season. However, the poor strata of the society are not able to purchase a cow which makes it difficult to use cattle widely in poverty alleviation.

Small ruminants such as sheep and goats can frequently be slaughtered at village level and may supply the rural population with animal protein. Their carcass weight is suitable for consumption in small, familial or village communities (CTA, 1986). Their product is easily and quickly sold and thus serves as monetary reserve for rural farmers. They can be owned by rural households and then can have a significant contribution to income generation and food

Table 1. Rural financing multiple criteria matrix for four types of financing in Zounwéogo Burkina Faso

Criterion	Accessibility	Liquidity	Security	Profitability	Total
CECC & COOPEC	1	2	4	1	8
Family & friends	2	1	3	2	8
Cereals	4	3	1	3	11
Livestock	4	3	2	4	13

Judgement of the authors based on all presented data (1= low; 4 = high); CECC = Cellule d'Epargne, Credit et Commercialisation (Saving, Credit and Commercialisation Unit); COOPEC = Coopérative d'Epargne et de Crédit (Saving and Credit Cooperative). After Slingerland, 2000.

security in a large scale in developing countries. Other very important reasons for keeping animals are their functions as capital asset, insurance and finance (Bosman *et al*., 1997; Udo and Cornelissen, 1998; Sonaiya *et al.*, 1999). According to Slingerland (2000), small ruminants are so frequently sold for urgent cash needs that optimal biological production is not being reached.

Several authors (Sonaiya, 1990; Sonaiya *et al*., 1999; Ramlah, 1999; Guèye, 2000; Slingerland, 2000) have helped to demonstrate the important role of livestock in income generation. Slingerland (2000) showed that in term of accessibility and profitability, livestock is the most attractive type of financing (Table 1). These functions got the higher judgements of the population during the investigation of this author. However, it can be noted that in term of security, livestock is not well appreciated mainly because of risk of theft. That role of security is more assured by credits and saving. Unfortunately rural farmers have low accessibility on these sources of financing.

Cattle yield of course a large quantity of money when sold, but their accessibility to poor farmers is low due to the high cost of initial acquisition. In their study in Nigeria, Bosman *et al.* (1996) noted that the most important species kept are poultry and small ruminants. Furthermore, cattle cannot be sold easily and are only sold in exceptional situations. Hence, small ruminants transfer is generally used in case of ordinary expenses, while cattle is only sold or slaughtered in extreme cases of food shortage or sanitary care (Slingerland, 2000).
Slingerland (2000) suggests that fattening of sheep, especially those of Bali-Bali breed, should be planned in conjunction with Muslims feasts such as the religious 'Tabaski', when prices are higher than in any other period of the year. Fattening for export might also be an option.

For poultry, many studies indicated the possibility to use its production for poverty eradication and promotion of gender issues (Kazi, 1999; Guèye, 2000). In Bangladesh, a project has shown a model that allowed poor rural farmers, mainly women, to increase their income by poultry rearing. Rural family poultry, namely village chickens, are capable of providing the population with cheap and readily harvestable meat and eggs (Aini, 1999; Guèye, 2000).

Small ruminants and poultry have reproductive advantages over cattle. Due to their short reproductive cycle, sheep and goat can produce one to two offspring a year and village chickens can give three clutches of 12 to 18 eggs (Guèye, 1998) in a year.

Conclusion

The current review showed the important socio-economical roles of animal species for farmers in developing countries in general and in Sahelian countries in particular. Rearing animals appears to be an easy way for poor farmers to fit in the formal economical market. Small ruminants and poultry are best fit for income generation for the poorer farmers. Both species contribute to sustainable livelihood at farm level.

Scope of the study

The review showed that small ruminants and poultry are best fit for income generation for the poor farmers. The current study investigates how to improve each of these two production systems at farm level for poverty alleviation in Sahelian countries in general and in Burkina Faso in particular. For small ruminants, sheep fattening is a promissing technology already implemented at farm level. Yet feed resources for fattening are scarce and expensive. For village chickens, improved technology still needs to be developed (CNRST, 1995).

Sonaiya (1990) suggested the need to develop system approaches to rural poultry development and Lee *et al*. (1993) indicated that only by systems' analysis, the production system could be better understood and interventions for improvement of production can be studied. According to Nianogo and Somda (1999), a strategic combination of animal species at farm level, and the analysis of such combinations may be helpful in improving livestock productivity in African villages. According to these authors, it is possible to find mutually beneficial combinations of different species at farm level, leading to the improvement of livestock productivity. They indicated that there is promise in combining poultry with goat, sheep and/or cattle.

Furthermore, in developing countries, the rural population doesn’t have access to formal credits for their activities in general and for livestock production in particular. Sometimes, farmers may receive support from donors as is the case in the ‘Fonds d’Appui aux Activités Rémunératrices des Femmes’ (FARSF)[1] and the ‘Projet de Développement de l’Aviculture Villageois’ (PDAV)[2] in Burkina Faso or like the project that supported the Bangladesh model for rural poultry production (Kazi, 1999). The Women income generation activities (FAARF) was initiated by the government of Burkina Faso in 1991 with the assistance of the United Nation Programme for Development (PNUD). It aimed at increasing access of rural women to formal credits by giving them small credits or garanties for other financial structures. At the same time this project provided training on the management of their activities. According to Saunders (1984), the PDAV was a project that aimed to develop family poultry by sanitary and zootechnic training, diffusion and sensibilisation including research components. It supported rural farmers to improve village chickens rearing by a large vaccination campagne against Newcastle disease. In the Bangladesh model (Kazi, 1999) the strategies to make village poultry rearing more profitable included provision of improved breed in an integrated package for landless and particularely distressed women. The package included motivation, group organisation and training on poultry management, vaccination and supply of small credits to the target groups and regular supervision and advice.

For Sonaiya *et al.* (1999) livestock development requires a strategy to optimize production from available feed resources. The identification and careful study of feed and animal resources are essential first steps. In the case of village chickens, it is clear that one of the major problem to be solved will be the feeding as the system is mainly based on scavenging. Scavenging feed resources do not lead to an efficient village chicken production. If complete diets are available there is improvement of production, but rural farmers may not be able to invest or village chicken production may not be sufficiently high to earn back such investments. For resource poor farmers, there is a need to identify strategies that minimise the

[1] Fund for the income generating activities of women
[2] Village poultry development project

input, allow the chickens to roam freely and assure the use of other improved techniques such as improved housing, health care and management against low costs.

The current study analyses village chicken and sheep production systems, their constraints and the possibilities for low cost improvements. The study includes as a higher system level, the farm household, to identify household resources and possibilities. At this level, trade-offs and synergies between poultry and sheep production are identified. One major question to be answed is how to organise the supply of adequate feed (energy and protein supply; use of locally available feed resources) in both chicken and sheep production systems at farm level. Therefore, feeding strategies are explored for each of the animal system. Complementarity and competition between poultry and sheep for the scarce feed resources may be a key issue.

The objectives of this research are:

- To describe and analyse village chickens and small ruminants production systems in Burkina Faso;
- To identify various feeding regimes for village chickens and sheep and to investigate their advantages and limitations;
- To identify which factors of each sub-system can contribute to or be beneficial to the other;
- To explore an integrated poultry-sheep system

Presentation of the study area

The current thesis has its field work realised in Burkina Faso. Burkina Faso is a country in West Africa (Figure 2) located in the Sahelian zone between 9°20' and 15°05' Northern latitude and 2°20' Eastern and 5°30' Western longitude.

The neighbouring countries of Burkina Faso are Ivory Coast, Ghana, Togo and Benin in the south, Niger in the East and Mali in the north. The surface area of the country is 274,000 km^2 and it has 10 millions inhabitants constituted for 85% of rural farmers. The main activities are crop and animal production. The climate of the country is Sahelo-Soudanien with a dry season from October to April and a rainy season from May to September. Variation in rainfall occurs from year to year and in the same season from one zone to another.

According to the Ministry of Economy and Finance of Burkina Faso (MEF, 1998), the crop and animal production sectors involve 90% of the active population in Burkina Faso. These sectors assure 40% of the Gross Domestic Product (GDP) in the country and constitute 65% the value of the total export. Animal production alone represents 18% of the export.

The country is subdivided into five agro-ecological regions by the ‘Institut de l’Environnement et de Recherches Agricoles (INERA)’. These correspond to five research regions with different agricultural potentials. Within each region, the circumstances (altitude, rainfall, population density, vegetation, farming systems) are more or less homogeneous. These regions are:

- Sahel Region with rainy season from June to September, less than 600 mm of rainfall, livestock is the most important activity in this region;
- Central Region with rainfall between 600 and 900 mm during less than 6 months, and with high population density;
- North-west Region with 600 to 800 mm of rainfall;
- West Region with 900 to 1200 mm of rainfall during about six months;
- East Region with annual rainfall from 600 to 900 mm but with a low population density.

Figure 2. Location of Burkina Faso in Africa

The fieldwork of the current thesis was carried out at eight research sites (Figure 3) through out the Central and the East Regions. These sites were the villages of Yambassé, Villy-Moukouan and Matté in the Central Region; the villages of Konli II, Louanga, Kouaré in the East Region; the PAPEM (Point d’Appui à la Prévulgarisation et aux Essais Multi-locaux) of Bogandé; as well as the research stations of Kouaré (East Region) and Saria (Central Region).

Figure 3. Location of the research sites

Table 2. Small ruminants (head) distribution according to the agro-ecological Region of Burkina Faso

Agro-ecological region	Localisation in the country	Rainfall (mm)	Sheep number	Goat number
Sahel Region	Extreme north	<600	940,126	1,682,756
North-West Region	North-west	600-800	960,089	1,394,206
Central Region	Central	600-900	2,190,608	3,314,278
West Region	West	900-1200	1,397,246	1,806,732
East Region	East	600-900	1,214,571	1,837,715
Total			6,702,640	10,035,687

Computed from MED and MRA (2004)

The choice of the regions of research is based on the importance of small ruminants and poultry in these regions. Livestock numbers according to the second census on livestock in Burkina Faso (MED and MRA, 2004) can be used to indicate the importance of small ruminants in the country. Sheep and goats represent respectively 40% and 60% of the total small ruminants in the country. According to the region of research as defined by the research institute of the country (INERA) the most important number of small ruminants is localised in the Central Region (Table 2). About 2.2 million sheep and 3.3 million goats are observed in that region. In comparison, village chickens distribution in the country follows the same tendency with the most important number of 9.1 millions of chickens (MED and MRA, 2004) in the Central Region. The East Region has also 1.2 million sheep, 1.8 million goats and about 3.85 million chickens.

Outline of the thesis

The improvement of livelihood of poor farm families is a challenge that developing countries are facing. Improving indigenous animal production gives the opportunity for millions of rural farmers to have an important source of protein and/or income. The current thesis studies the possibilities to improve the system at three levels:

- chicken production sub-system,
- sheep production sub-system, and
- farm household level by integrating poultry and sheep production sub-systems.

The Central and East regions of Burkina Faso, a Sahelian country in West Africa, are used as the study area. The thesis describes on station and on-farm trials. These were conducted with the perspective to improve village chicken production and sheep fattening in Burkina Faso. The results of these studies are reported in seven chapters.

Chapter 1 describes village chicken production systems. It is composed of three studies. The first study aims to give the background on village chicken production systems and their main constraints. It is based on literature review. In the second study, a system analysis approach is used in one village (Yambassé village) in the Central Region of Burkina Faso in order to study village chicken production at household level. The method used is a Rapid Rural Appraisal followed by a monitoring on main parameters of village chicken production. The third study is a review that gives the state of research and development activities on village chicken production in Burkina Faso.

Chapter 2 gives an overview on small ruminant production systems in Burkina Faso. It is based on literature and aims to identify the main constraints in this production and to describe the perspectives of improvement.

Chapter 3 is composed of two studies designed to study the feed ressource base for sheep fattening and village chicken production. The first study investigates the availability of agro-industrial by-products (AIBP) in Burkina Faso. A formal survey at factory level in three towns in the country is performed to generate information on the quantity of feed produced by mills and on its availability for livestock feeding. The study concerns the main factories that produce AIBP in the country at the period of the study.

The second study is done on the local feed resources for sheep fattening and village chickens. For sheep, the local feed resource base is evaluated through a case study on crop residues in a village in the East Region of Burkina Faso. A sample of 10% of households in the village is randomly chosen for the study. In each household, all crop residues (cereal straw and legumes hay) produced in the fields or stored in the household are weighed. For the local resource base of village chicken production the availability of feedstuffs for village chickens and their impact on village chicken body weight in the different periods of the year (dry and rainy seasons) is evaluated. In this study on scavenging chicken, a survey on farmer practices in village chicken feeding is made. This survey is completed by measurement of chicken body weight and analysis of crop content. The crop content is collected and analysed at different periods of the year. From this, the availability of feedstuffs in different periods of the year can be deducted. Weighing village chickens at different stage of development (cock, hen, pullet or cockerel) and analysing their slaughter performances is used to derive the impact of availability of feedstuffs for village chickens in different periods of the year.

From the results of Chapters 1, 2 and 3, feeding strategies for village chicken production and sheep fattening are designed and tested in Chapters 4 and 5.

In **Chapter 4,** two *in vivo* trials are reported on village chicken feeding. In the first trial, the use of sorghum feed and artisanal beer malt in village chicken supplementation is investigated. Three strategies of supplementation are tested at farm level. In the second trial, the use of commercial feeds in village chicken feeding are investigated. This study aims to identify feeding strategies for the use of balanced feed at farm level. A feeding trial with factorial design is used for the study. Three strategies of feeding are tested.

In **Chapter 5** two trials on sheep fattening and one study on production of an alternative fodder crop are conducted. The first trial aims to demonstrate how available crop residues at farm level can be better used in sheep fattening. The main crop residues (cowpea hay, groundnut hay and sorghum straw) at farm level are used in combination with different quantities of concentrates. The second trial is an on-farm trial. It aims to test two approaches of transfer of diets for sheep fattening from the research station to farmers, to appreciate the fattening performance with these diets at farm level and to get to know farmers' opinions on these diets. Six fattening diets formulated and studied in research stations in Burkina Faso are tested at farm level in five villages used as research sites. The third study investigates how forage with high nutritive value (the *Dolichos lablab*) can be combined to cereals in rural farming in order to increase the availability of forage for sheep fattening. For this association (*Dolichos lablab* and cereals) a trial was conducted in a research station in order to test the possibility to associate the production of this forage to maize, sorghum or millet in fields with different spatial arrangements for *Dolichos lablab* and cereal.

Chapter 6 aims to combine knowledge on village chickens and sheep production in order to understand their functions in the overall farming system. It outlines the economic aspects of village chickens and small ruminants at farm level. The chapter reports first on a case study in a village (Matté village) of the Central Region describing how village chicken and small ruminants act as a source of income at farm level. A formal survey was carried out with 30 households in the village. Secondly an analysis is addressing the question how the village chicken production system can be improved in relation to sheep fattening. The interrelation between feed resources for chickens and sheep is investigated. Also, farmers were asked how they attempted to improve village chicken production. From the survey and the actions of farmers, the possible improvement of village chicken production in relation to sheep fattening were extracted.

The results of the studies in the former chapters led to **Chapter 7** in which an Integrated Production System (IPS) was designed and studied. The integration consisted of village chicken production and ram fattening in one system. The aim of the study was to evaluate the viability of IPS through a feeding trial on village chicken meat production. For that, two strategies of village chicken feeding were tested in the integrated system. The supplements were commercial pullet feed and artisanal beer by-product. It was assumed that the sheep fattening subsystem would procure the scavenging feedstuffs for village chickens and that village chickens could thus be reared in full feeding control.

Finally, the major conclusions and recommendations of the thesis are summarised and discussed in the **General discussion**.

CHAPTER 1

Village chicken production systems

1.1. Village chicken production in developing countries
1.2. Comparative analysis of village chicken production system between two farming systems in Burkina Faso*
1.3. Research and development activities on village chickens in Burkina Faso so far**

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1.1. Village chicken production in developing countries

Villlage chicken production systems

Village chicken production plays an important socio-economical role for farmers in developing countries. They provide regular household income and are used for gifts, sacrifices and starting capital for young people (Guanaratne *et al.*, 1993; Guèye, 1998; Sonaiya *et al.*, 1999). For example in Burkina Faso, Ouédraogo and Zoundi (1999) indicated that about 5.84 billions of FCFA of income are earned by rural farmers by the provision of Ouagadougou town in village chickens. In developing countries, traditional poultry production development programmes were either lacking or limited in scope. As a result, village poultry production is not sufficiently understood in relation to existing farming systems (CNRST, 1995). Moreover, offtake (sale or consumption) from the system at farm level is low. Furthermore, there is no significant improvement of family poultry production system in general and indigenous chickens production system in particular. Aini (1999) claims that many studies have been done to improve the performance of village chickens, either by cross-breeding or improved feeding (e.g. Noraziah and Engku-Azahan, 1995; Engku-Azahan and Noraziah, 1996; Abd. Khalid, 1997), but the impact of these studies in practice has been minimal.

Many authors described the indigenious domestic fowl (gallus gallus) reared in the African rural areas and gave names to them in terms such of ‘African chicken’, ‘bush chicken’ or ‘runner chicken’ (Berte, 1987; Oluyemi, 1989; Sonaiya, 1990; Kounta, 1991; Guèye and Bessei, 1997). As indicated by Van Eekeren *et al*. (1995) and Guèye (1998), village chickens are not pure-bred animals as considerable crossbreeding took place. Village chickens seem to be well adapted to their environmental conditions such as hot or cold weather, rain and periodic feed shortages (Guèye, 1998).

Three types of village chicken production systems have been reported:

(1) The free range system

In the free-range system, birds find the main part of their daily ration by scavenging. There is little intervention in the life cycle of the birds (Sonaiya *et al*., 1999). The major intervention is in the area of feed and water supplementation, overnight housing and, to a much lesser degree, health care. Supplementation consist of giving household wastes or grains of cereals, generally in the morning or late in the afternoon according to the farmer’s ability (Chrysostome *et al*., 1995).

(2) The backyard system

In the backyard system (Sonaiya *et al.*, 1999), poultry are part-confined within a fenced yard or merely within an overnight shelter. Sometimes, the semi-intensive system is referred to as the backyard system (Kitalyi, 1999). Because the animals are confined they need to be fed and watered.

(3) The semi-intensive system

The semi-intensive system is generally observed in Asian countries. In this system, the chickens are fed with formulated diets either bought commercially or produced from feedmills (Aini, 1999). In this system, flock size varies between 50 and 500 birds on average (Sonaiya *et al*., 1999). Roberts (1999) suggested to use specialised birds in this type of system rather than indigenous animals.

The manual of poultry production in the tropics (IEMVT, 1987) gives an exhaustive description on traditional husbandry. It shows that in Africa, traditional poultry husbandry has the following characteristics:

- The birds range freely during the day, they are usually gathered at night into a basic shelter to avoid losses through predators;
- The feed is limited to what the birds can find by themselves (insects, seeds, kitchen wastes);
- Sometimes a supplement is given, but this supplement depends on the availability of the feedstuffs used in the household;
- Very poor productivity: the hens lay a low number of eggs per year, the growth rate of broilers is slow and the losses in the flocks are important;
- Eggs are rarely consumed. They are preferably hatched. Only the chickens are consumed and they are appreciated for their taste, their relatively dry meat being well adapted to the prolonged cooking practised in Africa (IEMVT, 1987).

Village chicken productivity

The productivity of village chickens production systems in general and the free range system in particular is known to be low (Gunaratne *et al*., 1993; Guèye, 1998). According to Aini (1999), poor reproductive performances, diseases and high feed costs are the main constraints. Under village conditions, the annual egg production per hen ranges from 20 to 100 eggs with an average egg weight ranging from about 30 to 50 g (Sonaiya *et al*., 1999; Aini, 1999; Guèye, 2000). In south-east Asia, village chickens reach a market weight of 1.0 - 1.5 kg at the age of 4 to 5 months (Aini, 1999). In Africa, the adult male and female weights range from 1.2 - 3.2 kg and from 0.7 - 2.1 kg, respectively (Guèye, 2000). Mortality is high and can reach up to 53% until four weeks of age (Guèye, 2000). In a study on village chicken characteristics in Guinea, Mourad *et al.* (1997) indicated that on average, the age at first laying was 180 days, egg weight was 30.7 g and hatching rate was 83% (Table 1.1.1).

Guèye (1998) indicated some advantages of village chicken production such as good eggs and meat flavour, hard egg shells, high dressing percentages and especially low cost with little special care required for production. Village chicken meat is well appreciated in the developing countries and has a premium price: two to threefold in Indonesia and a 10 to 20% increase in Sri Lanka over the price of product from an intensive farm (Roberts, 1999). High dressing yields (carcass weight divided by live weight) were observed for village chickens. Guèye (1998) has cited previous work (Joseph *et al*., 1992; Buldengen *et al*., 1992) which

Table 1.1.1. An example of productivity of local chickens (n = 166)

Parameter	Mean value (± SE)
Age at first laying (d)	180 ± 17
Number of egg/clutch	10.05 ± 0.15
Number of clutch/year	3.78 ± 0.07
Hatching rate (%)	83 ± 1
Egg weight(g)	30.74 ± 0.03
One-day chick weight (g)	22.82 ± 0.23
Fertility rate (%)	87.49
Chick viability rate (%) at one day of age	89.31

SE = standard error; Source: Mourad *et al.* (1997).

indicated carcass yields ranging from 54 to 79%. Chrysostome *et al.* (1995) reported that the local breeds have a reputation for hardiness and resistance to diseases. Because village fowl are maintained with very low levels of input (land, labour and capital), they can be kept by those in the poorest social strata of rural population (Guèye, 1998).

Targeted interventions carried out with the support of development partners, have been noted in many African countries for the improvement of village chicken production systems. In Burkina Faso (BF), such programs (Ouandaogo, 1997) were mainly based on disease control (especially Newcastle disease), the improvement of housing, as well as the genetic improvement of local chickens by crossing with exotic breeds. These programmes, however, were not that successful as village chicken production system remain essentially the free range system with small flock sizes, high mortality in the flocks and low offtake (Kitalyi, 1999; Okitoi *et al.*, 1999 in Asgedom (2000); Sonaiya *et al.*, 1999).

In conclusion, the extensive free range system is still the most representative production system of village chickens in developing countries and previous authors (Guèye, 1998; Sonaiya *et al.*, 1999) already showed that the productivity of such systems in terms of growth and egg production is very low. There is scope and need to improve such systems making village chicken production an important tool for poverty alleviation. This was already demonstrated in Bangladesh (Kazi, 1999), where with the technology package used in the programme, village poultry rearing generated varying amounts of income from $60 to $375 per annum per women.

Constraints in village chicken production

The New-agriculturist (1998) indicated that the management of village chickens is complicated because of the presence of multi-age individuals in the same group. High chicken losses have been attributed to poor feeding, no housing, and minor health control practices. With no preferential treatment of the small chicks, some starve to death because of high competition for the available scavenging feed resource.

Below some of the major constraints are reported in detail.

Low availability of adequate feed resources

Many scavenging feed resources are already described by numbers of authors (Gunaratne *et al.*, 1993; Dieng *et al.*, 1998; Sonaiya *et al.*, 1999). Among these resources, sorghum and local beer by-product are mentioned to be of great importance as poultry feed. The *Institut de l'Elevage et de Médécine Vétérinaire des Pays Tropicaux* (1987) estimated that the composition of sorghum is close to that of maize, but it is richer in cellulose and poor in fat. The feed resource base for scavenging is limited and varies with seasonal circumstances such as rainfall, cultivation, harvest and crop processing. If the supply of the scavenging feed resource is exceeded by the nutritional requirements of the animals, then the 'biomass' of the village flock is reduced accordingly. In addition, production will fall and some birds may die (Gunaratne *et al.*, 1993). Tadelle (1996) also indicated that crude protein, metabolisable energy and calcium intake from scavenging sources appear to have a seasonal nature. In the rainy season, there is an increase of sources of protein (worms, insects) for scavenging birds.

In general, farmers try to supplement the diet of village chicken by giving household wastes or grains of cereals (Chrysostome *et al.*, 1995). Mostly birds scavenge during the day for protein (insects, worms, larvae, etc.). This lead Sonaiya *et al.* (1999) citing Branckaert (1990), to the conclusion that the real need is to determine the nutrient content of the available feed resources and to provide appropriate nutrient sources to birds at the right time.

The study of Rashid *et al.* (2005) on chemical analysis of village chickens' crop contents during the two seasons (harvesting and non-harvesting) of the year in Bangladesh, showed that they contained 47.8% of dry matter (DM). The overall mean nutrient compositions in % of DM of the crop contents were 10.5% of crude protein, 2.1% of ether extract, 6.4% of crude fiber, 12.5% of crude ash, 68.7% of nitrogen-free-extract, 0.96% of calcium and 0.38% of phosphorus. The calculated metabolisable enery content was 11.49 MJ/kg DM. These values are somewhat below the requirement particularely for protein and for calcium for high growth or egg production when taking into consideration the recommended level for chicken diets. Chicken requirements (Daghir and Jones, 1995) for egg production are 15 to 16% of protein, 11.3 to 11.5 MJ/kg metabolisable energy; 3.2 to 3.4% calcium and 0.4 to 0.45% available phosphorus. For growth, requirements are 15% of protein, 11.3 MJ/kg metabolisable energy, 1% of calcium, 0.45 of available phosphorus. Tadelle and Ogle (2000) cited by Glatz and Ru (2004) found that the overall mean of the materials present in the crop as estimated by visual analysis, were seeds (30%), plant material (27.4%), worms (6.8%) and insects (11.2%). Furthermore there were unidentified materials (23.6%). Indigenous poultry mainly get their feed by scavenging, but Sonaiya *et al.* (1999) state that the scavenged feed is not concentrated enough in terms of energy because it does not contain sufficient quantity of starch, and it has a high crude fiber content. Protein may be critical during the dry season, whereas the energy supply may be critical during the rainy season (Tadelle, 1996). Futhermore, in the dry season, poultry can rapidly develop vitamin deficiency because of the scarcity of succulent vegetables on the range (Sonaiya *et al*., 1999).

Feed resource has an important impact on village chickens survival and production. Only few investigations have been done on the feed resource base for scavenging itself. Also the scavenging system as a tool for improvement of village chicken production has been scarcely studied.

Improvement of village chickens feeding should work well in a rural household, as the quantity of feed needed for supplementation in addition to scavenging is low (Kazi, 1999). Special attention should be given to seasonal demands for protein and energy sources. Ramlah (1996) cited various authors (Ramlah and Kassim, 1992; Yeong, 1992) and indicated that the total feed intake of a village fowl during the growing period of 16 weeks was about 6 kg (53 g/bird/day) with feed conversion ratio of 4.6. The daily feed intake of village fowl for adult male and female ranged from 85.7 to 93.8 g/bird/day. In developing countries, low cost production will continue to predominate (Williams, 1997) therefore supplementation of scavenging birds should be feasable for improvement of village chicken production.

Mortality due to diseases

One of the major constraints of village fowl production in Africa is undoubtedly the prevalence of various diseases (Guèye, 1998). According to Chrysostome *et al.* (1995), the local breeds have a reputation for hardiness and for resistance to diseases. However, the review of Guèye (1998) and the study of Mourad *et al*. (1997) revealed high mortality in rural flocks, ranging from 50% to 80%. Many studies indicate that Newcastle Disease (NCD) is the main cause of this mortality (Guèye, 1998; Chrysostome *et al*., 1995; Sonaiya *et al*., 1999). The wild birds are a reservoir of NCD-virus (Guèye, 1998). Other diseases that affect village chickens to a lesser extent (3% to 14%) are fowl pox, *pullorum diarrhoea*, and fowl cholera coccidiosis (Atteh, 1989; Bonfoh, 1997; Mourad *et al*., 1997). In the study of Mourad *et al*. (1997) the most important cause of mortality for adult chickens was Newcastle disease. For chicks and pullets, the most important one was the *pullorum diarrhoea* (Table 1.1.2). In addition to the diseases mentioned there is a high degree of internal and external parasitism. Also, aerial and terrestrial predators contribute to mortality (Chrysostome *et al*., 1995; Sonaiya *et al*., 1999).

Appropriate measures against chicken diseases such as NCD have been suggested by several authors (Card, 1961; IEMVT, 1987; Alders *et al.*, 1994; Nguyen *et al.*, 1996). In West Africa, June and December are the most strategic months to vaccinate chickens. These months were chosen to ensure that immunity is established before the outbreaks are most likely to occur (Alders *et al*., 1994). Losses caused by NCD are highest in the cold dry season in West Africa (Sonaiya *et al*., 1999). According to Guèye (1998) in Senegal, outbreaks of Newcastle disease occur generaly during the dry season, from January to June. Mourad *et al.* (1997) show in their study in Guinea, that NCD outbreaks were observed at the beginning of the raining seasons (May and June) and at the cold dry season (December, January and February). Alders *et al.* (1994) stated that the introduction of an effective vaccination against NCD should be the first step in assisting village poultry production.

Low genetic potential

In the past, livestock development efforts were focussed on rapid genetic improvement. It was argued that improvements in feeding will be ineffective when animals with low genetic potential are raised. In the case of village chickens, Van Eekeren *et al*. (1995) indicated that in various countries, cock exchange programmes have been successfully carried out. They suggest that the production of local chickens can be improved by replacing the local cocks with cocks of more productive breeds and to slaughter the non-productive animals.

Investigations on village chickens describe the level of performance under village husbandry conditions and they also attempt to establish the potential of indigenous birds to perform under optimal conditions of confinement (Tadelle *et al.*, 2000). The level of performance in optimal conditions are generally low compared to those of an improved breed. Table 1.1.3 summarises some performances of village chickens compared to those of the

Table 1.1.2. Mortality causes of local chickens (in %)

Causes of mortality	Adult chickens n = 892	Chicks and pullets n = 897
Newcastle disease	54.70	25.31
Pullorum diarrhoea	26.91	35.34
Chicken pox	10.99	18.17
Bad management and other	7.40	21.18

n = number of death chickens; Source: Mourad *et al*. (1997).

Table 1.1.3. Performance of village chickens in comparison to some exotic chickens

Performance Strain of Chicken	Egg production (eggs/hen/year)	Egg weight (g)	Mature weight of the male (g)	Mature weight of the female (g)	Consulted references
Village chicken in Africa	20-112	34.4-50	1.2-3.2	0.7-2.1	Guèye (2000); Farrell *et al.* (1999); Paterson *et al.* (2000);
Village chicken in South Pacific Region	50-90	-	1.5-2.5	1-1.5	Ajuyah (1999); avitats.com (2004); Kintaline Farm (2004);
White leghorn	167	58-70	1.7	1.4	Brannang and Pearson (1990)
Rhode Island Red	150-200	66-71	3-4	2.5-3	cited by Tadelle *et al.* (2000); Wilson *et al.* (1987).

Table 1.1.4. Different ecotypes of village chicken in Africa

Ecotype	Characteristics	Base of classification	Localisation	Consulted references
Kei	Red	Plumage	Ethiopia	Guèye (1998); Tekerel (1986) and Abebe (1992) cited by Tadelle *et al.* (2000)
Tikur	Black	Plumage	Ethiopia	
Kokima	Reddish brown	Plumage	Ethiopia	
Gebsima	Greyish mixture	Plumage	Ethiopia	
Netch	White	Plumage	Ethiopia	
Naked neck	Naked neck	Plumage	Ethiopia	
Fayoumi	Big size	Selected chicken	Egypt	
Konde chicken	Big size	Size	Burkina Faso	

exotic breed. Egg production performances of exotic breed are about twice those of village chickens. However, what should also be taken into consideration is that many improved breeds are bred towards only one production objective. The white leghorn is optimised to lay eggs, not to take care of small chicks or to scavenge adequately or to grow fast. Such a single purpose breed does not fit in local circumstances of free ranging chicken in West African villages.

In Table 1.1.4 different local ecotypes of village chicken are presented as identified by various authors (Guèye, 1998; Tekerel, 1986 and Abebe, 1992 cited by Tadelle *et al*., 2000). These ecotypes are different mainly by the colour of their plumage. That can be red, black, white or mixed colour. An other distinction can be made by the size of the chicken. As the production is constrained by many factors (feeding, diseases, management) the parameters of village chicken presented in this table are probably below village chickens genetic potential.

Harsh environmental and housing conditions

Village chicken production depend on environmental conditions. A high mortality of village chickens is observed due to unfavourable environmental conditions in relation with housing, diseases and predators. Many authors (Guèye, 1998; Sonaiya *et al*., 1999; Kitalyi, 1999) reported on housing conditions for village chickens: (1) Birds may perch on high places or shelter in human houses or kitchens; (2) Some traditional housing systems have a saddle roof; the housing may be a round thatched hut, box or basket. These traditional poultry housing structures are small and have poor hygienic conditions. Often there is high infestation with external parasites (Kitalyi, 1999). In Mali fowl houses were mostly small and constructed from sundried clay (Kuit *et al*., 1986). Nevertheless, some authors report on improved houses for village chicken rearing (Saunders, 1984; INRA and SEDES, 1976). One of the improved housing system for village chickens was developed in Burkina Faso (Saunders, 1984). The house is a round compartment of three metres of diameter with two or more windows. In Zimbabwe, a run is attached to the poultry house and the term fowl-run in local poultry is commonly used (Kitalyi, 1999).

Low investment possibilities due to poor socio-economical conditions

Family poultry is usually the responsibility of women. In the rural areas of sub-Saharan Africa, more than 70% of the chicken owners are women (Guèye, 1998b cited by Sonaiya *et al*., 1999). Because village fowl are maintained with very low levels of input (land, labour and capital), they can be kept by those in the poorest social strata of rural populations (Guèye, 1998). Many authors (Gunaratne *et al*., 1993; Panda and Mohapatra, 1993; Guèye, 1998; Sonaiya *et al*., 1999) already indicated that family poultry in general and village chickens in particular represent a significant part of the rural and national economies. They play a significant role in the cultural life of rural people as gifts, starting capital to young, and as sacrifices. Improvement in village chicken production will need investements which will be hard to find in the poorest poultry owners.

Conclusion

The main village chicken production system is the free range system based on scavenging. Many feed resources are available through scavenging and they have been described by a number of authors (Gunaratne *et al.*, 1993; Dieng *et al.*, 1998; Sonaiya *et al.*, 1999). However, the availability of these resources is seasonal. Protein may be critically low in the dry season and the energy content may be critical during the rainy season (Tadelle, 1996). The feeds that village chickens ingest when they feed themselves even with the occasionally given household wastes will give them a high chance on nutritional deficiencies. This results in a low productivity and reduced resistance to diseases. The factors mentionned above are major reasons for the small size of village chicken flocks. This means that there is a limited capacity to maintain or increase a certain flock size because of feeding constraints. This is confirmed by Okitoi (1999) cited by Asgedom (2000), stating that the main reason which limits increase in flock sizes in rural household is the limited scavengeable resource base. To improve productivity of village poultry, an integrated approach is needed and one of the major components is controlled nutritional conditions. There is no doubt that a system which integrates housing, health care and feeding may lead to improvement of village chicken productivity. Integrated approaches can provide interesting returns on investments while effects of isolated investements may be negligible due to the others constraints.

1.2. Comparative analysis of village chicken production systems between two farming systems in Burkina Faso

Abstract
This study aims to describe and compare the village chicken production system in two farming systems in Burkina Faso. These are the crop/livestock and the livestock farming systems. The crop/livestock farming system is mainly found with the Mossi farmers while the livestock farming system is characteristic for Fulani farmers. A rapid rural appraisal preceded a monitoring study in which data were collected fortnightly for two months. The study revealed that village chickens are used for sacrifices, gifts, as objects of exchange for traditional medicine or sold for a little money under both systems. The chicken production system is free-range in both farming systems, but there are differences in management. On average, the flock size was 33.5 ± 3 birds, of which 57% were young chicks. During the period of two months in the rainy season, the overall mortality was relatively low (8.8% ± 1.5), but mortality in chicks was high (31.7%). The main cause of loss in village chickens was mortality that represents up to 84% of the total exits. The hatching rate and mortality in young chicks differed significantly ($P < 0.05$) between the two farming systems. Hatching rate was 70% and young chick mortality was 24.2% in the crop/livestock system. In the livestock system they were respectively 46 and 52.3%. These results suggest that under certain circumstances village chicken production parameters can be improved.

Keywords: Burkina Faso, free-range, monitoring, production system, village chickens.

Introduction

In developing countries, such as Burkina Faso, West Africa, village chickens are kept and maintained with very low levels of inputs (land, labour and capital). There are kept by people in the poorest social strata of rural populations (Guèye, 1998). Many authors have shown that family poultry in general and village chickens in particular, represent a significant part of the rural and of the national economy. They also play a significant role in the cultural life of rural people as gifts, starting capital for young people and sacrifices (Gunaratne *et al.*, 1993; Panda and Mohapatra, 1993; Guèye, 1998; Sonaiya *et al.*, 1999).

Despite these facts, village chicken production has been neglected in the research and development policies of many developing countries including Burkina Faso. Consequently, productivity, as expressed in flock size, growth and egg production is low. High mortality rates are registered in village chicken flock. To address this situation the strategic plan for research in Burkina Faso (CNRST, 1995) recommended that studies be undertaken in order to improve village chicken productivity. The current study was conducted in response to this recommendation. It aimed to contribute to a better understanding of dominant village chicken production systems in the Central Region of Burkina Faso.

Materials and methods

Study site

As mentioned in the General Introduction, in Burkina Faso, most chickens are found in the Central Region (MED & MRA, 2004). In this Region, the national agricultural research Institution (INERA) has identified some villages for research, which are supposed to be representative of the whole region. A technology appropriate in one of them is considered to be feasible in the whole region. The village of Yambassé in the Central Region of Burkina Faso was selected as the site of our research. The criteria of the choice consisted of the facilities to conduct the study: acceptability of the study by the local farmers, importance of village chickens in the village and presence of both crop/livestock and livestock farming systems. According to a census in 1996 (INSD, 2000a) the village had about 1,500 inhabitants. Both crop/livestock and livestock farming systems are practiced in the village. In the crop/livestock system (Lauro, 1998) animals provide manure and draught power for cultivation. Animals and crops form part of the same production unit. In the case of the study site most of the animals are small ruminants and poultry. In the livestock system, the main activity is livestock production. Gorse (1985) indicates that farmers in this system tend herds of different species, sex and age composition and occupy environmental niches that meet the need of their herd. Crop production is a secondary activity with little attention in this system. Households may cultivate crops as sorghum, millet or maize. Cattle breeding play a key role in this system with milk as the basic diet for home consumption.

Data collection procedure

A Rapid Rural Appraisal (RRA), as described by IISD (International Institute for Sustainable Development, 1995), on village chicken production was carried out in the village of Yambassé by a multidisciplinary team over three successive days. Two zootechnicians, an agro-economist, a veterinarian, a sociologist and two technicians constituted the team. Aspects about the activities, the role of family members, the type of village chickens and the relationships of the chicken production system with other production systems within each farming system were qualitatively investigated. With respect to the principle of the RRA, the following tools were used:

- the literature review consisted of reviewing all documents available on village chickens in Burkina Faso and on the village of Yambassé in particular;
- the semi-structured interview, which is the main tool of the RRA. It was used as a tool and a component of other tools. Questions were formulated during the interviews and a checklist was used to be sure that relevant topics were addressed;
- the calendar which allows to make a description of the change of an activity over time,
- the preferential classification which consist of asking the interviewed to give his preference, need or opinion on different alternatives;
- the revealing citations: citations given by interviewers about the topic are registered during the discussions.

The group that was interviewed in each farming system comprised women and men, including adults and teenagers. The questions asked during these group meetings dealt with:

- the different activities in the village;
- the method of livestock production (husbandry, feeding, health care, the socio-economical use of livestock);
- the objectives of production;
- the preferential classification of livestock species;
- the relationships between chicken production and the other production systems;
- the methods of chickens production (husbandry, feeding, health care, housing);
- the different strains or varieties of chickens in the village;
- the role of each family member in the chicken production;
- the important calendar and the constraints in village chicken production.

After analysing the qualitative data from the RRA, a conceptual model (Figure 1.2.1.) of the village chicken production system in the rural area was designed and used as the basis for a monitoring study during two months from 20 July to 15 September 1999. The conceptual model has three groups of components. A group of components inside the boundary of the system composed of the household (which manages the production), the chickens (the producer) and the products that are produced and used within the farm household. The second group of components are the inputs, which are the factors of production, which enter in the system. These consist of feeds, housing capital, drugs or chicken received as gifts. These components are placed at the left hand side of the figure and left of the system boundary. The third group is constituted by the components of outputs leaving the system. These outputs may be the losses (placed at the bottom of the figure under the system boundary) or the exits for multiple purposes (sale, gift, exchange, fertilisation) placed in the right side of the figure, right of the system boundary. Monitoring was conducted in the two farming systems. It was related to the main components of the chicken production system in the village. It included flock size, flock mortality, sales, purchases, gifts, egg production, hatching, loss due to predators, and loss due to bad weather and miscellaneous parameters.

The monitoring reached at least 10% of the households (random choice) in each system in the village. A number of 8 on 73 households in the livestock system and 22 on 152 households in the crop/livestock farming system were investigated.

Statistical parameters and analyses

Flock size was calculated as the mean of the flock sizes observed during the five counts done in a period of two months time. Flock size = 1/5 × (flock size on day 1 + flock size on day 15 + flock size on day 30 + flock size on day 45 + flock size on day 60).

Percentage mortality (MR) was calculated according to the model suggested by Faye and Perechon cited by Mourad *et al*. (1997), where MR = ND/AF × 100; ND = the total number of dead or missing chickens during the observation period, being the sum of deaths due to disease and losses due to predators, bad weather or unknown causes; AF = average flock size = 1/2 × (flock size on day 1 + flock size on day 60).

Difference between components of the two farming systems was studied by ANOVA. The statistical model was $y_{ij} = u + a_i + e_{ij}$ where y_{ij} is the production parameter involved (mean number of flock, eggs per clutch, hatched eggs per clutch, hatching rate, percentage mortality, or losses); u is the overall mean of the analysed parameter; a_i is the effect of the respective farming system; and e_{ij} is the error term with $E(e_{ij}) = 0$. The significant level was 0.05.

Results

Results of the RRA study

Activities of farmers in village chicken production

The scheme on Figure 1.2.2. summarises the major activities in village chicken production in the crop/livestock and livestock farming systems. Similar actions are observed but some differences relative to housing, socio-economic use, and roles of family members are noted. In the crop/livestock farming system (CLFS) houses are build in clay because they are meant for long-term use. In the livestock farming system (LFS) houses are build in straw and can be used only for short period of time. Men are the main owners of village chickens in the CLFS whereas in the LFS it is the women. Furthermore the socio-cultural use of village chickens has greater importance in the CLFS than in the LFS. Finally chicken manure is more important to CLFS than to LFS.

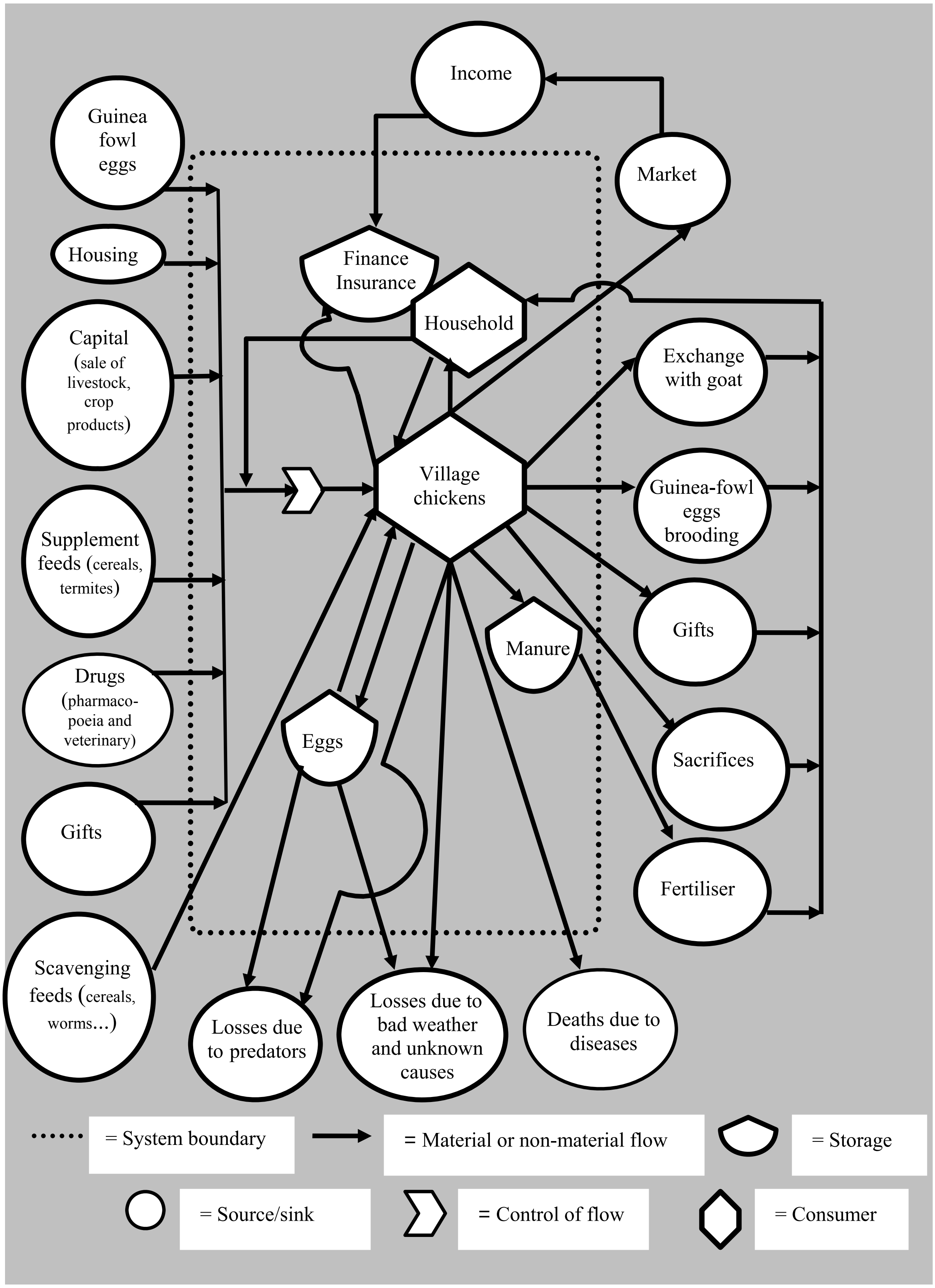

Figure 1.2.1. Conceptual model of village chicken production system in Yambassé

Role of household members in village chickens production system

Labour in village chicken husbandry is exclusively provided by the family. Any household member can own village chickens but the following differences in the activities related to village chicken rearing were observed between the two farming systems (Table 1.2.1).

In the crop/livestock system there was no distribution of tasks in chicken production by sex or age. Each member of the household (children, women, men and teenagers) can do any task such as providing supplementary feed or water and surveillance. The most active in these tasks were the young children and women. Women supply the chickens with household waste and water. Teenagers or children look for termites to supplement the chicks' diet and ensure that chickens are confined to an enclosure in the evening. The farmers referred to the actions of women, teenagers and youths by citing the following proverb: "If the left hand holds a spear, it helps the right hand". The men tended to sell most chickens in this system. The women, children or adolescents can sell their chickens for their own needs, but have to inform their household head. The household chief can sell or use for any other purpose (e.g. as a gift or for sacrifice) chickens belonging to any member of his household, merely needing to inform the owner.

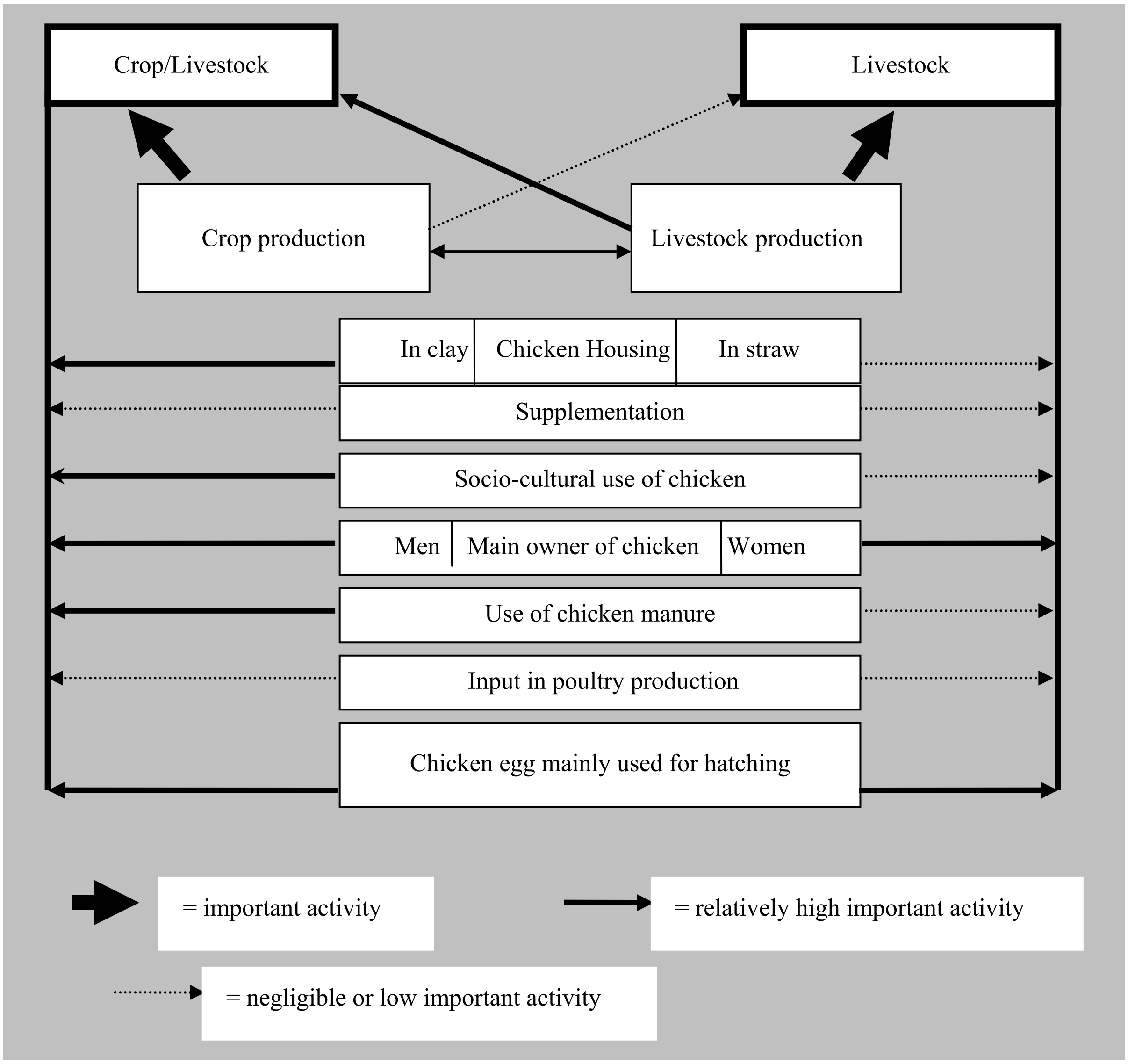

Figure 1.2.2. Major activities in village chicken production in the two farming systems

Table 1.2.1. Role of household members in village chicken rearing according to the faming system

	Farming system							
	Crop/livestock				Livestock			
	Family member looking for				Family member looking for			
Type of activity	Men	Women	Teen-agers	Children	Men	Women	Teen-agers	Children
Providing water	*	**	*	*		**		
Providing household waste	-	**	-	-	-	**	-	-
Providing supplemental feed	**	*	*	*	-	-	-	-
Providing termites	**	-	*	**	-	-	-	-
Surveillance	*	-	*	**	-	**	-	-
Chicken selling	**	-	**	-	*	**	-	-
Housing chickens	*	-	*	**	-	*	-	*
Chicken owning	**	-	*	*	*	**	*	*

** = great involvement in the activity; * = lower involvement in the activity;
- = non involvement in the activity.

In the livestock farming system, women were the main partakers in village chicken husbandry, men being concerned with cattle keeping. The women provided the supplementation, surveillance, and also sold the birds in the market. They were generally the main owners of village chickens in the household.

Types of village chickens

In the case of Yambassé village, local names are used to differentiate the types of chickens. Four different types of village chickens could be distinguished, all of which have multiple coloured feathers:

- The Noa-kuiguiga. This medium-size bird was the main type of chicken in the village. Every farmer kept some of them.
- The Noa-kondé. According to the farmers, this kind of chicken has resulted from crossing local and imported chickens a long time ago. It has a relatively large size and was kept mainly in the livestock farming system.
- The Noa-rigré. This dwarf chicken is characterised by short legs. According to the farmers, it does not lay within the household compound. It will lay eggs at a long distance from the farm. Therefore, it can be a source of conflict among neighbouring farmers.
- The Noa-ibrongo. This chicken is featherless on the neck. It grows fast, but is owned by only a few farmers because it was just introduced in the village a few years ago.

Farmers in the village prefer the Noa-kuiguiga variety for its high prolificacy and adaptation to the environmental conditions while the Noa-kondé is valued for its higher market value and the Noa-ibrongo for its rapid growth. The Noa-rigré is not widely kept because farmers believe that it is a potential source of misfortune.

Relationship between village chickens and other production systems

An exchange system between village chickens and goats has existed in the village for a long time at an exchange rate of seven chickens for one goat according to farmers of the village.

Cattle owners sell village chickens to pay for health care or to purchase industrial by-products such as cattle feed. In general, farmers prefer to sell chickens rather than ruminants when they need a small amount of money. Conversely, the sale of ruminants (cattle, sheep or goats) allows the purchase of village chickens from other farmers to increase flock size or to reconstitute a flock, which has been decimated by disease. In the crop/livestock production system, chickens were slaughtered to nourish hired labour or to be used as payment for labour instead of money. Village chickens may also be sold to buy tools for crop production or to repair ploughs. Conversely, crop products may be sold to enable the purchase of chickens from other farmers.

The village chicken and guinea fowl production systems were considered to be complementary as chickens are used to hatch guinea fowl eggs. Ducks in combination with hens have both negative and positive characteristics. Negative, because ducks are potential predators of chicks. Positive, because they can be used for hatching hens' eggs, which allows the hens to return faster to laying eggs again.

Labour in village chicken production can be provided by one family member (man, woman or children) and needs only a short time investment per day, so that competition with other productions system is low. For other resources as feeds, water, space for housing, village chickens use in general those left by the other components of the farming systems.

Production objectives of village chickens at farm level

The different roles of village chickens are presented on Table 1.2.2. Village chickens are raised for several purposes. Any sacrificial ceremony begins with village chickens, even when the main object of the sacrifice is another animal such as a sheep, goat or ox. Chickens are also used to honour hosts, friends or as a gift to the family of a spouse. Chickens are used as objects of exchange for traditional medicine and are indispensable in funeral ceremonies. Farmers also consider chickens as a source of funds for small expenses such as for clothes or modern medicines, so they are frequently sold. Hence, chickens were found in all households' compounds.

It appeared that the sociological and cultural role of village chickens was more important in the crop/livestock farming system than in the livestock farming system. This is due to the fact that almost all households in the livestock farming system are Muslim, whereas many households in the crop/livestock farming system practise traditional religion including sacrifices. Village chickens were regarded by the farmers in the crop/livestock system as the foundation for wealth. According to them, engaging in livestock husbandry starts with owning

Table 1.2.2. Importance of the production objective of village chicken according to the farming system

Production objectives	Farming system	
	Crop/livestock	Livestock
Sale	**	**
Small expenses source	**	*
Sacrifices (religious, funeral)	**	-
Gifts	**	**
Exchange with traditional medicine	**	-
Foundation of wealth	**	-

** = Important objective of production; * = Lower important objective of production;
- = not an objective of production.

chickens. After keeping chickens, one can move on to the husbandry of small ruminants before expecting to undertake cattle husbandry, the ultimate sign of wealth and prestige.

Nutrition of village chickens at farm level

For the farmers, village chickens find most of their food by scavenging. Nevertheless, they may sometimes give supplements to chickens depending on the availability of feedstuffs in their households. Supplementation was mainly provided for younger chicks. However, supplementation may be used as a means to ensure that there is no loss in the flocks. It may also be used to lead chickens into their night enclosure or to catch them in the day. The most available feedstuffs for supplementation throughout the year were, in decreasing order, household waste, millet, termites, red sorghum and maize.

The village chickens were not provided with feed troughs, supplementation is provided on clean ground. In the dry season, water was provided in various kinds of containers, such as a dish, tin canary, or a specially made clay container. In the rainy season, the chickens drank anywhere from puddles.

Health care and mortality of village chickens at farm level

Preventive care was rare although in exceptional cases, farmers vaccinated against Newcastle disease. In general, farmers treat their birds mainly with substances from local trees such as the bark of *Kaya senegalensis* (Caïcédrat) or *Vittelaria paradoxa* (shea butter tree) in the cases of diarrhoea. For Newcastle Disease, they use pepper in the drinking water. The farmers were aware that these substances are not very efficient as high mortalities occurred despite these practices. Predators (cats, snakes, sparrow hawks,...) are other causes of mortality in village chickens due to the poor housing or the location of the households in the bush.

Housing of village chickens at farm level

In the crop/livestock farming system, the chickens were housed at night in a hut of clay covered by a roof of straw. In this system, young chicks were generally raised in a large hut, which had been abandoned by people. Some of the huts had a perch and sometimes laying boxes were available. Cleaning the houses may occur once each year in this system.

In the livestock farming system, the housing for the night was always built with straw and was very small. Laying hens and their chicks were housed whereas the other birds had to spend the night in trees in an attempt to avoid predators. Cleaning was not done, but the farmers changed the place of the huts after about two years or when excessive numbers of external parasites were observed in the housing. Sometimes, trees or branches were used as shelters for village chickens in this farming system.

For the two farming systems, hens may lay in other houses than chicken housing. A laying nest is always made for laying hens. After hatching, the hen and its chicks are isolated and will be reared in a shelter in which chicks are protected from predators and receive termites and broken cereals.

Products of village chickens

In the crop/livestock farming system, when the quantity of chicken manure increased in the houses, manure was collected and spread on the maize fields or placed in manure pits for making compost. In the livestock farming system, manure was not exploited. The chickens in this system were mainly kept for sale by women.

In both farming systems, the eggs were mainly used for hatching, only eggs that had not hatched being given to children for consumption. Eggs were never sold in the market.

Inputs in the system were negligible as they were small and very irregular and the chickens found the most important one, feed, themselves by scavenging.

Important timetable for village chicken production system

A high mortality was reported to occur in the dry season between December to May. Mortality was said to be lower in the rainy season (from June to November).

Higher prices were obtained for village chickens from December to May, months, which include Christmas, traditional and sometimes Muslim feasts.

Results of the monitoring study

Flock composition of village chickens

The flock size of village chickens did not differ significantly ($P \geq 0.05$) between the two farming systems (Table 1.2.3). Mean flock size was 33.5 ± 3 chickens all categories confounding. Young chicks represented 60% of the flocks. The sex ratio (cocks/hens) was 0.29. The proportions of cockerels and pullets in the flock are more and less the same.

Egg production and hatching rate

The mean number of eggs per clutch was 11.8 ± 0.2 with no significant difference ($P \geq 0.05$) between the two farming systems. However, there is a significant difference ($P < 0.05$) in the hatching rate between the two farming systems (Table 1.2.4). Low hatching rate (46% versus 70%) is observed with the livestock farming system.

Table 1.2.3. Mean numbers (head) of birds per flock of village chickens according to the farming system

Composition of flock	Farming system			
	Crop/livestock n = 22	Livestock n = 8	Overall* n = 30	SEM
Hens (>5 months)	5.1	6.6	5.5	0.5
Cocks (>5 months)	1.7	1.5	1.6	0.3
Cockerels (2-5 months)	3.0	2.7	2.9	0.5
Pullets (2-5 months)	3.4	3.8	3.5	0.4
Chicks (0-8 weeks)	21.1	16.7	20.0	2.2
All ages	34.3	31.3	33.5	3

n = number of households; * = weighted average; SEM = standard error of the mean.

Table 1.2.4. Number of laying hens (head) per household during two months, hatching rate (%), number of eggs per clutch and number of hatched eggs per clutch of village chickens

Component	Farming system			
	Crop/livestock n = 22	Livestock n = 8	Overall* n = 30	SEM
Laying hens	1.9	2.0	1.9	0.8
Eggs/clutch	11.7	12.2	11.8	0.2
Hatched eggs/clutch	8.2	5.6	7.6	0.6
Hatching rate	70^{a}	46^{b}	64	4

Mean values in the same row with different superscripts are significantly different at $P < 0.05$

Note: n = number of households; * weighted mean; SEM = standard error of the mean.

Table 1.2.5. Mortality (%) in village chickens (means per household)

	Farming systems			
Category	Crop/livestock n = 22	Livestock n = 8	Overall n = 30	SEM
Hens	5.1[a]	1.9[b]	4.2	1.6
Cocks	6.5[a]	13.3[b]	7.8	2.7
Cockerels	10.6[a]	6.6[a]	9.5	2.3
Pullets	7.3[a]	6.3[a]	7.0	2.2
Chicks	24.2[a]	52.3[b]	31.7	8.6
Overall	8.7	8.9	8.8	1.5

Mean values in the same row with different superscripts are significantly different at $P < 0.05$
n = number of households, SEM = standard error of the mean.

Table 1.2.6. Causes of losses of village chickens from the flocks per household

	Farming system			
Cause of loss	Crop/livestock n= 22	Livestock n = 8	Overall n = 30	SEM
Sale	1.4	1.6	1.4	0.6
Gifts	0.7	0.6	0.7	0.4
Sacrifice	0.2	0.0	0.2	0.1
Predators	0.7	2.6	1.1	0.5
Bad weather and miscellaneous causes	1.3	0.3	0.8	0.5
Disease	10.2	7.5	9.5	2.3
Overall	14.5	12.6	13.7	2.6

n = number of households, SEM = standard error of the mean.

Mortality of village chickens during the rainy season

Mortality rates in both farming systems during the two months are summarised in Table 1.2.5. Mortality was due to diseases, predators, bad weather and miscellaneous causes. There was no significant difference ($P \geq 0.05$) in mortality between the two farming systems, although distribution of mortality over age and sex groups differed between the systems. In crop/livestock system, high percentage of mortality of hens was observed while in the livestock system higher mortality of cocks was noted.

A high mortality rate was observed for the chicks in both farming systems, particularly in the livestock farming system. In term of percentage (expressed as the number of death due to a certain cause over the total number of death) overall 83% of the mortality was due to disease, 10% to predators and 7% to bad weather or unknown causes.

Flock movements

Purchases of village chickens were negligible during the two-month period of the study in the village; only 1 or 2 chickens were being purchased per household. Table 1.2.6 presents the number of birds, which left the village flocks during these months. No significant difference was observed between the two farming systems for these exits. On the different kinds of losses, mortality due to disease was the most common in both farming systems, while losses caused by predators were only common under the livestock farming system.

No household consumption was recorded during the observation period. Use of village chickens in sacrifice ceremonies was exclusively found in the crop/livestock farming system because traditional religion is practised in this farming system.

Discussion

The current study indicates that village chickens play an important role in rural households because they are used as a source of income, as gifts, and as elements in various ceremonies. There is a difference in the socio-cultural use of village chickens between the crop/livestock and the livestock farming systems. Village chickens appear to be a starting point for livestock production in the crop/livestock farming system as they are exchangeable for goats. Men are actively involved in village chicken production in this farming system whereas, in the livestock farming system, women play the major role in chicken production. In the livestock farming system, the men are mainly interested in ruminant production particularly cattle breeding according to farmers.

The socio-cultural roles of village chickens are similar to those indicated by previous authors (Gunaratne *et al.*, 1993; Panda and Mohapatra, 1993; Guèye, 1998; Sonaiya *et al.*, 1999) in many developing countries.

Only low inputs are provided for village chickens as the birds got most of their daily diet from scavenging. They are poorly housed: In many cases, chickens do not have a house or are housed under shelters made with straw in the livestock farming system. When houses are built (case of crop/livestock production system) they are rarely cleaned and are small. Housing is only used for enclosure during the night. This kind of production is similar to the free-range system described by IEMVT (1987), Sonaiya (1995), Guèye (1998) and Okitoi *et al.* (1999) in Asgedom (2000). Sonaiya (1995) described the free-range or traditional system as one in which the birds are free to roam around the homestead. Such a free-range production system is the common situation in the village Yambassé but some differences in the management and the exploitation of the flocks could be observed between the two farming systems. In the crop/livestock system, chicken housing is generally in clay whereas in the livestock system, it is in straw. Crop/livestock systems use chicken manure in their crop fields.

The four types of village chickens found in the flocks (Noa-kondé, Noa-kuiguiga, Noa-rigré, and Noa-ibrongo) are not specific breeds. Farmers practice no selection. This is in agreement with the reports of IEMVT (1987) and Guèye (1998). These studies indicate that the local stock in Africa is the result of disorderly crossings of local and exotic strains. There is no systematic breeding system so the concept of breeds is not applicable.

In the rainy season, the mean flock size consisted of 20 ± 2.2 chicks, 3.5 ± 0.4 pullets, 2.9 ± 0.5 cockerels, 1.6 ± 0.3 cocks and 5.5 ± 0.5 hens. These results are consistent with those of Gunaratne *et al.* (1993) who indicated an average flock size of 2.3 cockerels, 1.4 cocks and 4 hens for village chickens in Sri Lanka. Mean flock size (33.5 ± 3) is higher than that indicated by Sonaiya (1995) who reports flock sizes in a free range system between 5 - 10 birds in Nigeria, but it is within the range (10 - 50) indicated by Aini (1999) in South East Asia. As our study covered 2 months (September - October) of the end of the rainy season, flock size may be higher than average annual village chicken flock size. In their study in Mali, Kuit *et al.* (1986) showed that loss of fowls were particularly high in the cold dry season which may induce seasonal fluctuations in production. There is no significant difference ($P > 0.05$) in numbers of birds per flock between the two farming systems and it appears that, excluding chicks, the flock size is very small at 13.5 birds per household.

The sex ratio of 29% is concordant to 28% found by Kuit *et al.* (1986) in Mali, lower than the 38% indicated by Mourad *et al.* (1997) but higher than the value of 10% indicated by IEMVT-CIRAD (1989) as cited by the same author. It appears that there is great variability in this ratio in village chicken production systems.

The differences in hatching rate observed in our study (70% and 46%) are probably related to the housing conditions. In the crop/livestock farming system, the chicken houses provide more protection against the infiltration of rainwater than those used in the livestock farming system. The mean hatching rate (64%) found in this study is in the ranges as indicated by Mourad *et al.* (1997) from 42 to 100%, Guèye (1998) for tropical regions with 60 - 90% and Wilson *et al.* (1987) in Mali with 69.1%.

The number of eggs per clutch observed in our study (11.8 ± 0.2) is comparable to the range of 12 to 18 indicated by Guèye (1998), but it is higher than that of 10 eggs per clutch indicated by Mourad *et al.* (1997) in Guinea, and 9.4 eggs per clutch in Mali (Kuit *et al.*, 1986).

Our study shows a mean of 8.8% ± 1.5 of mortality over the period of two months in the rainy season and no significant difference ($P \geq 0.05$) between the two farming systems. This result is lower than the annual mortality rates indicated by many authors, which range from 50 to 80% (Guèye, 1998; Mourad *et al.*, 1997). The period of observation, which is the rainy season, could be a period of low mortality of village chickens in the region. This assertion is in agreement with Sonaiya *et al.* (1999) and Kuit *et al.* (1986) who indicate that the losses from Newcastle disease are highest in the cold dry season in West Africa.

The high mortality for young chicks (31.7% as a mean during the rainy season) in this study is probably due to bad weather and the inadequate housing. The mortality of 52.3% ± 29.3 in the young chicks in the livestock farming system is even higher. In that system, housing is both too small and of poor quality, being constructed of straw, so that the chickens are exposed to predators and bad weather. Kuit *et al.* (1986) in Mali also found that 66% of pastoral households did not house their chickens at all while 71% of crop/livestock systems provided housing for the night.

Eighty three percent of the mortality is due to disease, so this was the main cause of losses in the village chicken flocks. It especially emphasises the inefficiency of the current village chickens production system and indicates that priority actions should aim at reducing these losses.

Conclusion

The study showed that village chickens are seen as starting point for livestock production in CLFS, while livestock is seen as sign of wealth. This confirms the potential importance of poultry in poverty alleviation. In LFS, poultry was especially important for women. Integration of poultry in CLFS was assured by their value as ‘pocket money’ to buy equipments and inputs and by their manure to fertilise the fields. Both are means to lift household livelihood and food security.

The current study shows that village chicken production system remains essentially the free-range system at farm level in Burkina Faso. This system is characterised by poor housing, feeding and management conditions. As a consequence of low productivity, low hatchability and high percentage (83%) of mortality due to disease, the flock size is low with only 14 adult chickens and grower chickens per flock. The mentioned constraints, the low productivity, and the difference between the two systems at the level of housing & hatchability & mortality, indicate that there is scope for improvement of the system. One aspect may be appropriate housing in the rainy season. Some previous research and development activities for improvement of village chicken production have been applied in the past in Burkina Faso. The main results and the main reasons for their non adoption at farm level should be elucidated in further studies.

1.3. Research and development activities on village chickens in Burkina Faso so far

Abstract
Several development and research activities were conducted in order to improve village chicken production systems in Burkina Faso. A review of these activities reveals some technologies and recommendations on improved housing, management, feeding and health care. It appears that village chicken vaccination against the Newcastle disease at farm level can allow significant increases in productivity. Genetic improvement by cock exchanges and improvement of diets by supplying modern balanced diets were proposed to improve the potential of village chicken for growth and egg production. Farmers do not adopt these technologies and village chicken production systems remain the traditional free-range production system. Such a production system is characterised by low productivity with regard to egg and meat. There are important risks of Newcastle disease outbreaks and also there are important losses due to predation and miscellaneous causes. Due to this situation, policy makers tend to neglect village chicken production, leaving improvement efforts to only a few farmers. However, appropriate technologies with village chickens will allow small farmers to have an extra source of income that will contribute to poverty alleviation. Also, other directions for the improvement of village chicken production system need to be investigated, taking into account the possibilities at village level.

Keywords: Village chicken, production system, technologies, review, Burkina Faso.

Introduction

In Burkina Faso, poultry production is known to be a regular source of income for small farmers in the rural areas and plays an important economical role at the national level. Poultry also plays an important socio-cultural role as object of gifts or sacrifices. This production is mainly family poultry (99%) of which village chickens represent 2/3 in the country (Ouandaogo, 1997). In 1994 the total number of village chickens in Burkina Faso was estimated 24.4 millions (MED and MRA, 2004). Most of family poultry production is concentrated in the Central Region of Burkina Faso. Such concentration is in relation with the high density of human population and coincides with the importance of cereal production in this region (Ouandaogo, 1997). With regard to the importance of family poultry in the country, research and development activities on this production were executed in the past. These investigations led to the recommendations of improved technologies and the gathering of basic knowledge on poultry production in general and village chickens in particular.

The current study gives a review on these activities and suggests recommendations for further improvements. The study was based on literature review with available documentation on village chicken production in Burkina Faso.

Research and development projects executed on village chicken production

Many authors (INRA and SEDES, 1976; SEDES, 1977; Saunders, 1984) have given a general view on development and research projects that have been conducted on village chicken production systems in Burkina Faso.

Specific projects on village chicken production system were sub-projects of family poultry in the West of the country and the 'Projet de Développement de l'Aviculture Villageoise' (PDAV). Additionally some related activities were undertaken by the Regional Development Bodies[1], some training institutions (such as the Matourkou Agricultural Polyvalent Center[2]) and some NGOs (such as the West African Center for Social Studies). The activities of these projects or services are well described by INRA and SEDES (1976) and Djabi (1983). These projects aimed at the development of traditional family poultry. Sanitary programmes were conducted by all the projects but not always as rationally as expected. Furthermore there were some attempts to improve village chicken production systems by cross breeding and by improvement of feeding practices. Rhode Island Red cocks were used in cock exchange programmes to upgrade local breeds in order to achieve higher body weight and egg production performances. Another approach used cocks of the Harco breed. However, according to SEDES (1977), some particular types of village chickens are researched by farmers according to their circumstances. For gifts white poultry is needed whereas for sacrifices red poultry is required. In some other cases, dwarf chicken or chicken with larger combs may be needed. These reasons explain that the cock exchange programmes were not so successful. Additionally one-day old chicks of improved breeds were introduced in the traditional systems. INRA and SEDES (1976) indicated that this programme failed quickly due to feeding and sanitary problems. Feeds high in protein with added anti-coccidian were also introduced by some of the projects (Djabi, 1983; Werem, 1985). Such use of complete diets in village chicken feeding is object to controversy (Saunders, 1984; Van Eekeren *et al.*, 1995). Nevertheless, it is indicated that these operations show some success in the village chicken programmes where the project was executed but just during the project life.

Taking into account the experiences of the previous projects, the second phase of the PDAV, which was the largest and most well known project on family poultry in the country focused on improving village chicken production at farm level by large participatory vaccination campaigns. This project realised many studies on village chicken production parameters (PDAV and AFVP, 1981; Brunet *et al.*, 1983; Brunet *et al.*, 1984a, b, c). Results from these studies show a mean hatching rate of 60% with large variation between the rainy (80 to 90%) and the dry season (50%). The sexual maturity of village chicken was observed at 6 months. The project created a centre for the improvement of village chicken productivity and suggested some technologies for village chicken production systems. On the basis of sanitary interventions only, this project achieved an increase of village chicken production of 110% (PDAV and AFVP, 1981).

Improved housing and house equipment proposed for village chicken rearing

Improved housing is recommended by the PDAV and is well described by Saunders (1984). Proposed options are:
- a round house of 3 meters of diameter with a capacity of 25 hens per house,
- a rectangular house of 32 m² (8 m × 4 m) similar to the modern house with a capacity of 100 hens per house,
- a rectangular house of 60 m² (12 m × 5 m) for the growing chicken with 12 boxes of 4 m² for separate groups at different ages.

Additionally INRA and SEDES (1976) recommended for village chicken rearing, a mobile chicken house type in wood and wire which makes cleaning easy.

[1] Organismes Régionaux de Développement (ORD); one such example is the Integrated Development Project of the Eastern Region, carried out by the Eastern ORD.
[2] Centre agricole polyvalent de Matourkou

For Ouandaogo and Ouédraogo (1988), village chicken houses should be located under shadow, oriented from north to south, total window surface should be equal to 1/10 room surface, and the roof must be high. These authors recommend a density of 8 chickens per m² and separated rooms for young and old chickens.

The PDAV recommended some house equipments that can be used in village chicken rearing. These equipments are well described by Djabi (1983) and Saunders (1984). For the young chicks, one has a feeder through with a capacity of 1.5 l, a rectangular feeder of 40 cm of length or a round feeder of 36 cm of diameter. For older chickens, rectangular dishes of 0.8 to 1 m of length are recommended. Upside-down bottle drinkers for chicks and traditional drinkers for old chickens are also described. Wood shavings or chopped up straw are recommended by the project as litter in the houses.

All these technologies are not commonly observed as shown in the study on village chicken production in Yambassé, a village of the central region of Burkina (Chapter 1.2) in which, none of these technologies was observed at farm level. Maybe the cost of implementation of these technologies was high as according to Djabi (1983) high cost improved housing cannot be popularised in the rural areas of Burkina Faso.

Recommendations on village chicken care

The centre for the improvement of village chicken productivity of the PDAV did the most important studies on improvement of village chicken production in the country. Djabi (1983) gives the following recommendations for village chicken health care based on the results of his study.

- monthly disinfection to be done on the house and the house equipment;
- vaccination against Newcastle disease and small pox;
- in the first week, disinfection of boxes before putting the chicks, vaccination against small pox, treatment with oxyfuran against infectious diseases;
- in the fourth week, vaccination against Newcastle disease and treatment against internal parasites;
- in the 8th week, treatment against internal and external parasites;
- in the 12th week, treatment against internal and external parasites, disinfection of houses before introduction of laying hens;
- in the 18th to 20th week, vaccination against Newcastle Disease and treatment against parasites;
- a new administration of the inactivated vaccine against Newcastle Disease the ITA-New is necessary between the 8th and the 12th week in order to reach 20 weeks with security.

Furthermore, Saunders (1984) indicated the following vaccination strategies adopted by the PDAV for village chicken at village level:

- vaccination of all the flocks in the village in a short period around the months of September to November,
- vaccination during the year of young chicks at 2 months of age.

Unfortunately, according to SEDES (1977) adoption of sanitary programme needs some logistics such as specialised workers with fridge and many travels in the field, which are not available after the projects. It is not surprising that such measures are not implemented in the fields as could be seen in the study in Yambassé in Chapter 1.1.

Research on village chicken marketing in Burkina Faso

The yearly poultry production is evaluated at 20 millions of birds in Burkina Faso (Ouandaogo, 1997). From this number, 2/3 are village chickens with a mean exploitation rate (number of chickens consumed and sold/mean number of chicken) of 75% (Brunet *et al*., 1984c). Village chickens are exploited for different purposes (sacrifice, gifts, and sale). Many authors (Brunet *et al*., 1984c; Ouandaogo, 1997; Kondombo *et al*., 2003a, b) agree that selling is the most important mode of village chicken exploitation. In Burkina Faso village chickens are sold in different markets throughout the country and in neighbouring countries such as Ivory Coast and Ghana.

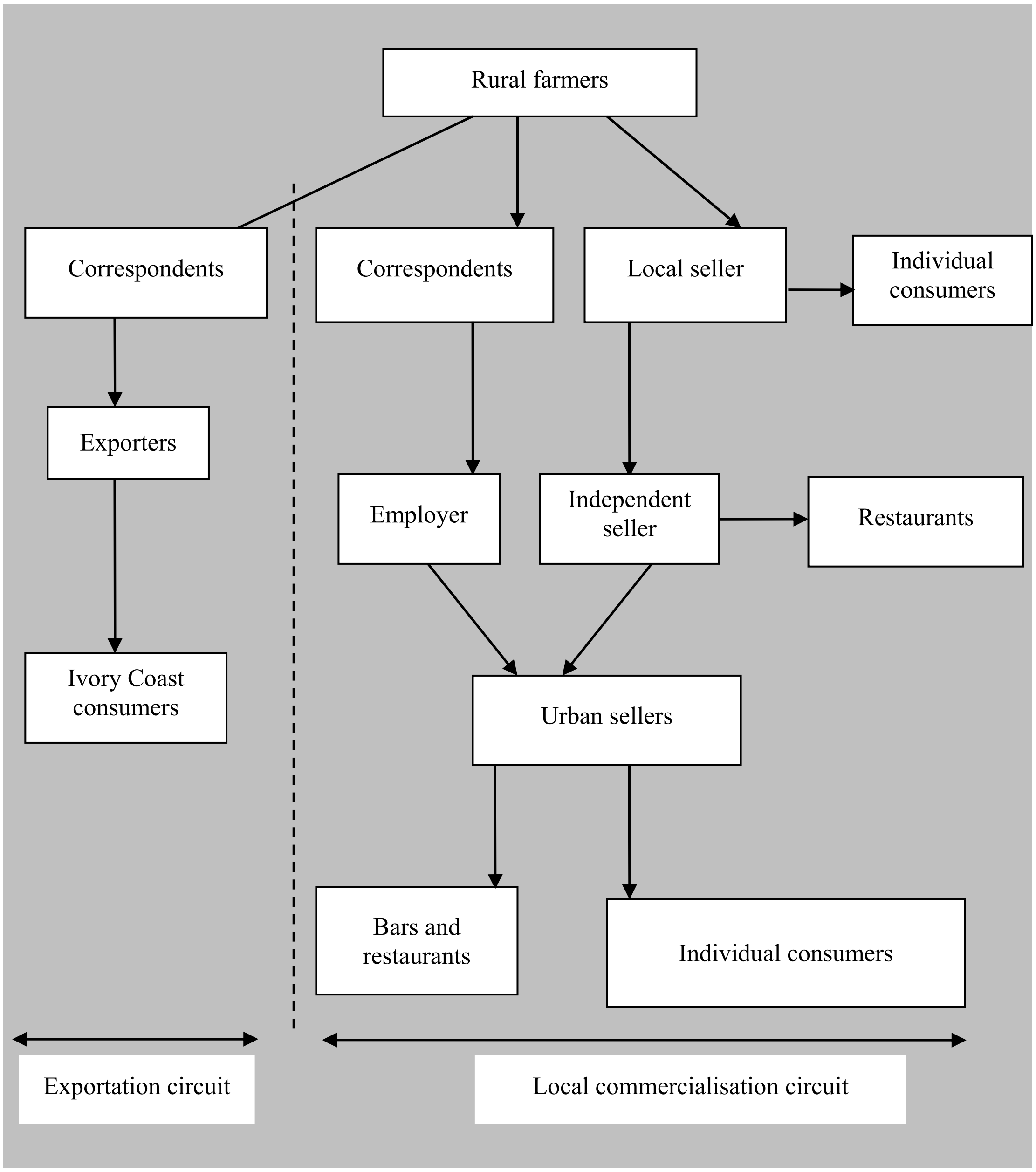

Figure 1.3.1. Village chicken commercialisation circuit in Burkina Faso (Source: Marchand, 1984)

The selling prices of village chicken depend on various factors such as the season, the location, the body weight, the colour of feathers and the sex. Low prices are observed during the period of February and high prices in the periods of April-May and August-September. There is a geographic distribution of village chicken prices in the country (Saunders, 1984). The lowest price is observed in the North and East of the country with an increase of the price towards Ouagadougou and the South-West region. The maximum price was found in Bobo Dioulasso, the second important city of the country after Ouagadougou. In relation to the years, it was noted that the price of a cock of 2 to 2.5 kg was estimated at 1000 FCFA in 1983 (Marchand, 1983). In 1988, Ouandaogo and Ouédraogo (1988) reported estimated prices of 600 FCFA for growing chickens and 1300 FCFA for cocks. Ouédraogo and Zoundi (1999) indicated a selling price of 800 FCFA at farm level and 1300 to 1400 FCFA at urban level in 1999. In 2000, mean prices of 955 to 980 for village chickens were noted for Burkina Faso by the index market (Cretescm.net, 2004). According to Marchand (1984), the most important markets of village chicken are located in the towns of Boussé, Pouytenga, Kombissiri, Manga, Yilou and the big exporters of village chickens are located in Yako and Kaya. This author revealed a veritable organisation in village chicken commercialisation as indicated in Figure 1.3.1.

The extensive marketing system and variation in price between localities and seasons show that there is potential to sell village poultry and to make money by appropriate timing and choice of markets.

Analysis of the research and development activities on village chicken production in Burkina Faso

The current review shows research and development efforts to improve village chicken production systems in Burkina Faso. Unfortunately, these actions were too short in time and space and the results are poor. Most authors agree that the long term results of these actions were insufficient (Kuit *et al.*, 1986; Sonaiya *et al.*, 1999). The introduction of day-old chick of improved breeds in the rural areas in which hygienic measures are not adequate, led to high mortality within the first few weeks. Improved cock exchange programs also failed for several purposes: sanitary, genetic as well as socio-cultural constraints. The reality is that rural farmers appreciate the natural phenotype and genetic diversity found in local breeds (SEDES, 1977), which are more resistant to harsh environmental conditions (Guèye, 1998).

Furthermore, technologies of improved houses, house equipment and sanitary health care were recommended for the improvement of village chicken production system (Djabi, 1983; Saunders, 1984). However, there is no recommendation of how to combine the different technologies in an economical way. It appeared also that the problem of village chicken feeding has not found adequate solutions as the use of modern complete diet is subject to controversy.

With regard to the actual knowledge of improvement of village chickens production systems in developing countries in general (Sonaiya *et al.,* 1999; Kazi, 1999; Aini, 1999), and in Burkina Faso in particular (Saunders, 1984; Oandaogo and Ouédraogo, 1988; Kondombo *et al.,* 2003a,b), further investigations on village chicken improvement are needed.

Appropriate measures against diseases, mainly Newcastle disease, have been indicated by several authors (Card, 1961; Alders *et al*., 1994; Nguyen *et al*., 1996; IEMVT, 1987; Aini, 1999). Housing and hygienic measures can be applied. But these measures cannot be applied if feeding schemes for village chickens are not appropriate (Chapter 1.1). When flock sizes grow seasonal feed shortages can become even more disastrous and the need for supplementary feeding increases accordingly. Unfortunately, relevant feeding strategies are not yet available for village chickens, in contrast to commercial chicken production systems.

Current commercialisation of village chickens involves several categories of people from farmers to the final consumers. This highlights the economical importance of village chickens in Burkina Faso and shows that village chickens can be an important source of income at farm level.

Conclusion

With regard to the analysis of previous development and research activities on village chickens production system in Burkina Faso, adequate measures for health care, housing and housing equipment for village chickens are already available. However, these need some investments, which are not economically feasible when the system of production is based on scavenging, that involve lots of risks such as diseases, predations and other losses. Scavenging systems are not commercial enterprises in which inputs and outputs are calculated, hence costs of inputs are avoided as they do not guarantee financial benefits. Therefore a priority in improving village chicken production seems to carry out systems in which the production risk will be minimised. To do so, it is necessary to carry out feeding strategies that will lead to better control of village chicken production at farm level, and can support higher production of larger flock sizes. An integrated strategy based on the recommendations and including appropriate feeding strategies should thus be developed.

CHAPTER 2

Overview on small ruminant's production system in developing countries

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2. Overview on small ruminants' production system in developing countries

Abstract
Small ruminants play an important socio-economical role in developing countries. The current study was based on a literature review. It aimed to give an overview on small ruminants' production systems and to situate the importance, the constraints and attempts to improve the system. In the case of Burkina Faso, there are 10 million goats and 6.7 million sheep in the country. The Central Region of Burkina Faso is numerically the most important for small ruminants' production. Two main breeds of small ruminants are observed in the country; the Fulani and the Djallonké sheep or goat. The small ruminants' production system is mainly extensive based on grazing. The improvement of this system is oriented towards sheep fattening.

Keywords: Goat, sheep, review, production system, Burkina Faso.

Introduction

Small ruminants are found almost everywhere and India and China have the highest densities of these animals (FAO, 2002). Sheep and goat populations in Africa have recently been estimated at about 191 and 159 millions heads respectively which represent 30% and 32% of the world total population of sheep and goat respectively. During the 1980s the interest for small ruminants has increased in sub-Saharan Africa (Thys *et al*., 1989). The two species have an important place in livestock production at farm level due to their socio-economical and religious role. Seyoum (1992) described small ruminants repartition in the sub-Saharan Africa (SSA). Most small ruminants are found in the arid and semi-arid zones of the Sahel and East Africa, mainly in pastoral and agro-pastoral systems (IICA, 1980 in Seyoum, 1992). Flocks in these areas are generally large (up to 100 head per household) and are often kept with other livestock for both meat and milk production. Small ruminants are comparatively less important in humid and sub-humid zones. Nevertheless, it is estimated that in 1981, about a third of SSA's small ruminant population was found in these ecological zones (Onim *et al.*, 1986 cited by Seyoum, 1992). In both zones, small flocks are mostly kept by smallholders who rely mainly on crops but keep small ruminants as a subsidiary source of income and meat and a safeguard against crop failure and low crop prices.

Goats are more numerous than sheep in developing countries in general and in SSA countries in particular. The reasons are not very clear but seem to be related to differences in physiological/adaptation characteristics and socio-economic roles of sheep and goats (Seyoum, 1992). In much of Africa, sheep production is a relatively market-oriented activity aimed mainly at satisfying urban and ceremonial demand for meat (CRED, 1980 and Nestel, 1986 cited by Seyoum, 1992). In contrast, goat production tends to be subsistence oriented and to cater the needs of a larger number of rural and lower income consumers (Zimbabwe Government, 1987 cited by Seyoum, 1992).

According to the second livestock census (MED and MRA, 2004) 6.7 million sheep and 10 million goats are found in Burkina Faso. Their importance in Burkina Faso is also proven by the high number of studies that were conducted on these species as those of Bourzat (1980), Dianda (1981), Pitroipa (1983), Kaboré (1986), Ouédraogo (1990), Savadogo (2000), Kalkoumdo (1994), Nianogo *et al.* (1995), Ouédraogo *et al.* (2001), etc.

Many aspects of the production and productivity of small ruminants have been investigated by authors in developing countries in general and in Burkina Faso in particular. The current review will not repeat them all but focus on the production system, the socio-economical and religious role, the productivity, the constraints and the attempts of improvement of small ruminants' production.

Social, religious and cultural functions of small ruminants

In the Middle East regions a large number of sheep is reared for slaughter at religious feast (FAO, 2002). Centrès (1996) in a study in urban and peri-urban regions, indicated in a town of Burkina Faso, but also in the neighbouring country Mali, that small ruminants' production has an important function of saving and a social role for different feasts and ceremonies.

Jaitner *et al.* (2001) also indicated that small ruminants are kept mainly to generate income, as savings, for ceremonial purposes (like naming ceremonies, weddings, the Islamic feast Tabaski) and to obtain manure. For Nwafor (2004) small ruminants also serve as gifts to relatives and friends. These gifts have a social function or are part of religious charity. Some are given to relatives and members of the family to enable them to own and keep livestock in order to improve their livelihood sources.

Consumption of goat milk is also of some importance. The high level of protein in goat milk contributes to satisfying the need in animal protein of the rural population and is a source of income for those living near the centre of consumption (Ba Diao *et al*., 1996).

Farmers with increasing numbers of small ruminants tend to exchange them for cattle. In Gambia the ratio differs and depends on factors such as animal type involved. A common practice is to exchange between 5 - 7 small ruminants for a cow (Nwafor, 2004).

Small ruminants' production system

Small ruminants' production systems vary according to the ecosystem (CTA, 1986). Two main types of production systems can be observed: the purely pastoral system and the agro-pastoral system (CTA, 1986). In the purely pastoral system, livestock is the only economic activity for the families. In the agro-pastoral system, farmers practice crop and livestock production, but the most important activity is crop production. Both systems of small ruminants' production are present in Burkina Faso. The pastoral system is practised in the northern part of the country and the agro-pastoral system in the central and the southern part. Both systems are extensive systems with low external input and based on grazing of pasture. Slingerland (2000) classified small ruminant production in a village of Burkina Faso in three systems: agro-pastoral in which crop production is dominant; agro-pastoral in which animal production is dominant and a semi-intensive production system. According to this author, in the crop dominant system, small ruminants were kept for saving and reserve for calamities. The main investment consisted of vaccination against contagious diseases. In the animal dominated system, small ruminants were exchanged against grains or cattle and investments were generally absent. In the semi-intensive system, sheep were fattened with a commercial objective. Investment in this system consisted of adequate vaccination, collection and feeding of crop residues and occasionally cultivation of fodder crops.

In the crop-dominated system, Nianogo *et al.* (unpublished data) indicated that two main subsystems of small ruminant production could be distinguished: (1) the breeding system and (2) the fattening system. In the breeding system small ruminants were kept by children in the rainy season, or tied to a tree or post for the small flock or the household without labour. After harvesting of crops, small ruminants are free to roam anywhere and come back in the evening in the household compound. Some supplementation is provided in the dry season with essentially crop by-products (groundnut and cowpea hays, cereal straw). There is no control of mating. Small ruminants' drinking water comes from surface water in the rainy season and from underground water during the dry season when they are watered at wells.

In the fattening system the two different species can be used for fattening. In most cases, fattening animals were chosen from the flock of the breeding system or else bought in the market. The fattening period was 3 to 4 months. It was organised in such a way, that the animals could be sold during the Muslim feasts or the feasts of the end of the year when demand and prices are high. During the fattening period, small ruminants received supplementation feed in the evening after grazing during daytime. The feeds are composed of cereal straw, groundnut hay, cowpea hay, kitchen wastes, cotton cake or cereals seeds. In the condition of urban rearing, animals didn't have specific housing and the feeding was based on the purchase of grass, cereal brans and household wastes (Centrès, 1996).

Small ruminant breeds in Burkina Faso

Several authors (Bourzat, 1980; Nianogo, 1992) have described small ruminants' breeds in Burkina Faso. For the two species the Fulani and the Djallonké breeds are observed. The Fulani sheep has a large size. It is about 70 to 80 cm height, a mature weight of 40 to 45 kg for the males and 30 to 50 kg for the females. One variety of this breed is called the sheep 'Bali-Bali'. The Fulani goat has also a large size with the adults ranging from 60 to 70 cm, a live body weight of 30 to 35 kg for the males and 20 to 25 kg for the females. The Djallonké sheep has a small size of 60 cm for the males and 40 cm for the females. Body weight of the male is 30 to 35 kg and 25 to 30 kg for the female. The Mossi sheep and goat are varieties of these smaller breeds localised in the Central region of Burkina Faso. Milk of Fulani goat is collected for home consumption but for the Djallonké or Mossi goat only meat is considered.

The spatial distribution seems to be in accordance with the ecological adaptation.In the Sahel zone only the Fulani breeds (Nianogo *et al.*, 1994, unpublished data) are met. The Fulani breed is localised in the north of the country characterised by low rainfall (200 to 400 mm) and *Panicum laetum*, *Schoenfeldia gracilis*, *Balanites aegyptiaca*, *Acacia seyal*, *Cenchrus bifloris* pastures (Toutain *et al*., 1983). The biomass of pasture in this zone is very low but has a high nutritive value. Djallonké breed are localised in higher rainfall areas (400 to 1400 mm) with high biomass of pasture but of lower nutritive value. According to Ouédraogo *et al.* (2001) these breeds are actively researched in all parts of the countries for fattening speculation because of their large size. In the Central Region, mainly the Djallonké breeds are reared. Presence of Fulani breeds or cross breed (Fulani × Djallonké) increases into the south.

Constraints of small ruminants' production system

The constraints in small ruminants' production in terms of genetic improvement are well described by Jaitner *et al*. (2001). Individual flocks are very small with only a few breeding females. Males and females are rarely kept separate. The management system with respect to grazing, free roaming during the dry season and herding during the rainy season, makes controlled mating very difficult. In addition, females often mix with males of surrounding villages (Jaitner *et al.*, 2001).

For small ruminants feeding a major constraint is that the pasture quality and availability becomes very low in the dry season, particularly in the Sahelian Regions of Africa (Njoya *et al.*, 2005; Savadogo, 2000; Siulapwa and Simukukoko, nd).

The number of diseases in small ruminants and the lack of appropriate feeds lead to low productivity characterised by high mortality and loss of weight (Bourzat, 1980). According to a study reported by Bourzat (1980) the sheep mortality rate between 0 - 1; 1 - 2; 2 - 3 years was respectively 11.5%, 4.3% and 1% in rural area even after interventions of a project.

The main constraints to livestock production are the limited availability of suitable feed and the high mortality, especially in the dry season, which is generally from October to May in West African countries. The concentration of crude protein in the dry season falls below 6% thus below maintenance requirements (Savadogo, 2000; Njoya *et al.*, 2005). Furthermore, the quantity of forage available decreases with 25 - 50% as compared to the rainy season (Wolf *et al.*, 1991 cited by Savadogo, 2000). Njoya *et al.* (2005) indicated that despite the important economic, traditional, social and religious role of small ruminants, their productivity is seriously hampered by high mortalities due to mixed infections by ‘peste des petits ruminants’ and gastro-intestinal helminthoses and also by poor feeding and management.

Activities to improve small ruminants’ production in developing countries

In general, an increase of the productivity of small ruminants can be achieved by improving environmental factors like management, nutrition and health care and/or by improving the animal genetically (Jaitner *et al.*, 2001). Knowledge of the reasons for keeping small ruminants is a prerequisite for deriving operational breeding goals. A limited number of animals with high weight gains per animal per day fits an income generation strategy while a large flock fed at maintenance level may fit a strategy aiming at manure (Slingerland, 2000).

In Burkina Faso activities addressed specially sheep fattening as shown by several studies (Bourzat *et al.*, 1980; Bourzat, 1983; Bourzat *et al.*, 1987; Kondombo, 1991; Savadogo, 2000). The main objective of such improvement is to increase the value of forages and Agro-Industrial By-products and to get more return from small ruminants’ production. Different studies indicated the existence of three types of fattening (Sanfo, 1983; Ouédraogo, 1991): (1) the traditional fattening, in which, animals receive supplement of household wastes and minerals as kitchen salt after grazing; (2) the semi-intensive fattening with animals receiving supplementation of agro-industrial by-products after grazing and (3) the intensive fattening in which, animals receive complete diets in confinement conditions. The traditional fattening is done in both dry and rainy seasons. The semi-intensive and the intensive fattening are done in the dry season and aime to have more return from livestock during the period of the religious feasts as the Tabaski.

In Burkina Faso rural farmers practice the traditional and the semi-traditional fattening (Sanfo, 1983; Zoundi, unpublished data). The extension services and research structures in the country support these activities through training, financial support of farmers and formulation of complete diets for the intensive fattening. One can cite diets formulated from Bourzat *et al.* (1987); Sanon (1990); Kondombo (1991); Soma (1992); Nianogo *et al.* (1995); Nianogo *et al.* (1996). Some of these complete diets for sheep fattening are presented on Table 2.1. As can be noted, the majority of these diets is composed with various feedstuffs and have a high proportion of concentrate feeds.

Productivity of small ruminants in Burkina Faso

Sheep flock sizes were estimated to 10.8, 7.43 and 12.2 heads respectively for agro-pastoral dominated crop, agro-pastoral dominated animal system and semi-intensive system. For goat, these numbers were 11.7, 14.3 and 10.5, respectively (Slingerland, 2000). In a study in 6 villages in Burkina Faso, Savadogo (2000) indicated an average flock size of 9.88 sheep and

Table 2.1. Composition (%) of diets formulated for sheep fattening in Burkina Faso

Feedstuffs	Composition (%) of the diets				
	Diet I*	Diet II*	Diet III**	Diet IV***	Diet V***
Cottonseed cake	22	24	-	18	15
Cottonseeds	22	34	-	-	-
Wheat bran	22	-	29.48	-	-
Panicum laetum hay	5	8	32.82	-	-
Sorghum straw	20.6	22.2	-	-	-
Groundnut hay	7	10	-	-	-
Dolichos lablab hay	-	-	37.70	-	-
Oysters shell	1.4	0.8	-	-	-
Salt	-	1	-	-	-
Molasses	-	-	-	60	53.5
Urea	-	-	-	1.5	1.5
Rice or millet straw	-	-	-	20.5	20
Sorghum grain	-	-	-	-	10

Source: * Nianogo *et al.* (1995); ** Kondombo (1991); ***Bourzat *et al.* (1987).

Table 2.2. Weight gain of fattening sheep according to the conditions of fattening

Type of breed	Conditions of breeding	Daily weight gain (g/d)	Authors
Mossi sheep	Traditional fattening	27-44	Dumas and Raymond (1974); Sanfo (1983)
	Semi-intensive fattening	43-78	Nianogo *et al.* (1996)
	Intensive fattening	98-113	Bourzat *et al.* (1987)
Fulani sheep	Traditional fattening	60	Sanfo (1983)
	Semi-intensive fattening	107	Kissou (1983)
	Intensive fattening	76-126	Bourzat *et al.* (1987); Sanon (1990); Kondombo (1991)

8.42 goats. Bourzat (1979) indicated for the male Mossi sheep, a weight of 8.6, 13.5, 19 and 20.8 kg, respectively, at the age of 3, 6, 12 and 18 months. For the same ages Nianogo (1992) observed body weights of 10.32, 14.37, 20.43 and 24.87 kg. The age at first parturition varied according to the authors but ranged between 11 and 17 months (Nianogo, 1992; Dumas and Raymond, 1974). Interval between parturition ranged from 7 to 9 months (Nianogo, 1992).

Growth of small ruminants is strongly related to the condition of breeding as reported in Table 2.2. In the extensive condition of breeding, sheep growth ranged from 28.2 to 31.71 g/d for the Mossi sheep (Nianogo, 1992; Soma, 1992). For Mossi goat, Tamboura and Berté (1996) reported also growth of 29 g/d. These growths can be improved by fattening systems and many authors indicated sheep growth ranging from 30 to 60 g/d with the traditional fattening. With the semi-intensive or the intensive fattening, growths of 43 to 113 g/d can be observed with the Mossi sheep. For the Fulani sheep growths of 76 to 126 g/d are reported.

Conclusion

As shown, small ruminants' production in the traditional production has low productivity characterized by low flock size, late reproductive age, high interval between parturition, high mortality, and low daily growth. The main causes of such low productivity are diseases, poor conditions of husbandry and insufficient quantity and quality of feedstuffs in the dry season. To tackle these constraints, the main improvement in small ruminants' production so far is sheep fattening. This fattening seems the best way to improve the small ruminants' production systems in an economically feasible way. It may sustain development of small ruminants' production such as increasing herd sizes by vaccination, cultivating forage, buying feeds and getting more return from livestock. For the improvement of sheep fattening it is indispensable to evaluate the available feed resources both from the village territory and from agro-industries, to investigate their optimal use and to explore how to increase their availability and those of other resources to solve the feeding problem in the dry season and to support sheep fattening system.

CHAPTER 3

Feed resource base for fattening sheep and village chickens in Burkina Faso

3.1. Availability of agro-industrial by-products in Burkina Faso*

3.2. Local feed resources for fattening sheep and village chickens in Burkina Faso

3.2.1. Local feed resources for fattening sheep in Burkina Faso**

3.2.2. Seasonal variation in the availability of feedstuffs for scavenging village chickens at farm level

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** A part of this section was a communication paper at the workshop on animal production held in Ouagadougou/Burkina Faso from the 8 to 10 December 1997

3.1. Availability of agro-industrial by-products in Burkina Faso

Abstract
To guarantee adequate feed for improved livestock production in Burkina Faso, the potential of concentrate feeds is to be considered. To evaluate their availability, literature research was combined with a survey on the industry producing agro-industrial by-products (AIBP).

At the period of the study eight factories produced AIBP in Burkina Faso. Annually, the production of AIBP was 91,441 t of sugarcane residual straw, 59,425 t of cottonseeds (CS), 33,341 t of cottonseed cake (CSC) & cottonseed meal (CSM), 11,473 t of wheat bran (WB) and 10,697 t of molasses. However, only 33,341 t of CC & CSM, 11,473 t of WB, 7,650 t of CS, 5,125 t of beer malt and 703 t of rice bran are available for livestock feeding. The Village Domestic Animal Development Programme[1] (PDAV) and some private producers produce commercial chicken diets. Only 24.6% of the AIBP produced are allocated to livestock feeding. One strategy would be to improve the availability of AIBP for livestock feeding and a second strategy to find some alternatives concentrate feeds.

Keywords: Fattening sheep, village chicken, concentrates, crop residues, Burkina Faso.

Introduction

Agro-industrial by-products (AIBP) because of their high nutritive value are an important source of feed for ruminants and monogastrics. For improvement of livestock production the use of this feed resource is indispensable. In Burkina Faso, farmers already know the importance of the AIBP so many of them buy AIBP to supplement their animal during the shortage of animal feeds in the dry season from April to May. For those that practice sheep or cattle fattening, it is necessary to use AIBP in addition to natural pasture or crop residues for better weight gains.

With the perspective to improve ruminant's production it is necessary to gather knowledge on the availability of concentrate feedstuffs. The current study aims to do so in the context of Burkina Faso.

Materials and methods

A formal survey was realised in 1996 and 1998 in Burkina Faso. A literature review allowed identifying the sites for survey. These sites were the important factories that produce agro-industrial by-products (AIBP) in the country. The survey consisted of questionnaires addressed to the responsible persons at different levels of the factories. The questions asked dealt with the quantities produced and the commercialisation of AIBP at the factory or in the markets.

The factories were localised in the towns of Ouagadougou, Bobo Dioulasso and Banfora. The factories concerned were:

- the 'Grands Moulins du Burkina' (GMB)[2], the 'Société Sucrière de la Comoé' (SOSUCO)[3] located in the town of Banfora,
- the 'Société Nouvelle-CITEC' (SN-CITEC)[4], the 'Société de Brasserie du Burkina' (SOBBRA)[5], the 'Société National de Collecte du Riz' (SONACOR)[6] and the 'Société de Fabrication Industrielle Barro et Frères' (SOFIB)[7] in Bobo Dioulasso,

[1] 'Programme de Développement des Animaux Villageois' in French
[2] Wheat bran factory in Burkina Faso
[3] Sugar factory

- the 'Brasserie du Burkina' (BRAKINA) in Ouagadougou.

Furthermore, a semi-structured interview was addressed to the customer service of Bobo-Dioulasso and Ouagadougou on the import and export of the AIBP. The specific case of blood and bone meal was investigated at the slaughter house of Bobo Dioulasso.

Results

Production of agro-industrial by-products (AIBP) in Burkina Faso

The amounts of AIBP produced annually in Burkina Faso are given in Table 3.1.1. The quantities of AIBP depend of the availability of the raw materials and the capacity of the factory. Furthermore, the market opportunities for the product determine the availability of the AIBP. For any season of production, one has in order of decreasing importance sugarcane residual straw[8] (SCRS), cottonseed, cottonseed cake, wheat bran, molasses, beer malt and rice bran. The production of groundnut cake is very small. For example in 1996, the production of SCRS represented 42% of the total concentrate production.

Availability of the agro-industrial by-products for livestock feeding

Not all agro-industrial by-products (AIBP) produced in the factories are used for livestock. Molasses is mainly used to fertilise the sugarcane fields and about 2,114 tons of molasses are used each year by the factory SOPAL for the production of alcohol. In some cases, the factory supplies molasses to some farmers. For example in 1997, about 39 tons of molasses were sold

Table 3.1.1. Amount of agro-industrial by-products (AIBP) produced in Burkina Faso

			Annual quantity produced (t)				
	AIBP	Factory	1994	1995	1996	1997	Average
True concen-trates	M	SOSUCO	11,761	10,101	10,230	*	10,697
	CS	SOFITEX	49,027	63,180	66,067	*	59,425
	CSC & CSM	SN-CITEC & SOFIB	*	*	28,317	38,364	33,341
Assimilated products	WB	GMB	10,051	10,914	11,292	13,635	11,473
	RB	SONACOR	1,078	714	521	500	703
	BM	SOBBRA & BRAKINA	5,086	5,210	5078	*	5,125
Others products	SCRS	SOSUCO	97,297	90,117	86,909	*	91,441

* = Unavailable data, M = molasses, CS = cottonseeds, CSC & CSM = cottonseed cake & cottonseed meal, WB = wheat bran, RB = rice bran, BM = beer malt; SCRS = Sugarcane residual straw; SOSUCO = société sucrière de la Comoé, SOFITEX = Société des Fibres et Textiles, SN-CITEC = Société Nouvelle CITEC, GMB = Grands Moulins du Burkina, SOBBRA = Société Burkinabè de Brasserie, BRAKINA = Brasserie du Burkina, SOFIB = Société de Fabrication Industrielle Barro et Frères, SONACOR = Société National de Collecte du Riz; AIBP = agro-industrial by-products.

Note: The quantity of groundnut cake is negligible and has not been taken into account in the calculations.

[4] Factory using cotton seed for oil manufacturing
[5] Beer factory located in Bobo
[6] Factory for rice decortication
[7] Factory of livestock feed
[8] Straw remaining after sugar extraction

Table 3.1.2. Nutritive values of the available agro-industrial by-products in Burkina Faso

Agro-industrial by-products	Chemical composition						
	Dry matter (%)	Digestible or crude protein (%)	ME (Mcal/kg)	Cellulose (%)	Crude fiber (%)	Calcium (%)	P (%)
Molasses	78	3.4	2.16	-	-	0.13	0.03
Cottonseeds	92	16.1	3.27	-	18.2	0.14	0.67
Cottonseed meal	93	27.3	2.12	-	13.3	0.20	0.90
Wheat bran	89	11.8	2.28	9	10	0.11	1.22
Rice bran	91	8.7	2.43	10	11.6	0.07	1.54
Beer malt*	91.7	28.6**	2.03	15.7	-	0.28	0.60
Sugarcane residual straw	100	6.2	0.97	-	22	2.36	0.12
Blood meal	92	65	2.22	-	1	0.29	0.24

Source: National Academy of Sciences, 1985. * Meffeja *et al.* (2003); ** crude protein.

for livestock feeding purposes. Cottonseeds have many destinations: seeds for cotton production, edible oil consumption, exportation and livestock feeding (in the form of cottonseed, cottonseed meal, or cottonseed cake). In the period 1993/1994, only 12% of the total seed production was sold in the form of cottonseed for livestock feeding and in 1994/1995 this proportion was 18%. The sugarcane residual straw is exclusively used as fuel for the factory (SOSUCO). This AIBP is not available for livestock production.

Rice bran is more and more used in human nutrition as cake and a high demand for this product is reported. Only cottonseed cake, groundnut cake, wheat bran, and beer malt are exclusively allocated to livestock feeding. The most available AIBP during a sequence of four years were cottonseed cake and wheat bran which represent respectively 57% and 20% of the total available AIBP. Chemical analyses by the National Academy of Sciences (1985) show that all these AIBP have high nutritive values (Table 3.1.2). Digestible protein ranges from 6 to 28% and metabolisable energy from 1 to 3 Mcal/kg (NAS, 1985). Blood meal, cottonseed, cottonseed meal and beer malt are among the highest protein sources.

Availability of concentrate feeds for chicken in Burkina Faso

For exotic chickens, the Domestic Animal Development Programme (PDAV) and some private poultry farmers in Ouagadougou and Bobo Dioulasso produce starter, grower and laying diets. Only a few research activities on the use of balanced diets for village chicken feeding (Djabi, 1983; Brunet *et al*., 1984b; Werem, 1985) were conducted. These studies experimented with the complete diets from modern chicken feed production units. Results of these studies indicated that the village chickens reach an exploitable body weight of 1 kg in 5 months with the complete diets. Furthermore, Ouandaogo and Ouédraogo (1988) give the following recommendations for village chicken feeding in improved conditions: from 0 to 4 weeks: 20 g of complete diet (AFAB[9] diet)/chick/day.

Commercialisation of the agro-industrial by-products in Burkina Faso

In the period 1996/1998, the demands for agro-industrial by-products (AIBP) were directly submitted to the factories by the official service of concentrate feed commercialisation of the government as well as by private demanders. The SN-CITEC sold its product (cottonseed cake or cottonseed meal) directly to farmer groups, or to some institutions. The minimum quantity to

[9] Livestock feed production unit (AFAB)

Table 3.1.3. Purchase price at factory of the AIBP in Burkina Faso

Feedstuffs	Factory	Purchase price at factory (F CFA/t) according to the year			
		1990	1994	1996	1997
CS	SOFITEX	13,000	14,950	20,700	29,000
CSC	SN-CITEC	26,870	47,800	47,800	45,850
CSC	SOFIB	25,000	35,000	42,500	50,000
CSM	SN-CITEC	19,000	36,000	36,000	45,850
WB	GMB	12,000	28,290	34,614	44,500
BM	SOBBRA	1,000	1,000	1,000	*
BM	BRAKINA	800	800	800	3,900
RB	SONACOR	10,000	14,800	20,000	25,000

Actual exchange rate: 1 € = 655.957 FCFA

CS = cottonseeds, CSC = cottonseed cake, CSM = cottonseed meal, WB = pellet bran, BM = beer malt, RB = rice bran; SOSUCO = société sucrière de la Comoé, SOFITEX = Société des Fibres et Textiles, SN-CITEC = Société Nouvelle CITEC, GMB = Grands Moulins du Burkina, SOBBRA = Société Burkinabè de Brasserie, BRAKINA = Brasserie du Burkina; SOFIB = Société de Fabrication Industrielle Barro et Frères, SONACOR = Société Nationale de collecte du riz; * = Data unavailable during the period of the survey.

be purchased in this factory was 35 tons. The SONACOR factory sold its rice bran to any farmer at a minimal quantity of 1 ton. This factory was in competition with some other rice bran producers. The beer malt was sold with priority to beer factory workers who might have sold it to other farmers. According the GMB, its product constituted by maize and wheat bran, was an object of important speculations. This factory had a complete animal feed factory but this was not functional because of lack of expressed demands of wheat bran. This factory has a production capacity of 10 tons per year.

The factory prices of the different AIBP in four different years are presented in Table 3.1.3. A high increase of the prices after the devaluation of the CFA currency in 1994 (1 FF = 100 FCFA) was observed. Before the devaluation 1 FF = 50 CFA.

Importation and exportation of agro-industrial by-products in Burkina Faso

The custom service did not register any importation of agro-industrial by-products in Burkina Faso. These feedstuffs are taxed at a rate of 57.55% of their value, which makes their import unattractive. In terms of exportation, the custom services of the city of Bobo Dioulasso registered annually 100 tons of AIBP. There is some non-official export of cottonseed, cottonseed cake and wheat bran because they have substantial value.

Blood and bone meals

The production of blood and bone meals are still rudimentary in Burkina Faso. Monthly, a production of 800 kg of blood meal and 100 to 150 kg of bone meal were reported in the slaughterhouse of Bobo Dioulasso. With regard to the high content of protein of these feedstuffs (Table 3.1.2) this production needs to be improved.

Discussion

Production of agro-industrial by-products (AIBP) is essentially localised in the West of Burkina Faso, in the city of Bobo Dioulasso and Banfora. This geographical localisation may be a limiting factor for the supply of AIBP to the other regions of the country and may favour speculation resulting in high prices. The main AIBP produced are in descending quantity, sugarcane residual straw (SCRS), cottonseeds, cottonseed cake, wheat bran and molasses. However AIBP available for livestock feeding were in descending importance, cottonseed cake, wheat bran, cottonseeds and rice bran. It is important to be aware of this fact when formulating livestock diets in the country.

Although annual production of AIBP is relatively important in Burkina Faso, there is only a low quantity available for animal feeding. The relative low quality of SCRS explains its use as fuel for the factory but the use of high energy molasses for fertilising the field might be reconsidered. The high protein blood meal should also get much more attention. It is necessary to increase the availability and production of the AIBP in the country as their nutritive values are high with i.e. 6 - 28% protein and 1 - 3 ME (NAS, 1985). Illegal exportation should be limited.

Appropriate measures should be taken to increase availability of concentrate feeds. Options are to keep the AIBP for domestic consumption only, to encourage, if necessary, the importation of the AIBP by the reduction of the customs taxes and to promote the use of local feed resources to substitute the AIBP where and when possible. These measures, which should be taken at different levels (administration, development and research), will contribute to solve animal feeding constraints.

The prices of the AIBP were considerably increased with the years probably due to the devaluation of the CFA currency. Because of the low availability and the high prices of AIBP, alternative concentrate feeds should be found as already recommended by the Strategic Research Plan of Burkina Faso (CNRST, 1995). *Parkia biglobosa* pulp powder, *Piliostigma reticulatum* or *Acacia albida* pods, millet and sorghum bran and local beer by-product may be used as concentrates to improve livestock production (Palo *et al*., 1991; Kalkoumdo, 1994). Concentrate feed can be used for small ruminants and poultry species. Many AIBP have been subject to research in animal feeding in Burkina Faso. They were used in various combinations for livestock feeding, mainly in sheep fattening (Kalkoumdo, 1994; Nianogo *et al*., 1995; Kondombo and Nianogo, 2001; Ouédraogo *et al*., 2001).

The exploitable body weight of 1 kg in five months (Djabi, 1983; Werem, 1985) on the use of concentrates in village chicken feeding was very poor with regard to the feed costs. In the traditional conditions of feeding (scavenging conditions) this weight is obtained after six months (Brunet *et al*., 1984b, c) without additional costs.

The use of complete diets in village chicken feeding is not well accepted by some authors (Saunders, 1984; Van Eekeren *et al*., 1995). Their view is that complete diets are not the most logical way to improve village chicken production on the account of the (1) low productivity and (2) low feed conversion ratio of local breeds. For the improvement of village chicken feeding better use should be made of the available local feedstuffs. In the case of Burkina Faso, some authors already described some available local feedstuffs that can be used in village chicken feeding. Ouédraogo (1987) described the technique of producing maggots and termites, which are well used by farmers in village chicken chicks supplementation. The study of Ouélé (1989) described potential feedstuffs in chicken feeding in Burkina Faso as groundnut cake, cottonseed cake, fish meal, blood meal, milk powder, soy bean and brewery malt.

Studies should be conducted on poultry and sheep diets with good conversion rates and with economic gains that at least compensate the prices of the inputs. In these studies local feedstuffs and AIBP should be considered taking into account their current and future availability and prices.

3.2. Local feed resources for fattening sheep and village chickens in Burkina Faso

3.2.1. Local feed resources for fattening sheep in Burkina Faso

Abstract
The current study aims to quantify the availability of crop residues at farm level and to investigate which may be available and adequate for sheep fattening in Burkina Faso. A village in the east region of Burkina Faso was used as the research site with 10% of the households randomly chosen for the research sample. Surfaces of all the fields of these households were computed. Field areas of 25 m^2 were used to determine the yield of each crop residue produced on each field and farm. Quantities of crop residues stored in each household were weighed and a questionnaire on their use was submitted to the farmers. This study was completed by a literature review to identity and to quantify other feed resources for sheep fattening. Results show that with regard to quantity, the most important crop residue produced was millet straw, followed by sorghum straw, cowpea and groundnut hay. Other crop residues from e.g. rice, peanut, cassava, and potato were produced in negligible quantities. The stored crop residues represented only 3.7% of the crop residues produced in the fields. Local feedstuffs that may be used as concentrate feeds for sheep fattening are millet bran, sorghum bran, traditional sorghum beer malt, pods or fruit powder of some trees as *Parkia biglobosa*, *Piliostigma reticulatum* and *Acacia albida*. The quantities and qualities of crop residues produced and stored require actions to improve the use of these feed resources at farm level. To motivate farmers to improve the use of crop residues as animal feed, animal production need to be presented and recognised as an economic activity. Introduction of sheep fattening may be a successful case. Secondly, to increase storage of the residues the means for transportation need to be improved.

Keywords: Fattening sheep, farmers, crop residues, feeding, Burkina Faso.

Introduction

In the Sahelian countries in general and in Burkina Faso in particular, the natural herbaceous vegetation is either destroyed by bush fires or of very low nutritive value during the dry season. This contributes to a deficit of good quality feeds for domestic animals during a long period of the year leading to a chronic under-nutrition of livestock in the dry season. With regard to that situation and without any feasible option for improved management of pastures, it is urgent to explore options to improve use of crop residues. These crop residues take more and more importance in the agro-cultural zones (MAE, 1991). According to Savadogo (2000), from the major feed resources i.e. natural or cultivated forage, agro-industrial by-products (AIBP) and crop residues, only the latter is sure to increase the total production. Furthermore other sources of concentrate feeds should be explored with regard to the high cost of the agro-industrial by-products.

However, before any actions can be proposed one should investigate the actual availability of feedstuffs and their current use at farm level. The current study was realised in the village of Kouaré in the East Region of Burkina Faso and completed by literature review. The study aimed to identify the potential production of each crop residue and its use for animal feeding at farm level. In addition, it described other sources of concentrate feeds for sheep fattening.

Materials and methods

The village of Kouaré in the East Region of Burkina Faso was the research site for this study. This village was chosen because the national research institute recognises it as representative for the agro-ecological East Region of Burkina Faso and also a research station is located in this village. This village is located in the North-Sudanian zone, characterised by a rainfall of 850 to 1050 mm in 'normal' years falling in the one rainy season from June to October. Vegetation is savannah and the main activities in the village are crop and livestock production. In this village, 18 households which represent about 10% of the households were randomly chosen. In each chosen household, all the fields and crop residues were included in the study. Field surfaces were calculated after a measure of lengths and azimuths around each field. Cultivated areas of 25 m^2 were monitored for each type of crop residue in order to derive the crop residue yields. By identifying the surface of each field and the yield of the crop residue concerned, the crop residue production was obtained by applying the yield to the whole field.

After the harvest and the storage of the crop residues, which was done in bunches or bundles, the quantities stored were evaluated for each household. For the quantification of stored crop residues, the number of bunches or bundles are multiplied by their average weights. Questionnaires were submitted to each household, in order to describe how farmers harvest, store and use crop residues. A review of available documents on local feedstuffs resources completes this study.

Results

Crop residue production and use at farm level

The estimation of cultivated areas at farm level is presented in Table 3.2.1.1. It appears that the larger areas (7 ha/field) were used for cowpea/millet, followed by cowpea/millet/sorghum (3.7 ha) and millet (2.3 ha) farming. Most households (77.8%) produce maize. In terms of

Table 3.2.1.1. Surface of different crops per farm in the research site

Crops	Number of households producing the crop n = 18	Number of fields for the crop	Average field surface (ha)	Percentage of households producing the crop
Maize	14	18	0.1	77.8
Millet	5	6	2.3	27.8
Sorghum	6	7	0.6	33.3
Groundnut	10	11	0.5	55.6
Cowpea	8	8	0.7	44.4
Voandzou	3	3	0.03	16.7
Rice	1	1	0.2	5.6
Soybean	1	1	0.04	5.6
Cassava	1	1	0.1	5.6
Potato	1	1	0.1	5.6
Groundnut/voandzou	6	8	0.4	33.3
Cowpea/sorghum	5	5	0.9	27.8
Sorghum/millet	2	3	1.2	11.1
Cowpea/sorghum/millet	7	7	3.7	38.9
Cowpea/millet	2	2	7	11.1

n = number of household of the sample.

relative proportion of surface, 35.7% is used for cowpea/sorghum/millet, 19.3% for cowpea/millet, 7.7% for cowpea, 7.6% for groundnut, 6.2% for cowpea/sorghum and 5.8% for sorghum production. The other surface proportions vary from 0.05 to 4.4% for voandzou/groundnut, voandzou, cassava, potatoes, soy bean, rice, sorghum/millet and maize.

Table 3.2.1.2. presents the quantities of crop residues which are produced and stored per farm. The production of cereal (sorghum, millet, maize, rice) crop residues is estimated to be 28.5 t/household against 7.5 t/household for the leguminous species (cowpea, groundnut). In sequence of importance of quantities produced, millet straw, mixed sorghum/millet straw, cowpea hay, sorghum straw, groundnut hay account for 34.6%; 32.7%; 16.4%; 10.4% and 4.5% of the overall available crop residues. The quantities of the other residues (vouandzou, rice, cassava, potatoes) are negligible (1.4% together).

Cereal crop residues represent 79.2% of all residues against 20.8% for leguminous crop residues. The quantities of crop residues stored represent only 3.7% of the crop residues produced. From the quantities stored, 89% are cereal residues. Sorghum residues are the most important in quantity, representing 46.4% of all residues stored and 16.4% of all sorghum residues produced in the 18 farms in the sample. In relation to the available residues of each crop, 4.4% is stored of millet, 16.4% of sorghum, 5.3% of groundnut and 1% of cowpea. For groundnut, the whole plant is mostly taken home where the nuts are removed. As the residue is already at home, it is easier to store or to give it directly to the animal in the backyard. Maize is harvested before the rainy season ends. In combination with the ways of storage the residues run high risk of spoilage. Therefore, there is no storage of maize residues.

Crop residues are stored on sheds or in trees. The period of harvest is October-November for the legume residues and November-December for the cereal residues. Residues are left drying on the fields or are transported directly to the sheds or trees.

Crop residues are essentially destined for cattle, sheep, goat or donkeys. They are fed for maintenance of the animals rather than for production. Limited quantities of crop residues are provided to the animals on a daily basis. For farmers, such distribution is practiced to attract the free roaming animals to the household compounds during the dry season. The use of crop residues starts during the period of January-February and takes end in May-June.

The cereal grain by-products

Millet and sorghum bran are the most common cereal grain by-product in Burkina Faso. According to a study of the livestock extension services (MAE, 1991), the production of cereal seed by-products at a national level was about 270,000 tons in 1990 and it may reach 416,000 tons in the year 2005. Furthermore, the traditional sorghum beer by-product constitutes another energy and protein source for livestock. According to Zoma (1990) it is difficult to estimate the quantities of this product as its production takes place at small scale in many locations. Regarding the quantity of local beer production in Burkina Faso, this by-product could be very important.

The non-conventional concentrate feedstuffs

Some tree species in Burkina Faso, give a possibility to feed animals with their pods or fruits. The collection of these pods and fruits enables to produce concentrate feeds for livestock. Examples are *Piliostigma reticulatum, Parkia biglobosa* and *Acacia albida*. Pods of *Piliostigma reticulatum* are eaten well by all ruminants. *Piliostigma reticulatum* is abundant in the centre of Burkina Faso (Terrible, 1984). For *Acacia albida,* a study for its regeneration in Burkina Faso by Bonkoungou (1987b) indicated that the density of this tree reaches 20 to 30 plants/ha in many areas of the country. The pods of *Piliostigma reticulatum* are not yet sold in the markets. They are directly eaten from the trees. They are also collected by some farmers for their animals. *Acacia albida* pods are sold in some areas of the country.

Table 3.2.1.2. Available crop residues and their use at farm level in the research site

Crop residues	Number of field of the crop (d)	Crop residues yield (t/ha) (b)	Mean surface of the field (ha) (c)	Total available CR in the field (tons)* (a)	Number of household storing the CR n = 18	Percentage of households that stored the CR	Total quantity of CR stored by all households (tons)	Quantities of CR stored in % of the available CR
Maize straw	18	5.4	0.1	9.7	0	0	0	0
Millet straw	8	8.0	3.5	224	1	5.6	9.9	4.4
Sorghum straw	12	7.0	0.8	67.2	5	27.8	11.0	16.4
Groundnut hay	19	3.0	0.5	28.5	7	38.9	1.5	5.3
Cowpea hay	22	2.1	2.3	106.3	6	33.3	1.1	1.0
Rice straw	1	1.6	0.3	0.5	1	5.6	0.02	4.0
Sorghum/millet straw	10	7.3	2.9	211.7	1	5.6	0.2	0.1

n = number of households; CR = crop residues; Total available CR (a) = b × c × d

* Residues from the association cowpea/millet and cowpea/sorghum field are accounted for in cowpea, millet and sorghum fields separately.

Bonkoungou (1987a) indicated that *Parkia biglobosa* has a high density of plants in the Southwest of the country and all along the railway between Ouagadougou and Abidjan. The pulp from *Parkia biglobosa* pods is the object of important transactions in the markets in Burkina Faso in general and in the markets of Ouagadougou and Bobo Dioulasso in particular. The sellers of this product in Ouagadougou collect it in many rural markets, including Kokologo, Kombissiri, Bèga, Sakansé, Ipélsé, Sapouy and Réo. The sellers in the market of Bobo Dioulasso collect this product in markets of Toussiana, Gaoua, Banfora, Orodara and Péni where 100 kg was sold at 1,000 FCFA in 1996. This pulp is conditioned in bags weighing an average of 28 kg. The bag of powder was sold in 1996 at 3000 FCFA in the market of Ouagadougou (equivalent to 110 FCFA per kg) and at 1700 FCFA (60 FCFA/kg) at Bobo Dioulasso. In some localities of the North of Burkina Faso (Kaya, Dori, Gorom-Gorom) the bag of powder can reach 4000 FCFA according to some merchants in Ouagadougou.

Nutritive values of local feed resources
Chemical analyses giving the nutritive values (Table 3.2.1.3) of local feed resources show three categories of feedstuffs; cereal straws with low nutritive values of 2 to 4% of digestible protein (DP), legume hays with relative high nutritive values (7 to 8% of DP), and tree products with even higher nutritive value (around 10% of DP). Cereals not only have low amounts of digestible proteins but contain also high amounts of crude fiber and cellulose (20 - 30%).

Discussion

The results of our study show that in the village of Kouaré there are important quantities of crop residues produced at farm level (36 t/household), millet straw being the most important (34.6% of the potential production). This agrees with the estimation of Kanwé *et al*. (1997) at the national level who showed that since 1992, the quantity of millet straw is the most important and that in 2005, this production will represent alone 45.4% of the total crop residues. The result on the proportion of cereal residues (80%) is also in agreement with the result of Reed and Michael (1989) for the African continent. According to these authors, 70% of crop residues produced are cereal residues. For the extension services of Burkina Faso (MAE, 1991) this feed resource is gradually taking an important place in livestock feeding after the natural pasture in the agricultural zones of this country.

Table 3.2.1.3. Indicative nutritive value of local feed resources

	Chemical composition							
Feedstuffs	Dry matter (%)	Crude protein (%)	Digestible protein (%)	Metabolisable energy Kcal/kg	Cellu-lose (%)	Crude fiber (%)	Ca (%)	P (%)
Maize straw	85	3*	2.5	1.82	42.2*	29.30	0.49	0.08
Sorghum straw	97.5*	-	4	1.81	32	32.80	0.50	0.28
Millet straw	90.68	3.98	-	-	-	37.02	0.19	0.03
Groundnut hay	96.5*	7.4*	-	-	43.4*	20.01	0.51	0.05
Cowpea hay	97.3*	8.3*	-	-	50.1*	29.36	1.21	0.29
Rice straw	91.58	3.85	-	-	-	36.62	0.22	0.09
Acacia albida pods	90	11.4	-	-	-	-	0.40	0.17
Local beer by-product**	25	23.6	-	1.76	-	14.50	0.29	0.48

Source: * the current Thesis; NAS (1985); Fall-Touré *et al.* (1997); Siulapwa and Simukoko (nd);
** Dong and Ogle (2000).

It appears from the case study, that only a very small percentage (3.7%) of crop residues is stored at farm level for animal feeding during the dry season. According to the crop residue, 4.4% of millet, 16.4% of sorghum straw, 5.3% of groundnut hay and 1% of cowpea hay are stored. These values are lower than those indicated by Savadogo (2000) in an other village of Burkina Faso where in average 35% sorghum straw, 6% millet straw, 36% cowpea hay and 52% of groundnut hay were stored. The low percentage of the crop residues stored in our study may be explained by the lack of income generating livestock activities such as sheep fattening or milk production in the village of Kouaré. Another reason may be that most farmers do not have a cart for crop residues transportation. According to Savadogo (2000), household with carts stored more residues than household without carts. It means that important quantities of crop residues will remain in the fields and may be eaten by free roaming animals. Some may also be used for building material or as energy source for cooking. However, fire and termites will destroy a large part of these crop residues. Moreover, crop residues are stored in rudimentary conditions (shed or trees), allowing hardly appropriate preservation of the forage quality.

The currently small amount of crop residues stored asks for more efforts at farm level for rational conservation and use of the crop residues. Sheep fattening or milk production can provide opportunities for such rationalisation. Much research work has already been conducted on the matter. Soller *et al.* (1986) for instance tested diets composed of cereal residues with low protein supplements. It was indicated that these diets might be sufficient for draught animals to cover their energy requirement for maintenance and production. Drabo (1987) showed that urea treatment of rice straw can increase the nutritive value and the voluntary intake of this feedstuff. Soulama (1984) indicated that urea treatment on sorghum straw increases the crude protein level from 1.56 to 11.5%. Ouédraogo (1990) registered daily weight gains varying from 61.7 to 82.54 g/d with Djallonké sheeps using crop residues treated with urea. Bosma (1988) also used urea as source of non-protein nitrogen and ammonia for the improvement of the use of rice, sorghum and millet straws in animal feeding. Hebié (1992) evaluated the use of sorghum straw with urea treatment and supplementation with AIBP. There is sufficient evidence and agreement that the nutritive value of cereal residues (Table 3.2.1.3) is low and needs to be enhanced by the use of additives (urea) or in combination with AIBP to be a better source for improved livestock production.

The study also showed the availability of some alternative concentrate feedstuffs: *Parkia biglobosa* pulp powder, *Piliostigma reticulatum* or *Acacia albida* pods, millet and sorghum bran and local beer by-product. Farmer households that have *Parkia biglobosa* trees in their surroundings might consider using part of the powder for improvement of their animal production instead of selling the powder in the market. Each of these feedstuffs may be used in livestock production in general and in sheep fattening and village chicken production in particular.

Conclusion

The total amounts of crop residues produced at farm level are important but the parts available for livestock feeding are relatively small. Many constraints limit crop residues storage as the lack of transport materials, or the low practice of livestock activity that generates income such as sheep fattening or milk production. Appropriate measures are to be taken to store more quantities of crop residues in acceptable conditions, in order to increase their availability at farm level.

Storage can be motivated by the possibilities of valorisation of crop residues in sheep fattening activities that will be a source of income generation at farm level. Furthermore, the quality of crop residues is generally low. Measures to enhance quality by e.g. urea treatment or supplement with purchased AIBP or with local concentrate feeds is needed in the case of sheep fattening.

3.2.2. Seasonal variation in the availability of feedstuffs for scavenging village chickens at farm level

Abstract
The present study was conducted to investigate the availability of feedstuffs and slaughter performances for village chicken at farm level in Burkina Faso. A formal survey was conducted in 30 households with questions dealing with the farmers' practices in village chicken feeding. This formal survey was completed by analysis of chicken crop content. This analysis was performed after slaughter of village chickens according to the category of chicken (cocks, hens, cockerels or pullets) and the season (the rainy season, the dry season). The results of the study showed that the most important cereals used for supplementation were sorghum (57% of the households) and millet (33% of the households). Termites were also used as supplement in 30% of households. Sun dried crop content weight ranged from 10 to 14.67 g and no significant differences were observed between categories of chicken and between seasons. Fresh crop contents ranged from 32.2 to 54 g in the rainy season and from 17.9 to 27.2 g in the dry season with significant differences between these two seasons. The most available feedstuffs for scavenging chickens were cereal grains, which represent 73% and 53% respectively in the rainy season and the dry season. The contribution of insects and worms was negligible in both two seasons whereas they were found to represent 22% of crop content at the end of the rainy season in another study. Mean live body weights of village chicken were 1,223 g for cocks, 980 g for hens, 649 g for pullet and 771 g for cockerels. Between seasons there are significant ($P < 0.05$) differences of village chicken body weight with lowest body weights found in the dry season. From the crop content and body weights can be concluded that the nutritional status of village chicken is better balanced in the rainy season than in the dry season.

Keywords: Village chicken, feedstuffs, crop content, season, supplementation, feeding, Burkina Faso.

Introduction

Feedstuffs available for village chickens have been described for some developing countries (Gunaratne *et al*., 1993; Sonaiya, 1995) and it appeared that scavenging feedstuffs were specific to regions and even to countries. Kitalyi (1996) concluded that little has been done on the feeds resources for village chicken in Africa, where rural poultry in general and village chicken in particular, are mainly dependent on scavenging. In the rainy season there may be sufficient feed available for scavenging such as vegetables, insects and worms. In the dry season, there is scarcity of these kinds of feedstuffs but there may be more cereal grains available. Also, chaff and household wastes may be more available in the dry season. It is not known whether the available feedstuffs are sufficient in quantity and quality to sustain village chicken production and which supplements could be beneficial to support or even to increase chickens' production. Furthermore, in the different conditions of feeding, the performances at slaughter (live body weight, carcass weight, abdominal fat) of village chicken are not known.

The identification of strategies for village chicken feeding require at least an overview of feedstuffs that chickens have access to. That is in line with Gunaratne *et al.* (1993) who stated that it is desirable to look first at the possibilities for increasing productivity by more efficient use of the existing factors of production.

The research hypothesis of the current study is that the availability of feedstuffs for scavenging is season dependant and that analysis of the content of the crop of the animal and slaughter performances can be used to identify possible deficiencies. The specific objectives in this study were to identify per season of the year (dry versus rainy), the feedstuffs that contribute most to chickens' diets and to derive whether protein and/or energy are limiting factors in local village chicken feeding. This information will form the basis for the design of an appropriate feeding strategy for scavenging village chicken.

Materials and methods

The current study was carried out in the village of Matté in the Province of Oubritenga in Burkina Faso. This village was chosen as our site of research because it benefited from projects' support, which allowed an improvement of farmers' knowledge on village chicken production (Ouandaogo, 1997). The study was based on two methods: A formal survey based on a questionnaire and the method of crop content analysis modified after Tadelle (1996).

Survey

The formal survey deals with gathering information on farmers' practices in village chicken feeding through the use of questionnaires. This survey was conducted in 30 households. In each household, the head of the household was interviewed on how he fed village chickens and what feedstuffs he used to supplement his chickens. For each supplement, the percentage of household that uses the feedstuffs as supplement was calculated. Furthermore, the period of supplementation and the combination of the feedstuffs for the supplementation were appreciated through the frequency at which they were practiced in the households.

Analysis of crop content

Analyses of crop contents were done considering two periods of the year: the dry season from October to May and the rainy season from June to September. In each season, two slaughters of village chicken were done in order to analyse crop contents. In the rainy season, the slaughters were done in the months of June and July 2002 considered as the beginning of that season and in the dry season they took place in the months of March and April 2003. At each slaughter, 5 birds per category (cockerels, pullets, cocks, hens) of village chickens were randomly purchased in the village and sacrificed for crop content analysis, body weight and performance at slaughter. In each season, 40 randomly chosen birds (all categories confounded) were thus slaughtered (Table 3.2.2.1). The data of the nutritional status study collected during the end of the rainy season (Kondombo *et al.*, 2003a) completed the information.

Village chickens were randomly purchased in the village of Matté, the research site of the study. Birds were purchased a few days before slaughter. They were left to roam freely in the households of the seller until the hour of the slaughtering. The day of slaughtering, animals were caught after 11 hours. At that time, it is hot and birds are under the shadow of different shelters after scavenging. The caught birds were gathered at one place where they were killed one by one, feathers and digestive tract were being left off immediately. The time of each slaughtering, measurements and sun drying of crop content lasted about 3 hours. Measurements concerned live body weight, carcass weight and abdominal fat. The crops were removed, weighed and their contents were sun dried.

For carcass measurements, birds were slaughtered directly after weighing and the feathers were removed after dipping the carcass in hot water. Different parts of the carcass were separated. Carcass weight was taken after the feathers, lower leg, hearth, crop, pancreas,

Table 3.2.2.1. Experimental layout for collection of crop and carcass data

Season	Dry season								Rainy season							
Month of slaughtering	March				April				June				July			
Category of chickens	C	H	Co	Pu	C	H	Co	Pu	C	H	Co	Pu	C	H	Co	Pu
Numbers of birds slaughtered	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Total birds per slaughtering	20				20				20				20			
Total per season	40								40							

C = cocks; H = hens; Co = cockerels; Pu = pullets.

lungs, head and digestive and urogenital tracts were removed. Carcass percentage was determined as carcass weight/live weight at slaughter × 100.

After drying, crop content per bird was examined visually in the laboratory of the station of Saria. All differentiable feedstuffs were separated. The non-separable feedstuffs were considered as household wastes. The separate feedstuffs were then weighed with the electronic scale Mettler PM 4000 with 0.1 g of precision. The relative proportions of the different feedstuffs in village chicken crop were calculated on weight basis.

Statistical analysis

Quantitative data considering individual birds, were analysed with the software DBSTAT developed by the Animal Production System Group of Wageningen University. The model equation (Rash and Verdooren, 1998) used to analyse the parameters (crop content weight, body weight, carcass weight, dressing, etc.) was:

$$y_{ijk} = u + a_i + b_j + a_ib_j + e_{ijk},$$

with u the overall mean effect, a_i the effect of the season (I = 1,2), b_j the effect of the category of chicken (j = 1,2,3,4) a_ib_j the effect of the interaction, e_{ijk} the error term, E (e_{ijk}) = 0. Comparison of means was done by ANOVA using the t-test. The significant level was 0.05.

Results

Village chickens feed supplementation at farm level (survey data)

Supplementation of village chickens at farm level consists of a throw of cereal each morning. The principal period of the day for supplementation is the morning where 1/3 of the households provided the supplements (Table 3.2.2.2). For the majority of farmers (66%) supplementation of village chicken is done at each period of the year depending on the availability of feedstuffs in the household. However, supplementation decreases and even disappears during the rainy season. This is logical because at end of rainy season cereal grains become scarce even for human nutrition. Feedstuffs used for supplementation are dependent on what households have as cereals in store. Broken cereals are, in principle, given to chicks. In addition, farmers search termites in the bush and give them mainly to chicks. At periods of brooding, hens receive specially maize as supplement. Cereal chaffs are used as supplement, mainly during the period of human foods scarcity (July to August). Commercial chicken feed is generally unknown to farmers. For rural farmers, the lack of finance does not allow the use of such kind of feedstuffs.

Responses of farmers about the types of the supplements used are given in Table 3.2.2.3. This table shows that up to 57% of households use sorghum seed as supplement against 33% and 30% respectively for millet and termites.

In the households different feedstuffs sets are used for the supplementation. The frequency of each set used by households is presented in Table 3.2.2.4. The most important set used at farm level are sorghum/millet and cereals/termites respectively in 14.8 and 11.1% of the households. Commercial feeds were never used in the village.

Table 3.2.2.2. Percentage of household (n = 30) according to the period of village chicken supplementation

Period	Percentage of household
Each morning	33.33
Morning and evening	3.33
Only in the dry season	3.33
At all season	66.67
Sometimes	6.67

n = number of households.

Table 3.2.2.3. Percentage of households (n = 30) that uses a certain type of feedstuff for village chicken supplementation

Feedstuffs	Percentage of household
Sorghum	57
Broken cereals	10
Millet	33
Maize	17
Cereal chaff	0.1
Commercial feeds	0
Termites	30

n = number of households.

Table 3.2.2.4. Percentage of household (n = 27) according to the set of feedstuffs used in village chicken supplementation

Set of feedstuffs	Percentage of household
Sorghum and broken cereals	7.4
Cereal consumed in the household	29.6
Sorghum and termites	7.4
Cereals, chaff and termites	3.7
Sorghum and maize	7.4
Sorghum and millet	14.8
Cereals and cereal chaff	3.7
Sorghum, millet, maize and broken cereals	7.4
Sorghum and cereal chaff	3.7
Cereals and termites	11.1
Millet, sorghum and termites	3.7

n = number of households.

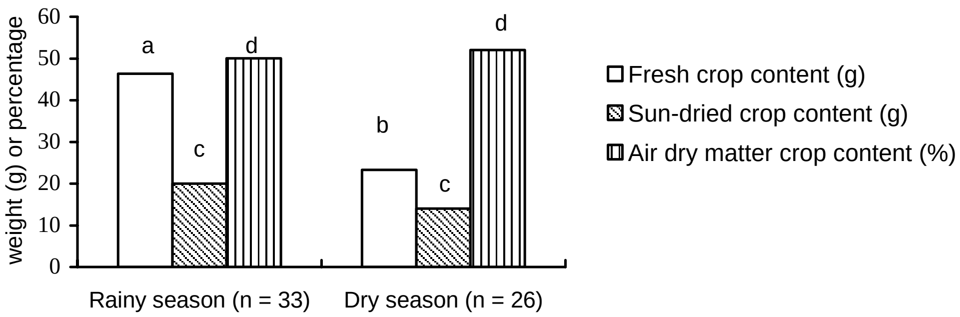

Figure 3.2.2.1. Fresh crop content weight (g), sun dried crop content weight (g) and air dry matter crop content percentage (%) of village chicken

n = number of crop contents analysed; n was different from setup because some purchased chickens were missing or the crop were empty the day of slaughtering. For the same parameter, means with different letters are significantly different at $P < 0.05$.

Crop content weight according to the category of chicken and the season

Results on crop content (Table 3.2.2.5) indicate that there are no significant differences ($P \geq 0.05$) between the different categories (cocks, hens, cockerels and pullets) of village chicken for fresh, sun dried crop content or air dry matter within a season of the year. Sun dried crop content weight ranged from 12 to 26 g. Between seasons however, one observed that fresh crop content was significantly higher in the rainy season (Figure 3.2.2.1). Fresh crop content ranged from 35 to 60 g in the rainy season and from 25 to 30 g in the dry season. This is the result of higher availability of water in the rainy season and higher water content of the feedstuffs in this season. In terms of air dry matter, ranging form 44 to 57%, no significant differences ($P \geq 0.05$) were observed between seasons.

Village chicken nutritional status according to the season

The results of the current study show that there are more different types of feedstuffs in the rainy season than in the dry season (Table 3.2.2.6). In the dry season 13 types of feedstuffs are noted: maize seed, red sorghum seed, white sorghum seed, groundnut seed, bone, *Tamarindus indica* leaves, millet, household waste, insects, stone, cereal chaff, egg shell, vegetable. In the rainy season, in addition to those observed in the dry season, other feedstuffs observed are bean seed, worm, and raisin. Insects, worm and tree fruit such as raisin are more specific to the rainy season.

Household waste and the unspecified feedstuffs appear to be the most important feedstuffs available for village chicken in both two seasons. They represent 29.3% in the rainy season and 41.6% in the dry season. Other important feedstuffs available during the two seasons are white sorghum and cereal chaff. When the feedstuffs are grouped by category (cereal seeds, insects/worms, household waste/unspecified materials, legume seed, bone/stone/egg shells, vegetable), it appears that the most available feedstuff in both seasons is the cereal seeds including cereals chaffs (53 to 77% of crop content) as is presented in Figure 3.2.2.2. In the dry season, the contribution of household waste higher (42%) than in the rainy season when it represents only 15 to 22%.

Table 3.2.2.5. Weight of village chicken crop contents per season and per category of chicken

Parameters	Cock	Hens	Cockerel	Pullet
Rainy season (n=33)	n = 7	n = 10	n = 8	n = 8
Fresh crop content (g)	50.0 ± 26.5	58.0 ± 87.0	42.5 ± 26.6	35.0 ± 27.3
Sun-dried crop content (g)	25.8 ± 14.7	16.7 ± 10.8	19.5 ± 13.0	19.6 ± 15.2
Air dry matter (%)	52.5 ± 20.1	44.2 ± 16.1	50.2 ± 20.6	54.9 ± 20.6
	Cock	Hens	Cockerel	Pullet
Dry season (n=26)	n = 6	n = 8	n = 7	n = 5
Fresh crop content (g)	30.0 ± 34.6	27.5 ± 16.7	30.0 ± 15.3	25.0 ± 16.6
Sun-dried crop content (g)	13.7 ± 14.3	15.1 ± 9.2	14.1 ± 5.5	12.7 ± 10.9
Air dry matter (%)	48.8 ± 22.5	56.8 ± 17.7	49.4 ± 11.5	51.9 ± 23.7

n = number of crop contents analysed; n was different from setup because some purchased chickens were missing or the crop were empty the day of slaughtering.

Table 3.2.2.6. Variability of feedstuffs found in chicken crops expressed in percentages of crop content air-dried matter in the village of Matté

	Season		
Feedstuffs in crop	Rainy season n = 33	Dry season n = 26	Overall (n = 59)
Maize	0.20	0.00	1.21
Bean seed	0.10	0.00	0.06
Red sorghum	4.95	0.33	3.39
White sorghum	14.99	41.05	23.33
Groundnut seed	0.15	1.56	0.61
Bone	0.46	0.41	0.42
Tamarindus leaf	0.00	0.08	0.02
Wood	0.05	0.00	0.03
Sorghum bran	32.33	0.00	21.45
Worm	0.05	0.00	0.04
Millet	5.41	0.66	3.82
Household wastes	6.02	44.83	18.60
Raisin	5.10	0.00	3.39
Insect	0.10	0.00	0.06
Stones	2.65	3.78	2.97
Cereal chaff	11.58	5.09	9.33
Egg shells	0.25	0.65	0.36
Vegetable	1.07	0.33	0.85
Chicken feather	0.01	0	0
Unspecified feeds	14.53	1.23	10.06
Overall	100	100	100

n = number of crop contents analysed; n was different from setup because some purchased chickens were missing or the crop were empty the day of slaughtering.

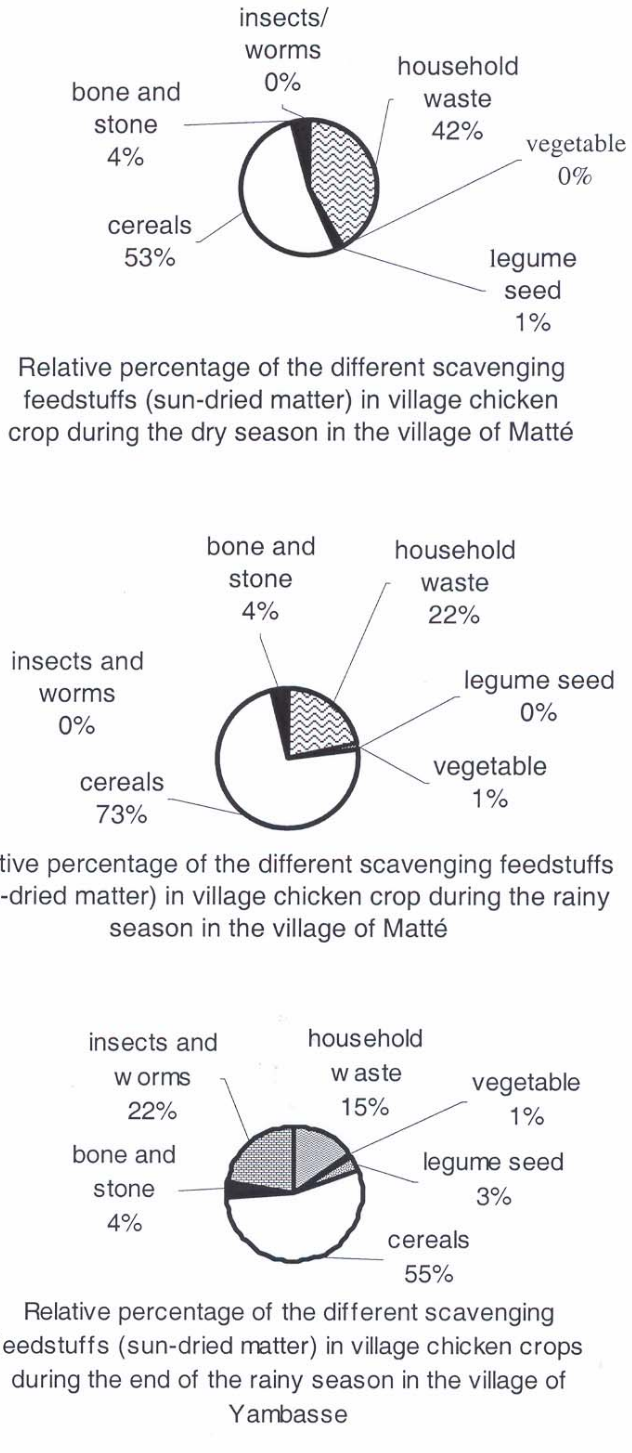

Figure 3.2.2.2. Relative percentage of the different scavenging feedstuffs (sun-dried matter) in village chicken crops according to the season of the year

Table 3.2.2.7. Slaughter performances according to the category of village chicken

Parameters	Category of village chicken			
	Cock n = 18	Hen n = 21	Cockerel n = 19	Pullet n = 21
Live body weight (g)	1223.1[a]	980.5[b]	771.3[c]	648.8[c]
Carcass weight (g)	933.3[a]	683.3[b]	547.9[c]	448.6[d]
Carcass dressing (%)	78.4	73.9	74.8	71.1
Abdominal fat weight (g)	3.4[b]	19[a]	3.2[b]	1.7[b]

n = number of chickens; n was different from setup because of the missing of the purchased chickens the day of slaughtering and/replacement by another category by farmer.
Means on the same row with different superscript letters are significantly different at P < 0.05.

Table 3.2.2.8. Influence of season and category of village chicken on slaughter performance

Parameters	Season							
	Rainy season (n = 41)				Dry season (n = 38)			
	Category of village chicken							
	Cock n = 10	Hen n =10	Cockerel n = 10	Pullet n = 11	Cock n = 8	Hen n = 11	Cockerel n = 9	Pullet n = 10
Live body weight	1362.0[da]	1196.0[a]	873.0[ab]	704.6[b]	1049.4[a]	784.6[b]	658.3[bc]	587.5[c]
Carcass weight	944.0[a]	721.0[b]	573.0[bc]	452.7[c]	920.0[a]	649.0[b]	520.0[bc]	444.0[c]
Carcass dressing	70.1[ac]	83.6[ac]	69.8[ac]	65.5[a]	88.7[b]	83.3[b]	80.3[bc]	77.3[bc]
Abdominal fat	3	14	2	0	3.9[b]	23.6[a]	4.4[b]	3.5[b]

n = number of chickens; n was different from setup because of the missing of the purchased chickens the day of slaughtering and/replacement by another category by farmer.
Within season, means on the same row with different superscript letters are significantly different at P < 0.05.

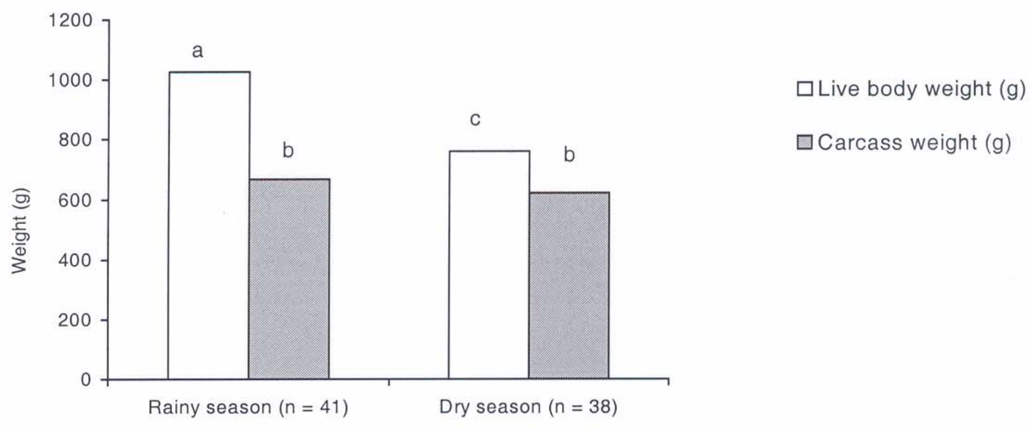

Figure 3.2.2.3. Village chicken live body and carcass weights (all age & sex confounding) according to the season
n = number of chicken; n was different from setup because of the missing of the purchased chickens the day of slaughtering and/replacement by another category by farmer.
For the same parameters, means with different letters are significantly different at P < 0.05.

In the current study insects and worms appear to be negligible in village chicken feeding in both seasons. In comparison to previous results (Kondombo *et al*., 2003a) it is noted that at the end of the rainy season insects and worms can however contribute up to 22% to the crop content.

Slaughter performance per season and per category of village chicken
Tables 3.2.2.7 and 3.2.2.8 present results of slaughter performance per chicken category and per season. Body weight differs significantly ($P < 0.05$) between the categories of village chicken. Body weight of cock is significantly higher than the other categories with a mean body weight of 1,223 g against 980 g for hens. Cockerels and pullets have similar mean body weights of respectively 771 and 648 g. Hens have more abdominal fat than cocks, cockerels or pullets. Village chicken body weight is significantly lower in the dry season ($P < 0.05$) than in the rainy season (Figure 3.2.2.3). Although in term of carcass weight, no significant difference ($P \geq 0.05$) was observed between seasons.

Discussion

A formal survey based on questionnaires was used to collect qualitative data to appreciate village chicken supplementation at farm level. Although there are some limits which are related to the method used (questionnaire and crop analysis), the study allowed having an overview of how village chicken are fed at farm level. The most important part of village chickens daily diet is assured by the animals themselves by mean of scavenging. Variable but small quantities of cereal grains (maize, sorghum or millet) are provided to poultry each morning, when family grain reserves permit it. In the research site, sorghum and millet respectively are given to chicken in 56% and 33% of the households. Termites are also often provided to village chicks.

Supplementation with cereals can obviously not be provided regularly or in high quantities as in general food security is not satisfied in rural households in Burkina Faso as is the case in many developing countries. In the current study, protein sources (termites) are reserved to chick supplementation and maize to brooding hens. The feed resources found in this study have low nutritive value compared to those used in some villages in Mali. In the village Kangba of Mali, feed resources used are sorghum (for 67% of poultry farmers), maize, bran and fish for 50%, oyster shells, termites and salad for 33% and worms for 17%. In the village Dioïla, also in Mali, termites, maize, sorghum, cereal chaffs, fish meal, oyster shell, local beerby-product and mango are used in village chicken feeding (Traoré and Modibo, 1997).

The simple principle of supplementation is an example of improved practices in village chicken feeding. According to Roberts *et al.* (1994) supplementing household refuse with protein sources improves both survival rate and growth rate in chicken.

The method of crop analysis used to identify scavenging feedstuffs at village level appears to be a snapshot observation and cannot give data on the quantity of feedstuffs that village chicken eat daily at household level. The method did however allow making an inventory of the seasonal availability of scavenging feedstuffs. The study indicated that availability of feedstuffs for scavenging village chicken is season dependant. In the rainy season, environmental feedstuffs (insects, termites, worm, vegetable) are more available ($P < 0.05$) and village chicken body weight is higher and more interesting for the market. Particularly at the end of the rainy season, the proportion of insects/worms becomes important (Kondombo *et al.*, 2003a). In the dry season, the availability and variability of feedstuffs is lower with the consequence of lower body weights for the different categories of village chicken. In the rainy season, the village chicken diet from scavenging is apparently more balanced. Supplementation may therefore have less effect in the rainy season than in the dry season. These results are in accordance with Sonaiya (1995) who stated that during the dry season, poultry can quickly develop vitamin deficiencies as a result of the scarcity of succulent vegetables on the range.

Crop content sun dried matter ranged from 14 to 20 g which is higher than found by Tadelle (1996). Further, the air dry matter percentage ranged from 44% to 57%. These results of crop content air dry matter are higher than the 34.4% indicated by Gunaratne *et al.*, 1993. From the nutritional status, it appears that in the dry season, cereals and household wastes are the feedstuffs most available for village chicken. At the beginning of the rainy season, vegetables and insects are more or less available. At the end of the rainy season, insects and worms can account for up to 22% of the crop content (Kondombo *et al*., 2003a).

The live body weights found in the current study are 1,064 to 1,419 g for cocks and 820 to 1,262 g for hens. These body weights are similar to those of village chicken indicated by Guèye (1998): body weights of 1.2 to 1.8 kg for adult cock and 0.7 to 1.2 kg for adult hens. Gunaratne *et al*. (1993) indicated body weights of 1,160 g for pullet, 1,259 g for hens and 1,778 g for mature cocks. Body weights significantly differ between seasons. The low availability of protein sources (worm, insects) for scavenging chicken in the dry season may explain the lower body weights in this period compared to the rainy season. As a consequence supplementation is more indicated in the dry season than in the rainy season if the possibility of scavenging is assured.

The higher weights are observed in the rainy season when village chicken price is lower than in the dry season. In the dry season there are more feasts, increasing demands, while at the same time lower number of village chicken are available due to outbreaks of diseases and particularly of Newcastle disease. It would be highly profitable to improve village chicken body weight gain during the dry season as it was demonstrated (Kondombo, 2000) that village chicken price is strongly correlated (r = 0.6) to body weight, and prices are exceptionally favourable in this season.

The study shows that the most available feedstuffs for scavenging chicken at any season are cereal grains. Although in the rainy season, vegetable, insects and worms appear. It seems that in any season, village chicken diets contain essentially energy sources. So, supplementation of village chicken at any season with protein source may be necessary to improve village chicken feeding.

Conclusion

The current study indicated that different feedstuffs are available at household level for village chickens feeding. The feedstuffs mostly used for supplementation are by decreasing importance sorghum, millet and termites. The analysis of crop content indicated that in addition to the cereals, vegetables, insects and worms are available for village chickens in the rainy season. In the dry season, village feeds are essentially cereals, cereal by-products and household wastes. With regard to the availability of feedstuffs for village chicken, and the lower weights in the dry season, the question raises whether the quantity and quality of the scavenging feedstuffs is sufficient for village chickens potential production. Maybe village chickens should be supplemented at any season for higher productivity. In the dry and the beginning of the rainy season, protein sources are low. This source becomes more important at the end of the rainy season due to the increase of insects and worms at that period. Village chicken feeding strategies based on scavenging and including seasonal protein and/or energy supplements need to be tested and compared to complete commercial chicken feeds in order to identify how village chicken production can best be improved.

CHAPTER 4

Feeding strategies for village chicken production improvement

4.1. Effects of local feedstuff supplementation on performance and nutritional status of village chickens during the end of the rainy season in Burkina Faso*

4.2. Effects of commercial pullet feed on village chicken performance

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4.1. Effects of local feedstuff supplementation on performance and nutritional status of village chickens during the end of the rainy season in Burkina Faso

Abstract
The effect of local feedstuff supplementation during the end of the rainy season, from September to October, on performance of village chicken cockerels was investigated using four treatments (T1 to T4) and four blocks. In T1, birds were allowed to find their daily ration by scavenging only. In T2, T3 and T4, birds received after scavenging supplementation with red sorghum seeds, artisanal sorghum beer by-product or the combination of both, respectively. Four household compounds, in a village in the Central Region of Burkina Faso, were assigned as blocks. The results suggested that during the end of the rainy season, scavenging enables an average weight gain of 5.9 g/d in the cockerels. No clear effect of supplementation on performance was observed. When scavenging feedstuffs were available, the local beer by-product or the combination of red sorghum and beer by-product gave higher body weight gains. At the end of the experiment, three to four birds per treatment and per block were slaughtered after scavenging, and crop contents were sun-dried and examined physically. The major components of scavenging feedstuffs during the period of the study were cereals (55%), and worms or insects (22%). This study provides some indications for stategic feeding of village chickens during the end of the rainy season.

Keywords: Village chicken, cockerel, supplementary feeding, poultry farming, Burkina Faso.

Introduction

A number of authors (Dieng *et al.,* 1998; Guèye, 1998; Sonaiya *et al.,* 1999) stated that indigenous poultry in tropical rural areas mainly find their daily diet by scavenging around households. However, the scavenging feed resource base is limited and varies with seasonal circumstances such as rainfall, cultivation, harvest and crop processing (Gunaratne *et al.*, 1993). In general, farmers supplement birds by giving them household wastes, or cereal by-products, generally in the morning or late in the afternoon (Chrysostome *et al.*, 1995). In the rainy season, many feedstuffs for scavenging are available, such as insects, worms, cereal seeds, vegetables (Tadelle, 1996). However, according to Sonaiya *et al.* (1999), most available feeds for scavenging have a relatively low energy concentration due to their high crude fiber levels. Then, the hypothesis can be stated that even in the rainy season, particularly at the end of the rainy season, when more available feedstuffs are present, supplementation with some local feedstuffs may improve village chicken growth.

In the case of the Central Region of Burkina Faso, farmers use in general red sorghum seeds as supplement. It was investigated in this study whether supplementation with red sorghum and/or artisanal beer by-product could be helpful in improving performance during the end of the rainy season (September to October). The current study aimed at identifying the effect of supplementation during the end of the rainy season on village chicken growth and slaughter performance by evaluating four dietary treatments.

Materials and methods

Birds, housing and management

A total of 160 cockerels of village chickens with a mean body weight of 756.3 ± 12.6 g were purchased at local markets for the trial. Housing consisted of pens with a surface area of 1 m^2 per group of 10 birds.

The birds were vaccinated with ITA-New as prophylaxis against Newcastle disease and received the 'Vermifuge Polyvalent Volailles' (VPV) 100 against internal parasites at the beginning of the trial; the birds were left to adapt to their pens and treatments for a week.

Scavenging birds were free ranged early in the morning (around 6 a.m.) and enclosed in their pens late in the evening (around 6 p.m.). Birds which received supplements were captured in the afternoon after scavenging and received supplementation in their respective pens. Supplementation was given *ad libitum*. Two types of local feedstuffs were used as supplements: (1) red sorghum seeds, and (2) artisanal sorghum beer by-product. Household compounds were the source for scavenging feedstuffs. Birds had free access to water throughout the day.

The study was carried out under village conditions during the end of the rainy season in the village of Yambassé, located in the Central Region of Burkina Faso. This period covers two months, September and October, when crop products are ready for harvesting. Daily capture of the birds and distribution of the different supplements in each household compound were performed with the help of the household chief and some members of his family.

Design of the experiment

Four types of feeding were assigned to treatments T1 to T4:

T1 scavenging only; cockerels found their feed around the household compounds;

T2 scavenging + *ad libitum* supplementation with red sorghum seeds;

T3 scavenging + *ad libitum* supplementation with artisanal sorghum beer by-product;

T4 scavenging + *ad libitum* supplementation with both feedstuffs given separately in two troughs.

Four household compounds were used as blocks. A set of five to eight birds were used in each treatment at each household. At the end of the trial, three to four birds per treatment and block were slaughtered in the morning at around 9 a.m. This time was chosen based on the observations by Faltwell and Fox in 1978 (Tadelle, 1996). They indicated that birds fill their crop in a four-hour cycle of eating.

Data collection

Collection of data started after one week of adaptation to the diet and to the pens in each block. The parameters measured were body weight gain, supplement consumption, dressing percentage, carcass weight and crop contents. For that, live body weights of individual chickens and feed refusals for each experimental unit were weighed weekly. At slaughter, the gut was removed and the carcass, head and legs of each cockerel were weighed.

Crop contents were sun-dried and dry crop contents were visually examined and weighed in order to distinguish different feedstuffs and their proportions in the crop. With regard to the statement that, for empirical experiments (Gous, 1986), responses in growth should be measured over a short time period, the present experiment was carried out in 4 weeks.

Cost benefit of the supplementation was assessed on the basis of feed cost, purchased price and profilaxis cost. In the market during the period of the study, the red sorghum price was 100 FCFA/kg and the local beer by-product was 10 FCFA/kg. The village chicken sale price was calculated on the basis of the regression equation that relates village chicken body weight with price (sale price = 175.4 + 0.7 body weight [g], with r = 0.6), as previously reported by Kondombo (2000).

Statistical analyses
SPSS was used for data analysis considering individual bird data. The differences between treatments and blocks were studied by ANOVA by the General Linear Model procedure. The model (Rasch and Verdooren, 1998) used to analyse the parameters (body weight gain, intake, dressing percentage, carcass weight, etc.) was:

$y_{ijk} = u + a_i + b_j + a_ib_j + e_{ijk}$,

with u the overall mean effect; a_i the effect of the treatment (type of feeding), b_j the effect of the block (household), a_ib_j the effect of the interaction; e_{ijk} the error term, $E(e_{ijk}) = 0$. The significance level was 0.05. Separation of means was done by the pair-wise multiple comparison test, using the Least Significant Difference (LSD) test.

Results

Effect of type of feeding (treatment) and availability of scavenging feedstuffs (block or household) on village chicken cockerels' weight gain
Results on cockerel weight gains per type of feeding (treatments) and scavenging conditions (household compound or block) during 28 days are presented in Table 4.1.1. Appreciation of the main effects indicated that there were no significant differences ($P \geq 0.05$) between treatments for four weeks in cockerel body weight gain; whereas between blocks significant differences were observed. Blocks 1 and 4 had higher ($P < 0.05$) weight gains (202.9 and 222.5 g, respectively) than blocks 2 and 3 (on average 125.3 g). Nevertheless, a tendency of higher weight gain was observed with supplementation by artisanal beer by-product T3 (184.8 ± 27.9 g and an average daily weight gain of 6.6 g/d). The slowest growers were the birds that could choose between red sorghum and local beer by-product (T4) with a weight gain of 155.2 ± 42.9 g and an average daily weight gain of 5.5 g/d.

The effect of supplementation was not similar in each household (Table 4.1.1). Hence, when the availability of the scavenging feedstuffs was large (B1), supplementation with red sorghum, artisanal beer by-product or both did not allow cockerels to gain more weight than scavenging alone. The combination (T4) even reduced body weight gain significantly. When there was scarcity of scavenging feedstuffs (B2, evidenced by the lowest weight gain of T1), supplementation with red sorghum (T2) resulted in the highest weight gain ($P < 0.05$), but the combination (T4) did not give the same result. When scavenging feedstuffs were relatively sufficient but in such a way that supplementation could have some effects (B4), the use of both feedstuffs (T4; red sorghum and artisanal beer by-product) gave better ($P < 0.05$) results, followed by the use of the local beer by-product only (T3).

Intake of feedstuff supplements by village chicken cockerels
Supplemental intakes of red sorghum and artisanal beer by-product, according to the treatments and the blocks, are presented in Table 4.1.2. Significant differences ($P < 0.05$) of supplemental intakes were observed between treatments with 43.4 g/day/bird for the red sorghum, 31.0 g/d/bird for the combination of red sorghum and artisanal beer by-product and 5.9 g/d/bird for the local beer by-product. When analysed by block, only intake in block 2 appeared to be higher than the intakes in the other blocks with 30.8 g/d versus, on average, 25.4 g/d of supplement intakes. Within blocks, higher intakes were observed in B2 for red sorghum (T2), in B4 for the beer by-product (T3), and in B1 for the combination (T4).

Table 4.1.1. Body weight gain of village chicken cockerels (mean [g] ± SE) according to the type of feeding (treatments) and the household (blocks) during 28 days

Blocks	Treatments (g)				Overall (g)
	T1	T2	T3	T4	
B1	233.3 ± 30.1 [a]	221.9 ± 24.7 [a]	209.4 ± 17.3 [a]	146.9 ± 20.3 [b]	202.9 ± 19.2 [ab]
B2	87.5 ± 18.3[b]	212.5 ± 6.7 [a]	125.0 ± 24.0[b]	106.3 ± 14.8 [b]	132.8 ± 27.6 [bc]
B3	128.6 ± 25.3 [ab]	95.8 ± 16.4 [b]	155.0 ± 13.8 [a]	89.3 ± 18.8 [b]	117.8 ± 15.3 [c]
B4	208.3 ± 12.6[b]	153.1 ± 17.3 [c]	250.0 ± 23.7 [ab]	278.6 ± 17.9 [a]	222.5 ± 27.3 [a]
Overall	164.4 ± 34 [a]	170.8 ± 29.3 [a]	184.8 ± 27.9 [a]	155.2 ± 42.9 [a]	

T1 = scavenging only; T2 = scavenging + red sorghum; T3 = scavenging + artisanal beer by-product; T4 = scavenging + red sorghum + artisanal beer by-product.

For the interaction, mean values on the same row with different superscripts are significantly different at P < 0.05. For the overalls, mean values on the same column or on the same row with different superscripts are significantly different at P < 0.05.

Table 4.1.2. Intake of supplement sun-dried matter (mean [g] ± SE) by village chicken cockerels according to the type of feeding (treatments) and the household (Blocks)

Blocks	Treatments				Overall
	T1	T2	T3	T4	
B1	-	43.0 ± 2.5	4.1 ± 2.3	33.4 ± 2.2	26.8 ± 1.4[a]
B2	-	53.8 ± 2.2	5.9 ± 2.5	32.8 ± 2.2	30.8 ± 1.3[b]
B3	-	41.7 ± 1.7	5.8 ± 1.7	26.7 ± 1.7	24.7 ± 1.0[a]
B4	-	35.3 ± 1.7	7.7 ± 1.8	30.9 ± 1.7	24.6 ± 1.0[a]
Overall	-	43.4 ± 1.3[a]	5.9 ± 1.1 [b]	31.0 ± 1.0[c]	

T1 = scavenging only; T2 = scavenging + red sorghum; T3 = scavenging + artisanal beer by-product; T4 = scavenging + red sorghum + artisanal beer by-product.

For the overalls, mean values in the same row or in the same column with different superscripts are significantly different at P < 0.05.

Effect of type of feeding on slaughter data of village chicken cockerels

Dressing percentages of cockerels were 61.0, 64.3, 65.5 and 61.5% for T1 to T4, respectively. Carcass weight varied between 370 and 690 g. No significant differences (P > 0.05) were observed between treatments or blocks for carcass weight and dressing percentage. Within block, some tendencies could be distinguished. Hence, in B1, T1 gave a higher carcass weight (640 g), whereas in B2, B3 and B4, T2 (634 g), T3 (690 g) and T3 (613 g) gave the best performances, respectively. In terms of dressing percentage, the effect of treatment within a block did not follow the same tendency as carcass weight. Hence, in B1, B2, B3, and B4, highest dressings were observed with T3, T2, T4 and T3, respectively.

Crop contents of village chicken cockerels

The diversity of scavenging feedstuffs was observed by examination of crop contents. Crops contained sun-dried matter and weighed between 8.9 and 12.7 g, with a mean of 9.9 g. Five types of feedstuffs could be distinguished: insects/worms; cereals; stones, eggshells and bones; grass; and legumes seeds. Cereals (55%) and insects/worms (22%) represented the most available scavenging feedstuffs for village chickens during the period of the study

(Table 4.1.3). In absolute numbers, cereals, insects/worms, stones, egg shells and bones, grass, legume seeds and unspecified feedstuffs, which were probably household waste, represented 5.5 g, 2.2 g, 0.1 g, 0.32 g and 1.5 g in the crop of village chicken cockerels, respectively.

According to the block or household, no significant differences were observed for sun-dried matter of crop content weights between blocks. However, the nature and percentage of the feedstuffs in the crop varied according to the block.

Economical assessment of the supplementation

To describe the economical effect of the supplements used, an economical assessment taking into account feed cost, purchased price and profilaxis cost is presented in Table 4.1.4. Costs of labor and housing were not taken into account as they could vary considerably from one farmer to another. Results indicated higher gross margins with treatments T3 and T1 and no significant difference ($P < 0.05$) was observed between these two treatments. Furthermore, it appeared that the use of red sorghum (T2 and T4) as supplement lowered the gross margin.

Discussion

The current study suggested that the effects of supplementation might be dependent on the availability of scavenging feedstuffs. In all scavenging conditions (B1, B2, B3, B4), a positive weight gain was found when birds were fed on scavenging feedstuffs only. Then, it can be stated that at the end of the rainy season, scavenging feedstuffs are enough to support village chicken body weight gain. These observations are consistent with a previous observation (Tadelle, 1996), indicating that in the rainy season, an increase of available proteins (insects, worms) and succulent vegetables prevent undernutrition of village poultry.

Table 4.1.3. Variability of feedstuffs found in chicken crops expressed in percentages of crop content air-dried matter per block

	Household compounds				
Feedstuffs in crop	Block 1	Block 2	Block 3	Block 4	Overall
Red sorghum	23.4	46.6	48.1	11.7	35.6
Worms	6.0	31.1	16.6	11.7	18.8
Maize	0.8	7.8	6.5	34.0	11.9
Rice	30.5	1.1	0.9	6.4	6.0
Insects	7.0	2.2	3.7	0	3.0
Stones	14.1	1.1	0.9	2.1	3.0
Groundnut seeds	0	0	1.8	4.2	2.0
Millet	0.2	0.1	0	0	1.0
Bones	0	0	0	4.2	1.0
Herb leaves	0.8	2.2	2.7	0	1.0
Herb seeds	3.1	0	0.2	0	0.5
Bean seeds	0	0	0.1	2.1	0.4
Egg shells	0	0	0.9	0.3	0.4
Groundnut shells	0	0	0	1.0	0.3
Unspecified	14.1	7.8	17.2	22.3	14.9
Overall	100	100	100	100	100

Table 4.1.4. Economical assessment of the supplementation

	Treatments			
	T1	T2	T3	T4
Starting weight (g)	792.7	726.0	770.4	736.1
Purchased price (FCFA) (A)	730	685	715	690
Weight (g) at week 4	957.1	896.9	955.2	891.3
Gross income (FCFA)/bird (B)	845	805	845	800
Supplement cost (FCFA) (C)	0	120	5	75
Prophylaxis cost (FCFA) (D)	30	30	30	30
Gross margin (FCFA)/bird (B – [A + C + D])	85[a]	–30[c]	95[a]	5[b]

T1 = scavenging only; T2 = scavenging + red sorghum; T3 = scavenging + artisanal beer by-product; T4 = scavenging + red sorghum + artisanal beer by-product.

Means of gross margin with different superscripts are significantly different at $P < 0.05$.

There were higher significant differences between blocks and this may indicate that the quantity and nutritive value of available scavenging feedstuffs varied widely between household compounds. Thus, the availability of scavenging feedstuffs had a high influence on the effect of supplementation of village chickens and had to be taken into account for the choice of feedstuffs to be used as supplements and the period of supplementation.

Sorghum has a mean content of 8.9% crude protein, 2400 kcal/kg calories of metabolisable energy, 2.3% crude fiber, 0.003% calcium, and 0.28% phosphorus (NAS, 1977). It is thus a valuable feed supplement. As a by-product of red sorghum, the artisanal beer by-product has a lower nutritive value (less starch) than the red sorghum itself.

In general, daily weight gains were low in this study (5.5 g/d to 6.6 g/d). This may be due to the inadequacy of the free-range daily diet, the low nutritive value of the supplements used in the study, or the low genetic potential of village chickens; indigenous chickens are known to have some disadvantages such as slow growth, poor egg production and late sexual maturity (Guèye, 1998; Guèye, 2000; Ndegwa *et al*., 2001).

Body weight gains were not significantly different ($P \geq 0.05$) between treatments, which is in contradiction with another study (Huque *et al.,* 1999); these authors stated that supplemental feed, especially protein sources, increased the productivity of scavenging and semi-scavenging chickens. The lack of effect of supplementation suggested that in the conditions of this experiment the availability of feed to scavenging chickens was not the major limiting factor for performance. However, in absolute terms, there was a higher weight gain with the supplementation of artisanal beer by-product (T3) and a somewhat lower weight gain with the supplementation of both feedstuffs (T4). It should be noted that there was a large interaction between households and treatments. Moreover, bird performance was not clearly related to the quantity of supplemental DM consumed by the cockerels. Some feed consumption results were difficult to explain, e.g. consumption was always higher in T2 than in T4. Intakes of red sorghum (24.6 g/d in T4 vs 42.7 g/d in T2) and artisanal beer by-product (5.4 g/d vs 6.7 g/d in T3) were both lower in T4 than in T2 and T3, respectively.

Palatability of the local beer by-product could have affected feed intake negatively. This might be due to the relatively high crude fiber content in the artisanal sorghum beer by-product and its structure (flour), which might have reduced feed intake. According to other studies (a.o., Sonaiya, 1995), about 35 g of grain supplement per hen per day is necessary for local chickens in the free-range system. The range of intake of the red sorghum (35 to 54 g) observed in the present study was consistent with this figure and should then have promoted a satisfactory growth.

Analyses of crop contents in this study showed that cereals remain the main available feedstuffs (55%) for village chickens during the period of study. The main cereal was sorghum seed, which represented 66% of the cereals present in the crop. This observation was related to the fact that households in this village grew mainly sorghum (essentially red sorghum) around household compounds. So, village chickens had more easily access to sorghum, as a source of energy in their daily diet, than to other seeds. The other feedstuffs seemed negligible in village chickens daily diets. A previous study (Tadelle, 1996) also showed high percentages of seeds in village chicken crops (about 30.9%) during the rainy season in the central region of Ethiopia.

The economical assessment in relation to the treatments showed a negative gross margin with the use of sorghum as supplement (T2). A better-expected gross margin (95 FCFA/bird) was observed with the use of the artisanal beer by-product due to its low cost, but it was not significantly different from the control. According to these results, it can be suggested that in the present conditions supplementing village chickens with artisanal beer by-product or sorghum is not appropriate.

Conclusions

The current study does not indicate the necessity to supplement village chickens with red sorghum or artisanal beer by-product at the end of the rainy season. However, it can be anticipated that in household conditions or in a season when scavenging feedstuffs are less available, supplementation could be more efficient, improving village chicken weight gain. Futhermore, the cost/benefit study of the supplementation showed the need to use low cost feedstuffs for village chicken supplementation. For that purpose, some by-products such as local beer by-product seem more suited for supplementation than cereals. This should be studied at periods when supplementation has a significant effect. But in that case, proteins might be the main limiting factor for scavenging birds. In further investigations, local available proteins from by-products should be identified, as well as their appropriate period of supplementation. Factors that influence palatability of supplementation should be studied as well.

4.2. Effects of commercial pullet feed on village chicken performance

Abstract
The use and economical assessment of commercial feed was investigated in village chicken feeding. The trial was a factorial design with 3 factors each at 3 levels. The first factor was the period of feeding (beginning of the rainy season, the rainy season, or the hot dry season). The second factor was the availability of scavenging feedstuffs represented by the household compound of three volunteer households. The third factor was the type of feeding strategy (scavenging only, scavenging + supplementation with commercial pullet feed, or permanent confinement and birds fed with commercial pullet feed). Ninety six village chicken cockerels with mean body weight of 432.6 g were purchased at farm level for the trial. At the end of the trial, the cockerel slaughter performances were recorded and an economical assessment was done. The results showed that the effect of the commercial feed is high during the first two weeks of feeding. During the rainy season, the scavenging + supplementation group showed better chicken weight gains (97.3 g) than the scavenging only group (8 g) or the confined + commercial feed group (32 g). In the hot dry season, the scavenging only gave the better weight gains (237.5 g) whereas in the beginning of the rainy season, non-significant differences ($P \geq 0.05$) were observed between the feeding strategies after 35 days of feeding. Overall, the use of commercial feed showed more effect in the hot dry season and the beginning of the rainy season. The best economical strategies of village chicken feeding were the scavenging only and the scavenging + supplementation for respectively 225 and 95 FCFA of gross margin per bird. The use of a commercial pullet feed for confined birds resulted in a very low gross margin (25 FCFA) per bird. The results of the study suggest that if scavenging feeds are available in a low risk period, the best strategy of village chicken feeding is scavenging only. However, when these conditions are not guaranteed, the supplementation with balanced diet may be an option.

Keywords: Village chicken, pullet feed, season, supplementation, Burkina Faso.

Introduction

Many authors (Tadelle *et al.*, 2000; Kondombo *et al.*, 2003b) showed that village chickens have low productivity characterised by small flock sizes, poor laying ability and low growth rates. In general, farmers sell few growing chickens, mainly cockerels and remain pullets and hens for reproduction. To increase the income from sale of village chickens, it may be necessary for farmers to raise important numbers of growing village chickens to an interesting market live body weight. Such strategy for production has been applied by a group of women in Ghana, as reported by Akunzule (2001). In Mali, a programme of village chicken improvement was initiated (Bengaly, 1997) for the south of the country and some feedstuffs like the clove of *Cajanus cajan*, *Leucena* leave and *Azolla* are used in village chicken feeding. Kondombo *et al.* (2003a) used local feedstuffs to supplement village chickens at the end of the rainy season and concluded that proteins might be the main limiting factor for scavenging birds and the appropriate period of village chicken supplementation should be identified.

It is clear that in the condition of improved production of village chickens, the problem of feeding will be crucial in connection with solving the sanitary problems. There are many solutions available like vaccination against Newcastle disease and prophylaxis against internal and external parasites. Then, it will be necessary to find out feeding strategies in which the availability of the supplemental feeds is ensured. For that, in spite of the high cost of commercial feeds (170 to 180 FCFA/kg), the use of these feeds may be one of the solutions. The aim of the present study was to investigate under which (seasonal) conditions it would be beneficial to feed village chickens with a commercial pullet feed.

Materials and methods

Birds, housing and management

In the current study, 96 village chicken cockerels with a mean body weight of 432.6 ± 85.2 g were purchased at farm level for the trial. Chickens were housed during the trial in the household compounds of three volunteer households in a village in the Central Region of Burkina Faso. The village is named 'Matté' and choosen because previous extension activities related to village chicken improvement programmes were done in this village (Ouandaogo, 1997). Housings were roundhouses in clay with a rough in straw, as described by Kondombo (2000). The trial was conducted during three periods (rainy season, hot dry season and beginning of the rainy season). In each period, 5 to 11 birds were allocated randomly to each household compound. Duration of the trial in each period was 6 weeks including one week of adaptation to the housing, vaccination against Newcastle disease with the ITA-new vaccine and the use of the 'Vermifuge Polyvalent Volaille' (VPV) against internal parasites. Animals were vaccinated if they did not show any sign of illness. They had been vaccinated just after their purchase. External parasites were treated only in case of need. According to the treatment, birds were permanently housed or were allowed to scavenge freely after supplementation or not. The feed used was a commercial pullet feed (Table 4.2.1).

Birds that were permanently housed received daily 50 g of the pullet diet which was supposed to meet the requirements. A supplementation of 20 g of the commercial pullet feed per bird per day was given early in the morning to the birds that received supplementation before they were allowed to scavenge.

Design of the experiment

The experiment was set-up as a factorial design with three factors at three levels each. Factor 1 was the availability of scavenging feedstuffs according to the season of the year. The levels (S1, S2, S3) were:

S1 the period of the rainy season with the cockerel feeding conducted from the 16 August to the 27 September 2002.
S2 the period of the hot dry season with the cockerel feeding conducted from the 16 March to 27 April 2003.
S3 the period of the beginning of the rainy season with the cockerel feeding conducted from the 3 May to 14 June 2003.

Factor 2 was household compound with three levels (B1, B2, B3) corresponding to three volunteers. Factor 2 was nested to Factor 1. Factor 3 was the type of feeding strategy with three levels (T1, T2, T3):

T1 scavenging only;
T2 scavenging + supplementation with commercial pullet feed;
T3 permanent confinement with the supply of only the commercial pullet feed.

Allocation of seasons and feeding strategies to household compounds was as follows:

	T1	*T2*	*T3*
S1	B3	B2	B1
S2	B2	B1	B3
S3	B1	B3	B2

In each season, 5 cockerels from each feeding strategy were killed for slaughter performance.

Table 4.2.1. Chemical composition (%) of the commercial pullet feed

Nutrient	Composition (%)
Dry matter	90.94
Mineral	9.12
Organic matter	90.88
Acid detergent fibre	9.22
Acid detergent lignin	2.00
Neutral detergent fibre	34.75
Cellulose	7.22
Crude protein	22.89

Data collection procedure

Collection of data started after one week of adaptation to the feeding strategies and to the pens in each block. Parameters measured were body weight gain, feed intake, dressing percentage, and carcass weight. For that, live weight of individual chickens in each experimental unit was weighed weekly. Feed refusals were weighed daily. At slaughter, the gut was removed and slaughter performance (carcass weight and dressing) were measured.

Economical assessment was done to calculate the gross margin of the feeding strategies on the basis of feed cost, purchased price and sanitary care cost. Commercial feed cost (FC) was 180 FCFA/kg and sanitary care cost (SCC) was 50 FCFA/bird. Birds were purchased from the farmers at a price (BPP) of 300 FCFA/bird. Village chicken sale price (the product P), was calculated on the basis of the regression equation (Kondombo, 2000) between village chicken body weight and price (sale price = 175.4 + 0.7 body weight (g) with r = 0.6). From these assumptions, Gross margin (GM) per bird was computed according to the following equation: GM = P – (FC + BPP + SCC). Labour and housing costs were not taking into account in the assessment of the feeding strategies as they are indirect charges with regard to the feeding process.

Statistical analysis

Data were analysed with the software DBSTAT 3.1. The model equation (Rasch and Verdooren, 1998) used to analyse the parameters (body weight gain, dressing percentage, carcass weight…) was:

$$y_{ijk} = u + a_i + b_j + c_k + a_ib_j + a_ic_k + e_{ijkl},$$

with u the overall mean effect, a_i the effect of the type of feeding strategy, b_j the effect of the season, c_k, the effect of the household compound, a_ib_j, the effect of the interaction feeding strategy and season; a_ic_k, the effect of the interaction feeding strategy and household compound; e_{ijkl} the error term, E (e_{ijkl}) = 0. The significance level was 0.05. Comparison of means was done by the Analysis of Variance using Student's t-test.

Results

Growth curves of village chicken cockerels according to the applied feeding strategy

Village chicken growth according to feeding strategy (T1, T2 and T3; Figure 4.2.1) shows a critical period of feeding. Hence, the first 2 weeks showed the best growth for all treatments with respectively 7.8, 9.8 and 10.4 g/d of average daily weight gain (ADG) for T1 to T3, respectively. After the second week, growth declined for all feeding strategies. Growth for T1 and T2, however, increased after the third week. At the fourth week, ADG became 4.3, 3.9 and 2 g/d respectively for T1, T2 and T3.

When the cockerel growth curves are analysed according to season (Figure 4.2.2), it appears that in the rainy season (S1) growth decreases. Cockerels in S2 and S3 show a regular increase in ADG with the duration of the feeding.

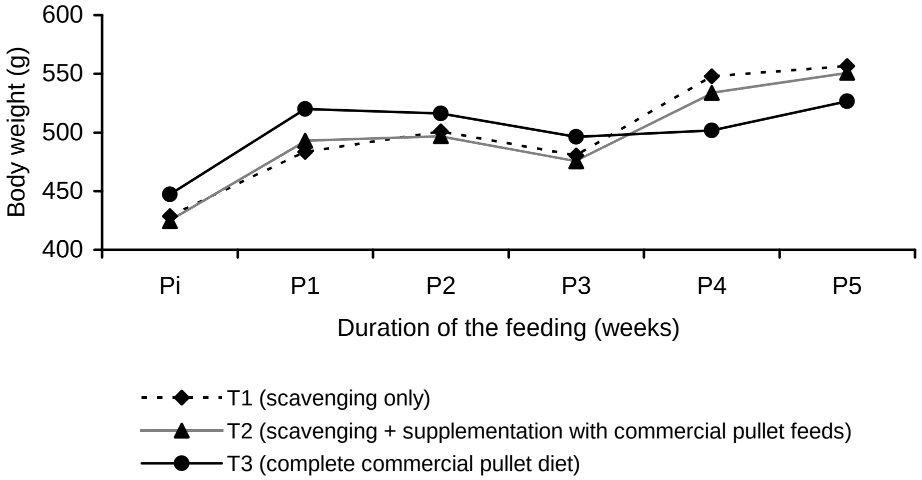

Figure 4.2.1. Growth curve of village chicken cockerel according to the treatment

Note: Pi = initial cockerel body weight, P1 = cockerel body weight (CBW) at 1 week, P2 = CBW at 2 weeks, P3 = CBW at 3 weeks, P4 = CBW at 4 weeks, P5 = CBW at 5 weeks.

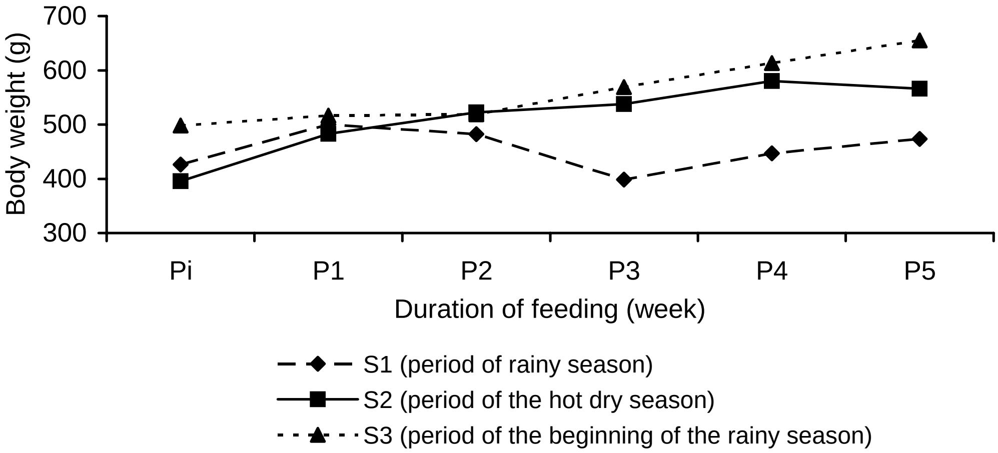

Figure 4.2.2. Growth curve according to the period of feeding

Note: Pi = initial cockerel body weight, P1 = cockerel body weight (CBW) at 1 week, P2 = CBW at 2 weeks, P3 = CBW at 3 weeks, P4 = CBW at 4 weeks, P5 = CBW at 5 weeks.

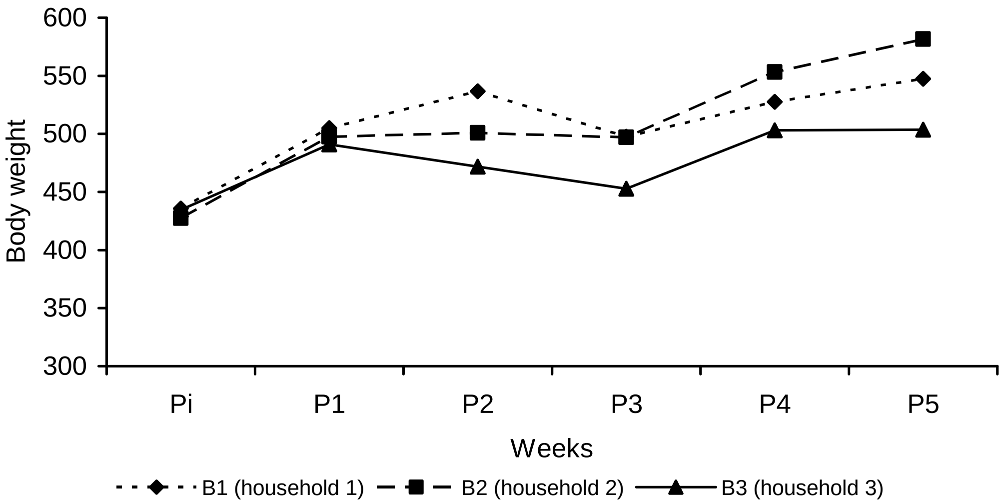

Figure 4.2.3. Growth curve of village chicken according to the availability of scavenging feedstuffs (household)
Note: Pi = initial cockerel body weight, P1 = cockerel body weight (CBW) at 1 week, P2 = CBW at 2 weeks, P3 = CBW at 3 weeks, P4 = CBW at 4 weeks, P5 = CBW at 5 weeks.

According to the household compounds (B1, B2, and B3), the growth curves (Figure 4.2.3) were very similar for B1, B2 and B3 in the first week. After this week, growth rate in B3 was lower than in the two other household compounds.

Effect of season, household compound and feeding strategy on weight gain of village chicken cockerels over the entire period of the trial

The effects of the interactions (season/feeding strategy and household compound/feeding strategy) can be analysed by inspection of Table 4.2.2. During the rainy season (S1), the use of commercial feed as supplement (T2) in the current study gave a higher ($P < 0.05$) body weight gain (97.3 g and a ADG of 2.8 g/d) compared to scavenging only (T1) with 8 g (0.2 g/d ADG) and the use of commercial feed as complete diet (T3) with 32 g (0.9 g/d ADG) after 35 days of feeding. In the period of the hot dry season (S2), cockerels that scavenged only (T1) gave better weight gains (237.5 g and ADG of 6.8 g/d). During the period of the beginning of the rainy season (S3), non-significant differences ($P \geq 0.05$) were observed between feeding strategies.

According to the household compounds (B1, B2 and B3), overall ADG (irrespective the feeding strategy) differed. Cockerel weight gains in B1 and B2 were higher (111.7 and 154.2 g, respectively) than weight gain in B3. Moreover, the (beneficial) effect of the use of a commercial feed was significantly ($P < 0.05$) different. Within household compound B2, where scavenging feedstuffs seems to be more available, supplementation resulted in a lower weight gain (97.3 g) than scavenging only (237.5 g) after 35 days of feeding. In return, when scavenging feedstuffs seemed to be lacking, as showed to be the case in B3, supplementation indicated an increased growth (136.7 g vs 8.0 g) after 35 days of feeding.

In general, village chicken cockerel daily weight gains ranged from 0.9 to 4.2 g/d with T3 and from 2.8 to 4.5 g/d and from 0.2 to 6.8 g/d with T2 and T1, respectively. Overall, there were no differences between cockerel weight gains in T1 and T2 after 35 days of feeding. Cockerel weight gains in T3, however, were significantly lower than weight gains in T1 and T2. The hot dry season (S2) and the beginning of the rainy season (S3) resulted in higher weight gains after 35 days of feeding with respectively 170.4 g and 156.9 g of weight gain.

Table 4.2.2. Body weight gain of village chicken cockerels (mean [g]) according to the feeding strategies (T1, T2 and T3), the seasons (S1, S2, and S3) and household compounds (B1, B2, B3)

Factors	Feeding strategies (n = 3)				SEM
	T1	T2	T3	Overall	
Seasons of feeding					
S1	8.0 [b]	97.3 [a]	32.0 [b]	47.4†	13.9
S2	237.5 [a]	155.6 [b]	103.3 [b]	170.4*	15.1
S3	192.0	136.7	146.0	156.9*	13.2
Household compounds					
B1	192.0 [a]	155.6 [a]	32.0 [b]	111.7*	18.2
B2	237.5 [a]	97.3 [b]	146.0 [b]	154.2*	18.4
B3	8.0 [b]	136.7 [a]	103.3 [a]	69.1†	16.4
Overall	127.8 [a]	126.5 [a]	79.5 [b]		
SEM	25.3	13.6	15.3		

n = group of 5 to 11 cockerels, SEM = standard error of the overall mean, S1 = period of rainy season, S2 = period of hot dry season, S3 = period of beginning of the rainy season, T1 = scavenging only, T2 = scavenging + supplementation with commercial pullet feed, T3 = permanent confinement with the supply of only the commercial pullet feed.

For the interaction season or household and feeding strategy, means in the same row with different supercript letters are significantly different at $P < 0.05$. For the season or household, means in the same column with different symbols are significantly different at $P < 0.05$.

Table 4.2.3. Commercial feed intake (g/d/bird) of village chicken cockerels according to the feeding strategies (T2, T3), the seasons (S1, S2, S3) and the household compounds (B1, B2, B3)

Factors	Feeding strategies (n = 2)			
	T2	T3	Overall	SEM
Seasons of feeding				
S1	19.9 [b]	29.0 [a]	24.5†	0.8
S2	16.8 [b]	23.5 [a]	20.1‡	0.7
S3	20.0 [b]	42.2 [a]	31.1*	2.3
Household compounds				
B1	16.8 [b]	29.0 [a]	23.7†	1.0
B2	19.9 [b]	42.2 [a]	25.8*	1.4
B3	20.0 [b]	23.5 [a]	22.4†	0.7
Overall	18.8 [b]	29.2 [a]		
SEM	0.2	1.0		

n = group of 5 to 11 cockerels, SEM = standard error of the overall mean, S1 = period of rainy season, S2 = period of hot dry season, S3 = period of the beginning of the rainy season, T2 = scavenging + supplementation with commercial pullet feed, T3 = permanent confinement with the supply of only the commercial pullet feed.

For the interaction season or household compound and feeding strategy, means in the same row with different supercript letters are significantly different at $P < 0.05$. For the season or the household compounds, means in the same column with different symbols are significantly different at $P < 0.05$.

Intake of commercial feed by village chicken cockerels
Commercial feed intakes during the trial were significantly different ($P < 0.05$) between the feeding strategies, T2 (supplementation above scavenging) and T3 (complete diet without scavenging). The intakes ranged from 16.8 to 20.0 g/d/bird for T2 and from 23.5 to 42.2 g/d/bird for T3 (Table 4.2.3). When considering the seasons, higher intakes (42.2 and 20.0 g/d/bird) were observed in the period of the beginning of the rainy season (S3), followed by the period of the rainy season (S1) with 29.0 and 19.9 g/d/bird, for T3 and T2, respectively. The lowest intakes (23.5 and 16.8 g/day/bird) were observed in the hot dry season (S2).

Effect of season, household compound and feeding strategy on slaughter performance
Table 4.2.4 shows significant differences ($P < 0.05$) of carcass weights and dressing percentages between seasons. Within each season, birds did not show significant differences ($P < 0.05$) of carcass weights and dressing percentages between the feeding strategies (T1, T2 and T3). When considering the household compounds (B1, B2 and B3), an interaction with

Table 4.2.4. Carcass weight and dressing of village chicken cockerels according to the availability of scavenging feedstuffs (seasons [S1, S2, S3] or household compounds [B1, B2, B3]) and feeding strategies

Parameters	Factors	Feeding strategies (n = 3)				
		T1	T2	T3	Overall	SEM
	S1	325	280	300	300*	14.4
	S2	444	412	348	401†	22.9
	S3	490	476	484	483‡	26.7
Carcass weight (g)						
	B1	490[a]	412[b]	300[c]	394*	27.5
	B2	444[a]	280[b]	484[a]	403*	30
	B3	325[b]	476[a]	348[b]	387*	31.8
	Overall	421.5	389.3	377.3		
	SEM	26.1	30.8	30.3		
	S1	67.0	62.8	67.8	65.8‡	1.0
	S2	62.8	63.6	62.4	62.9†	1.4
	S3	70.8	77.6	66.2	71.6*	2.0
Dressing (%)						
	B1	70.8[a]	63.6[b]	67.8[ab]	67.1*†	1.3
	B2	62.8	62.8	66.2	63.9†	1.6
	B3	67.0[b]	77.6[a]	62.4[b]	69.1*	2.2
	Overall	66.5	68.0	65.5		
	SEM	1.4	2.1	1.7		

n = group of 5 cockerels, SEM = standard error of the overall mean, S1 = period of rainy season, S2 = period of hot dry season, S3 = period of the beginning of the rainy season, T1 = scavenging only, T2 = scavenging + supplementation with commercial pullet feed, T3 = permanent confinement with the supply of only the commercial pullet feed.

For the interaction season or household and feeding strategy, means in the same row with different supercript letters are significantly different at $P < 0.05$. For the season or household compound, means in the same column with different symbols are significantly different at $P < 0.05$.

feeding strategy showed significant differences ($P < 0.05$) between feeding strategies for carcass weights. Over feeding strategies, households and seasons, dressing percentages ranged from 62.4 to 77.6% and carcass weights from 300 g to 490 g. The lowest dressing percentage (62.9%) is observed in S2 and the highest (71.6%) in S3.

Economical evaluation according to the feeding strategies and the availability of scavenging feedstuffs (season or household compound)

Economical assessment of the feeding strategies according to the availability of scavenging feedstuffs (seasons and the household compounds) are presented on Table 4.2.5. All feeding strategies gave positive gross margins. According to the feeding strategy, gross margin ranged from 23 to 227 FCFA per bird after 5 weeks of feeding. In any season, the free scavenging (T1) resulted in the highest gross margin ($P < 0.05$) followed by the supplementation with commercial feed (T2). Feeding a complete diet (T3) showed the lowest gross margin with only 23 FCFA per bird after 35 days of feeding.

Non-significant differences ($P \geq 0.05$) between households in gross margin were observed, wheras between season, gross margin in S1 was significantly lower than in S2 and S3.

Discussion

In the current study, average daily weight gain (ADG) of village chicken cockerels ranged from 0.2 to 6.8 g/d during 35 days of feeding. Although the commercial pullet feed is well balanced, weight gains of village chicken cockerels with the use of this feed were still poor and overall lower (79.5 g in T3) or similar (126.5g in T2) than the weight gain with scavenging only (127.8 g). This seems to indicate that if scavenging feedstuffs are available,

Table 4.2.5. Gross margins (FCFA) according to the feeding strategies (T1, T2, T3), the seasons (S1, S2, S3) and the household compounds (B1, B2, B3)

Factors	Feeding strategies				
	T1	T2	T3	Overall	SEM
S1	159.4^{a}	54.2^{b}	11.4^{b}	75.1†	17.2
S2	261.2^{a}	116.2^{b}	20.3^{c}	141.6*	23.4
S3	266.2^{a}	128.7^{b}	41.1^{c}	144.3*	30.1
B1	266.2^{a}	116.2^{b}	11.4^{c}	122.3*	26.8
B2	261.2^{a}	54.2^{b}	41.1^{b}	123.4*	23.5
B3	159.4^{a}	128.7^{a}	20.4^{b}	105.8*	21.1
Overall	226.8^{a}	94.4^{b}	23.3^{c}		
SEM	20.1	13.8	12		

SEM = standard error of the overall mean, S1 = period of rainy season, S2 = period of hot dry season, S3 = period of the beginning of the rainy season, T1 = scavenging only, T2 = scavenging + supplementation with commercial pullet feed, T3 = permanent confinement with the supply of only the commercial pullet feed.

For the interaction season or household compound and feeding strategy, means on the same row with different letters are significantly different at $P < 0.05$. For the main effect period of feeding or blocks (scavenging feedstuffs availability according to the household), means on the same column with different symbols are significantly different at $P < 0.05$.

the free-range system may provide better conditions for village chickens to perform well than the use of a well-balanced diet in a confined situation does. That assertion is consistent with Tadelle *et al.* (2000), who indicated that indigenous bird are poorly adapted to condition of confinement. That situation may be due to the fact that confinement become a stress for birds which are habit to scavenge.

These results suggest also, that supplementation may be an option in case of larger number of birds or in a scarcity of scavenging feedstuffs. The same conclusion has also been observed in the previous trial on village chickens feeding (Kondombo *et al*., 2003a; Chapter 4.1). In this previous trial, an ADG of 5.5 to 6.6 g/d was observed under the condition of a supplementation of local feedstuffs over a period of 28 days at the end of the rainy season.

Village chicken cockerels gained more weight ($P < 0.05$) in the hot dry season (S2) and the beginning of the rainy season (S3) than in the rainy season (S1). The weight gain in the hot dry season represented 3.6 times the weight gain in the rainy season and 1.1 times the weight gain in the beginning of the rainy season. This result may be due to a lot of rainfall during the period of S1, that did not allow chickens enough time for scavenging. It may due also to the feed scarcity that occur yearly at rural farm level in the country at this period of the year. Furthermore, in the hot dry and beginning of the rainy seasons, farmers may have enough cereals or household wastes for chicken scavenging.

The current study shows positive weight gains of village chickens in all seasons (S1, S2, S3). From that point of view, it seems that there are enough scavenging feedstuffs for village chickens throughout the year. Particularly, it appears that in the hot dry season, chickens got higher weight gains under scavenging conditions (237.5 g). This can be due to the fact that household waste and cereal chaff are particularly available in that period in the village (Chapter 3). This situation may not be the case in other villages. With regard to these results of the study, the necessity of village chicken supplementation or complete diet feeding should be justified by other reasons than body weight gain. These reasons can be the security of village chickens for diseases, mainly Newcastle disease, or predations. In that condition, supplementation may well be recommended in the dry season than in the rainy season. Indeed, according to Permin (1998), citing Moreki *et al.* (1997), the productivity of village chickens is likely to be improved by allowing chickens to roam during low disease and low predation risk periods (winter and autumn). But during high-risk periods, it is recommended to (partly) confine birds and give them supplementation. It can also be noted that the use of a complete diet lead to egg production improvement of village chickens according to previous authors (Elfadil, 1997; Huque *et al*., 1999). But in our case, the use of a balanced commercial diet as supplement seemed to be more beneficial and increased village chicken weight gain at the periods of dry season and beginning of the rainy season.

Intake of the commercial pullet feed in T3 ranged from 23.5 to 42.2 g per day with a feed supply per day of 50 g/day/bird. So, this level of feed supply seems adequate for *ad libitum* feed intake, and could even be slightly reduced for village chicken cockerels in permanent confinement. That might avoid unnecessary feed losses. For the supplementation group (T2), the results indicate to supply the birds with somewhat more feed than the 20 g/day/bird that was given. In the current study, some birds consumed all supplied feed and might have been restricted slightly in their *ad libitum* feed intake. That may assure enough feed for better performances in case of scavenging feedstuffs scarcity. Ouandaogo and Ouédraogo (1988) also recommended a supplementation of 40 g of cereals/day for village chicken cockerels from 3 to 6 months of age. Sonaiya (1995) also indicated that a supplementation with 35 g/d may be sufficient for village chicken hens. The low intake of feed (20.1 g/bird/day) in the hot dry season (S2) in this study is probably due to the high temperature in this period of the year that lowered intake.

Apparently, the type of feeding strategy did not influence slaughter performances. Hence, carcass weights and dressing percentages did not differ between feeding strategies. The range of dressing percentages (65.5 to 68%) in this study was in the range indicated by some previous studies (Tadelle, 1996; Kondombo *et al*., 2003a; Chapter 4.1). Nevertheless, the commercial feed may lead to some fat deposition as can be derived from the relative low dressing percentage of the birds that received supplementation (T2) or the complete diet (T3). It is suggested here that chicken meat with fat is more appreciated by consumers in developing countries and that the use of a commercial feed, by this fact, may lead to the increase of village chicken sale price.

The economical assessment after 35 days of feeding indicated the limits of the use of commercial pullet feed in village chicken feeding. Hence, gross margins of 95 FCFA and 25 FCFA per bird were obtained with the supplementation (T2) and the use of the complete diet (T3), respectively. So, the use of a commercial pullet feed in confinement conditions seems to lead to a negligible gross margin. This confirms the observation of Coligato *et al.* (1985), cited by Tadelle and Ogle (1997), who noted that the native chicken of the Philippines did not give any economic return on a commercial balanced feed. In a previous study (Kondombo *et al*., 2003a; Chapter 4.1), however, the use of a commercial feed resulted in a better gross margin than the use of local feedstuffs.

It can be concluded from the current study that, if scavenging feedstuffs are available, the free-range production system seems the better option for village chickens to perform well. Nevertheless, supplementation of village chickens may be an option that also can assure village chickens production improvement. In opposite, village chickens are not adapted to confinement conditions. Although a combination of scavenging in the free-range system and supplementation appears to be efficient in term of performance and benefit gains, there are some risks (predations, losses, diseases) related to the free-range nature of the system. A system in which the free run of village chickens can be assured without too many environmental risks seems indispensable to improve village chicken rearing. That may convince farmers to invest and improve village chicken production. Such semi-scavenging systems may be future integrated small enterprises. Investigations are needed to explore such systems.

CHAPTER 5

Strategies to improve ram fattening at farm level

5.1. Performance of Djallonké rams fed with crop residues*

5.2. Models to transfer the knowledge on sheep-fattening diets, formulated at research stations, to farm level**

5.3. Increase in the availability of forage by the combination of dolic with cereals***

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* Rewriting from a paper (Kondombo and Nianogo, 2001) published in French in: *Agronomie Africaine* (2001), 13(2): 59-66.

** A communication of part of this paper in the FRESIT (National Forum of Scientific Research and Technologic Inovation) held in Ouagadougou in May 2002 get two awards: The price of the 'Ministry of livestock of Burkina Faso' and the price of the Director General of CIRDES (International Centre of Research-Development in Soudano-Sahelian Zone).

*** Rewriting from a paper (Kondombo *et al*., 2001) published in French in: *Science et Technique* (2001), 25(2): 55-64.

5.1. Performance of Djallonké rams fed with crop residues

Abstract
A study was conducted in a research station in the East Region of Burkina Faso, and aimed to increase the value of available crop residues for rams at farm level. The crop residues were sorghum straw, cowpea hay and groundnut hay. Effects of 5 diets with 25 male Djallonké rams were studied. The experiment was set up as a complete randomised design with 5 dietary treatments in 5 replications: diet 1: Grazing (7 h/day) on a natural pasture plus a roughage diet (RD) composed of 49.07% cowpea hay, 40.59% groundnut hay and 10.34% sorghum straw; Diet 2: Roughage diet (RD) alone; Diet 3: 90% RD plus 10% concentrates. Diet 4: 80% RD plus 20% concentrates. Diet 5: 70% RD plus 30% concentrates. The concentrates used were cottonseed cake and wheat bran. The animals were fed during 70 days with a 14-days adjustment period. After that period of adjustment, feed intake and body weight were monitored daily and weekly, respectively. Results indicate that 20 to 30% concentrate feed in addition to a crop residues based diet notably increases weight gains. It also appears that crop residues were best utilised when fed to animals grazing on a natural pasture than as complete diet. When concentrates are available, the incorporation of 30% appears to be the more economical diet.

Keywords: Djallonké sheep, crop residues, performance, fattening, Burkina Faso.

Introduction

Preservation of crop residues is normal practice for rural farmers in Burkina Faso (Chapter 3). According to the regions of the country, preserved crop residues are destined essentially for draught animals and for small ruminants. The main crop residues at farm level in Burkina Faso are cowpea hay and groundnut hay and straw from sorghum and millet (Savadogo, 2000; Chapter 3). The importance of these crop residues with regard to the quantities stored and their use in animal feeding is such that they have been the objective of several studies (Bourzat, 1983; Richard *et al*., 1985; Bourzat *et al*., 1987). Two major options, treatment of the residues with urea and the additional supply of concentrates, were recently tested in Burkina Faso (Nianogo *et al*., 1995). With regard to the low income of rural farmers and the difficulty in supply of concentrates in certain regions (Chapter 3), options for low cost feeding in sheep fattening should be researched.

The current study was designed in this framework. It aimed to investigate the performance of rams in a variety of feeding strategies, consisting of the use of cowpea hay, groundnut hay, sorghum straw, natural pasture and cubic wheat bran.

Materials and methods

Animal choice
Twenty five Djallonké rams, ageing 12 to 18 months and weighing on average 22.7 kg, were purchased at local markets for this study. They were all Djallonké sheep, and belonged to the Mossi variety, as described by Doutressoule (1947).

Feeds
Crop residues used in the trial were cowpea hay; groundnut hay and sorghum straw. Cowpea

and groundnut hay were collected and sun dried after harvesting of grain. Sorghum straw was dried in the field before it was cut, transported and stored. Concentrates used were cottonseed cake and wheat bran. The nutritional composition of these feeds is presented in Table 5.1.1.

Animal feeding

Animals were randomly allocated to 5 treatments (T1, T2, T3, T4 and T5) with 5 replications each. The treatments were based on a Roughage Diet (RD). This RD was composed of cowpea hay (49.07%), groundnut hay (40.59%) and sorghum straw (10.34%).

T1 After a grazing period of 7 hours, animals received the RD in quantities estimated to provide 2/3 of the requirement needed for maintenance and a weight gain of 100 g/day. This diet is similar to the normal practice of farmers for sheep fattening. It was considered as the control diet.

T2 This treatment consisted of the RD only. The diet was formulated to meet the requirements of the fattening ram in digestible protein and metabolisable energy. The mixture from the crop residues in RD had 6.9% of digestible protein and about 0.7 UF/kg of metabolisable energy as recommended by Rivière (1978) for the category of body weight of the sheep used in the experiment.

T3 Diet 3 was composed of RD (90%) and 10% of concentrates.

T4 Diet 4 was composed of RD (80%) and 20% of concentrates.

T5 Diet 5 was composed of RD (70%) and 30% of concentrates.

The composition of the different diets and their theoretical nutritive values are presented in Table 5.1.2. The animals receiving the complete diets (T2 to T5) were in permanent confinement and received their diet at a quantity equal to 4% of their live body weight. Animal were supplied with minerals and water *ad libitum*.

Table 5.1.1. Chemical composition of crop residues and concentrates used in the diets of Djallonké ram

	Chemical composition of the feedstuffs (% of ADM)				
	Cowpea hay	Groundnut hay	Sorghum straw	Wheat bran	Cottonseed cake
Air dry matter (ADM) in % of the fresh matter	97.3	96.5	97.5	94.5	95.5
In % of ADM					
Minerals	7.6	13,7	6.9	4.3	6.8
Crude protein	8.3	7.4	3.0	16.2	41.6
Fat	8.3	0.6	1.5	4.4	10.7
Cellulose	50.1	43.4	42.2	7.3	15.1
Neutral detergent fibre	69.0	59.3	78.0	35.9	28.7
Acid detergent fibre	53.4	52.5	45.3	10.2	21.1
Acid detergent lignin	11.3	10.9	6.4	2.9	6.0
UFV*	0.4	0.4	0.3	0.8	0.8

UFV = Unités fourragères viande per kg of air dry matter (ADM). * = computed according to the recommendations of INRA N° DQ/SRF/C80/8123 of the 14th October 1980, relative to the energetic value estimation and the protein value of feed for animals.

Table 5.1.2. Composition of diets tested (treatments) on Djallonké rams

Feedstuffs		Diets				
		T1	T2	T3	T4	T5
NATURAL PASTURE (estimations)		33.3	-	-	-	-
CROP RESIDUES						
Cowpea hay		32.7	49.1	44.2	39.3	34.4
Groundnut hay		27.1	40.6	36.5	32.5	28.4
Sorghum straw		6.9	10.3	9.3	8.3	7.2
CONCENTRATES						
Wheat bran		-	-	6.0	18.0	30.0
Cottonseed cake		-	-	4.0	2.0	-
TOTAL		100	100	100	100	100
Theorical nutritive values of the diets	UF/kg DM	-	0.4	0.5	0.5	0.6
	DP (kg/DM)	-	34.1	52.0	55.7	59.2
	DP/UF	-	77.5	110.6	107.1	105.7

The nutritive values were estimated from the analysis data of the animal nutrition laboratory of the University of Ouagadougou.

UF = unités fourragères; DM = dry matter; DP = digestible protein.

Trial management

The animals were housed in boxes. They were allowed to adapt to the diet for a period of 2 weeks during which the animals where de-parasited and vaccinated against pasteurellosis. Thus, the duration of the trial was two weeks for adaptation and data collection took 8 weeks. Voluntary intake was evaluated each day and all animals were weighed the same day of each week at the same time before the supply of the daily diet.

Data collection

Feed intake was determined by daily weighing of the feed supplied and a weekly weighing of the refuses. The difference between feed supplied and feed refusal during a week, divided by seven days, gave the daily feed intake. Weight gain was recorded by weekly weighing of all animals.

Carcass study

At the end of the trial, two animals were randomly chosen from each treatment and sacrificed for slaughter performances. Slaughter of animals took place after 24 hours of fast. After slaughter, abdominal tract, legs, head, and skin were separated from the carcass and measured separately. Apart from the entire carcass, several organs and body structures were weighed: leg, head, kidney, liver, lungs, heart, rate, gut, stomach and testicles. Data were expressed relative to body weight

Statistical analysis

Statistical analysis was done with the software STATITCF and the comparison of means was done with the multiple comparison test of Newman and Keuls (Cochran and Cox, 1957). The statistical model used to analyse the data was: $y_i = u + a_i + e_i$ with, u the overall mean effect; $a_{i,}$ the effect of the treatment (the type of diet), e_i the error term. Significance level was 0.05.

Results

Body weight gain

In Table 5.1.3, it can be seen that the 100% RD generated a lower weight gain after 56 days of feeding (2.2 kg) compared to the other 4 diets (on average 4.0 kg; $P < 0.05$). The highest weight gains of 4.1 and 4.5 kg were obtained when 20% (T4) and 30% of concentrates (T5) had been incorporated, respectively..

The analysis of results in T1 (in which, animal had access to pasture) and T2 shows that access to pasture generated a higher performance ($P < 0.05$) than when the diet constituted exclusively of roughage (weight gain of 3.7 kg for T1 versus 2.2 kg for T2). The supply of the roughage diet as a supplement next to pasture (T1) generated performances slightly higher (non-significant) than those observed with an incorporation of 10% concentrates (63.9 g/d).

Feed intake

Statistical analysis of the data on feed intakes (Table 5.1.4) did not show any significant differences between the treatments. Voluntary intakes (in percentage of body weight) varied from 2.2% to 3.2% of ram live body weight.

Concerning feed conversion ratios (FCR), the diet with 30% of concentrates (T5) gave the lowest FCR (10.1). Those of the other diets are relatively higher.

Slaughter performance

The results at slaughter, presented in Table 5.1.5, indicated that they are no significant differences ($P \geq 0.05$) between dietary treatments for ram carcass weight and for dressing percentage. However, it can be observed that carcass weights and dressing percentages numerically increased if the percentage of concentrate in the diet became higher (see T2 to T5). Carcass dressings ranged from 37.8% to 40.6% for the treatments T3, T4 and T5 against 32.7% for the T2. The carcass weights varied from 10.2 to 11.2 kg for the treatments T3, T4 and T5, against 8 kg for T2.

The rams fed on pasture and receiving the RD as supplement (T1) got dressing percentages and carcass weights slightly higher than those receiving the complete diets (Table 5.1.5).

Table 5.1.3. Body weight and growth rate change of Djallonké rams in 8 weeks period as a function of diets

Parameters	Treatments					
	T1 (Pasture + RD) n = 5	T2 (100% RD) n = 5	T3 (RD + 10% C) n = 5	T4 (RD + 20% C) n = 5	T5 (RD + 30% C) n = 5	SE
Initial weight (kg)	22.9	22.3	23.0	22.8	22.3	4.2
Final weight (kg)	26.7	24.6	26.6	27.0	26.9	1.7
DWG (g/d):						
1er to 28th day	63.6^{a}	15.4^{b}	78.6^{a}	75.4^{a}	66.4^{a}	20.2
29 to 56th day	69.3	65.7	49.3	71.8	95.7	23.4
DWG on 8 weeks (g/d)	66.4^{a}	40.0^{b}	63.9^{a}	73.6^{a}	81.1^{a}	15.0
Total weight gain (kg)	3.7^{a}	2.2^{b}	3.6^{a}	4.1^{a}	4.5^{a}	0.6

RD: roughage diet, C = concentrate, SE = standard error, DWG: Daily weight gain.

Means on the same row with the different superscript letters are significantly different at 5%.

Table 5.1.4. Intake of the different diets by Djallonké sheep

Parameters	Treatments					
	T1 (Pasture + RD) n = 5	T2 (100% RD) n = 5	T3 (RD + 10% C) n = 5	T4 (RD + 20% C) n = 5	T5 (RD + 30% C) n = 5	SE
DMI in % BW	-	3.1	2.2	3.2	3.0	0.1
DMI (g/kg $BW^{0.75}$)	-	69.9	73.0	72.0	68.3	1.8
DWG (g/d)	-	40.0^{a}	63.9^{a}	73.6^{a}	81.1^{b}	15.0
FCR (kg DMI/kg WG)	-	21.7	13.3	11.6	10.1	5.4

RD = roughage diet, C= concentrate, DMI = dry matter intake, BW = body weight, SE = standard error, FCR = feed conversion ratio, DWG = daily weight gain, WG = weight gain.
Means on the same row with different superscripts letters are significantly different at 5%.

Table 5.1.5. Slaughter performances of Djallonké rams as a function of diets

Parameters	Treatments					
	T1 (Pasture + RD) n = 5	T2 (100% RD) n = 5	T3 (RD + 10% C) n = 5	T4 (RD + 20% C) n = 5	T5 (RD + 30% C n = 5	SE
Live body weight (kg)	27.0	24.5	27.0	26.7	27.5	2.6
Carcass weight (kg)	11.2	8.0	10.2	10.5	11.2	1.5
Carcass dressing (%)	41.5	32.7	37.8	39.1	40.6	3.0
Fresh skin weight/ LW	5.2	5.6	7.9	5.8	6.6	1.5
Leg weight/ LW	2.0	2.1	2.0	1.9	1.9	0.3
Head weight/ LW	6.5	8.4	7.1	7.9	8.1	0.7
Kidney weight/ LW	0.1	0.1	0.1	0.2	0.1	0.2
Liver weight/ LW	1.3	1.3	1.6	1.5	1.3	0.3
Lung weight/ LW	1.3	1.3	1.4	1.1	1.2	0.2
Heart weight/ LW	0.4	0.4	0.5	0.4	0.3	0.1
Rate weight/ LW	0.1	0.2	0.3	0.3	0.3	0.1
Gut weight/ LW	4.0	3.5	2.3	3.8	2.6	0.6
Stomach weight/ LW	1.9	1.9	1.8	0.0	1.9	0.2
Testicles weight/ LW	1.3^{a}	0.8^{a}	0.8^{b}	1.1^{ab}	1.0^{ab}	0.1

LW = live weight, RD = roughage diet, C = concentrate, SE = standard error.
Means on the same row with different superscript letters are significantly different at 5%.

Discussion

Average daily weight gain (ADG) observed in the current study ranged from 40.0 to 81.1 g/d. These data are comparable to the results of Richard *et al.* (1985) who registered ADG's of 35.9 g/d and 57.9 g/d respectively for diets composed of cottonseed, molasses, cottonseed cake and urea on one hand and cottonseed, molasses, cottonseed cake and wheat bran on the other. Our results are in agreement with those of Nianogo *et al.* (1995). Hence, in their study, the use of 30% of concentrates and 70% of sorghum straw generated a daily weight gain of 83.3 g/d and 54.8 g/d, respectively.

Furthermore, one can note that the incorporation of concentrates in the diet based on crop residues gave performances which are higher than those of mean performances of Mossi sheep in their usual conditions of life. Indeed, Dumas and Raymond (cited by Bourzat *et al*., 1987) reported in these conditions, DWG of 33 g/d for Mossi sheep aged from 5 to 18 months. Performances obtained in our study are considerably lower than those observed by Bourzat *et al*. (1987) in their feeding trial with weight gains of 9 to 10 kg in 90 days.

Ad libitum intakes of the experimental animals ranged from 2.2 to 3.3% of live body weight. These intakes are comparable to those observed by Rivière (1991) who estimated consumptions up to 3.3% of live body weight when the forage is provided with concentrates. Richard *et al.* (1985) found higher mean intake, corresponding to 3.6% of live weight, than the one of the current study for the same type of sheep.

The FCR (kg of dry matter intake/kg of weight gain) of 10.1 obtained with the diet with 30% concentrates is concordant with the one observed during an intensive feeding of the Mossi sheep by Bourzat *et al.* (1987). These authors reported FCR's between 7 and 8.

Slaughter performances were not influenced by the diet. It could be possible that the differences between the diets were not sufficient to affect dressing percentages and organ weights in the few weeks of feeding; such tendencies have been reported by previous authors too (Kondombo, 1991; Nianogo *et al.,* 1996).Carcass dressings ranging from 37.8 to 40.6% obtained with the treatments T3 to T5 are similar to those observed for the Mossi sheep by Zoundi *et al.* (1994) and Nianogo *et al.* (1996). Zoundi *et al.* (1994) indicated dressing percentages of 37.1 to 42.3% in the dry season in a situation of severe or moderate under-nutrition. In the case of feeding at the end of the rainy season, they registered dressing percentages of 40.5 to 43.8%. Nianogo *et al.* (1995) on the other hand, obtained dressing percentages varying from 46.8 to 53.9% with Mossi male sheep (aged 36 months and receiving 80% of concentrates in their diets).

Conclusion

The current study demonstrates that with diets composed in different combination with roughage of cowpea hay, groundnut hay, sorghum straw, natural pasture and cubic wheat bran, the following results can be observed. The roughage with the pasture gives 3.7 kg of weight gain after 56 days of fattening. Given roughage and in addition 10, 20 or 30% of a concentrate feed (cottonseed cake, wheat bran) gives weight gains of 3.6, 4.1 and 4.5 kg after 56 days of fattening, respectively. The roughage diet without concentrate gave 2.2 kg of weight gain.

The results show that, with only 10% of concentrates in the diet, one can clearly improve sheep growth. However, in the present study, only inclusion rates of concentrates of more than 20% resulted in acceptable feed conversion ratios.

It can be suggested that when the natural pasture is not strongly deteriorated, it seems more profitable to use crop residues as a supplement to the pasture than to formulate a complete diet without access to a pasture. Although, when one need to maximise the use of crop residues in ram fattening in terms of feed efficiency, an incorporation rate of 30% of concentrates in a diet based on crop residues seems to be the best option.

5.2. Models to transfer the knowledge on sheep-fattening diets, formulated at research stations, to farm level

Abstract
Research activities in agricultural research centres in Burkina Faso have been conducted on formulating sheep-fattening diets. The aim of the current study was to investigate the best way to transfer the knowledge on such diets to farm level. Two models of knowledge transfer were tested with six diets at five sites of investigation. In model I, the approach was via extension workers and volunteer farmers. In model II, the approach was via the village community. In model I, each diet was tested by one of the volunteer farmers. The four diets tested in this model were: (1) Diet I composed of 22% of cottonseed cake, 22% cottonseed 22% of wheat bran, 5% of *Pennisetum pedicellatum*, 20.6% of sorghum straw, 7% of groundnut hay and 1.4% of oyster shell. (2) Diet II composed of 30% of wheat bran, 7.24% of sorghum straw, 28.41% of groundnut hay and 34.35% of cowpea hay. (3) Diet III composed of 29.48% of wheat bran, 32.82% of *Panicum laetum*, 37.70% *of Dolichos lablab*. (4) Diet IV composed of 24% cottonseed cake, 34% cottonseed, 8% *Pennisetum pedicellatum*, 22.2% sorghum straw, 10% groundnut hay, 0.8% of oyster shell, 1% of NaCl. In model II, more than one farmer received randomly one of three diets for the test. The diets tested in this model were: (1) Diet II (tested also in model I). (2) Diet V composed of 39.26% cowpea hay, 32.47% groundnut hay, 8.27% sorghum straw, 18% wheat bran and 2% cottonseed cake. (3) Diet VI composed of 23.6% groundnut hay, 35.82% wheat bran, 39.18% cottonseed cake, and 1.4% oyster shell. Results show that the two models can be used for transfer of knowledge on fattening diets to farm level. However, it seems more efficient to apply consecutively model I before model II. Body weight gains of 2.95 to 5.5 kg in 56 to 98 days of fattening and gross margins varying from 3570 to 5095 FCFA were obtained. The test was well appreciated by farmers. The two models may be useful for the transfer of similar technologies.

Keywords: Sheep, fattening, on farm research, diets, knowledge transfer, Burkina Faso.

Introduction

In Burkina Faso, many research activities are conducted in research centres with the aim to develop dietary formulas for sheep fattening at farm level (Kalkoumdo, 1994; Nianogo *et al*., 1995; Nianogo *et al*., 1996; Kondombo and Nianogo, 2001; Ouédraogo *et al*., 2001; Chapter 5.1).
Such dietary formulas were developed in the conditions of conventional sheep fattening technology: (1) duration of the fattening period is in general 3 months; (2) feeds are weighed and distributed according to their live body weight; (3) diet formulas are rigorously respected; (4) animals are in individual boxes in a sheepfold.

Results of these investigations identified some interesting diet formulas for sheep fattening. For example, Nianogo *et al*. (1995) observed better results with diets composed of 22% of cottonseed cake, 22% cottonseed, 22% of wheat bran, 5% of *Pennisetum pedicellatum*, 20.6% of sorghum straw, 7% of groundnut hay and 1.4% of oyster shell. Kondombo and Nianogo (2001) indicated an other diet composed of 30% of wheat bran, 7.24% of sorghum straw, 28.41% of groundnut hay and 34.35% of cowpea hay (also described in Chapter 5.1). However, the acceptance of such sheep fattening diets at farm level requires adaptation. Indeed, conventional conditions of sheep fattening in the research stations cannot be realised by farmers. So, there is a need to identify knowledge transfer models (adapted to the socio-economical conditions of rural farmers) that allows a proper transfer of knowledge on sheep fattening diets, formulated in the research centres, to farmers.

The current on-farm research was designed to test two models of transfer of knowledge on sheep fattening diets, to analyze sheep fattening performances with these diets at farm level and to get to know farmers' opinions on these diets.

Materials and methods

The study was realised at five research sites in Burkina Faso: the villages of Konli II, Louanga, Yambassé, Villy-Moukouan and the extension service applied research centre (Point d'Appui de Prévulgarisation et d'Essai Multi-locaux [PAPEM]) of Bogandé. Two models of transfer of knowledge on sheep fattening diets to farm level were tested.

Model I

In model I, preliminary discussions were undertaken with the extension service workers of the research sites. These workers choose volunteer farmers willing to participate in the test. After that, a certain number of the available fattening diets, as formulated in the research centres, were proposed to each farmer to be chosen according to his possibility together with the advice of the extension worker. The main criteria for the choice of the diet were the availability of the diet feedstuffs at the site or the region and the possibility for the farmer to gather the quantities needed for the test.

At the site of Bogandé (PAPEM), the most available feeds were *Pennisetum pedicellatum*, *Panicum laetum*, sorghum straw, groundnut hay, cowpea hay and dolic hay. In the villages of Konli II and Louanga, the most available feeds were *Pennisetum pedicellatum,* groundnut hay and cowpea hay.

In model I, the number of animals fattened by each farmer constituted the number of replications for the diet tested by this farmer. In the current study, three sites of research were used with two diets tested consecutively at each site. Only, at PAPEM (an extension applied research centre) tested two diets at the same time. The scheme of model I is presented in Figure 5.2.1. The diets used in this model are presented in Table 5.2.1.

Table 5.2.1. Composition (%) of the diets used in model I

Feedstuffs	Composition (%) of the diets			
	Diet I*	Diet II**	Diet III***	Diet IV*
Cottonseed cake	22.0	-	-	24.0
Cottonseed	22.0	-	-	34.0
Wheat bran	22.0	30.0	29.5	-
Pennisetum pedicellatum or *Panicum laetum* hay	5.0	-	32.8	8.0
Sorghum straw	20.6	7.2	-	22.2
Groundnut hay	7.0	28.4	-	10.0
Cowpea or *Dolichos lablab* hay	-	34.4	37.7	-
Oyster shell	1.4	-	-	0.8
Salt	-	-	-	1.0

* Nianogo et *al.* (1995); ** Kondombo and Nianogo (2001), Chapter 5.1; *** Ouédraogo *et al.* (2001).

Table 5.2.2. Composition (%) of the diets used in model II

	Composition (%) of the diets		
Feedstuffs	Diet II**	Diet V**	Diet VI****
Cowpea hay	34.4	39.2	-
Groundnut hay	28.4	32.5	23.6
Sorghum straw	7.2	8.3	-
Wheat bran	30.0	18.0	35.8
Cottonseed cake	-	2.0	39.2
Oyster shell	-	-	1.4
Overall	100	100	100

** Kondombo and Nianogo (2001), Chapter 5.1; **** diet adapted from Kalkoumdo (1994).

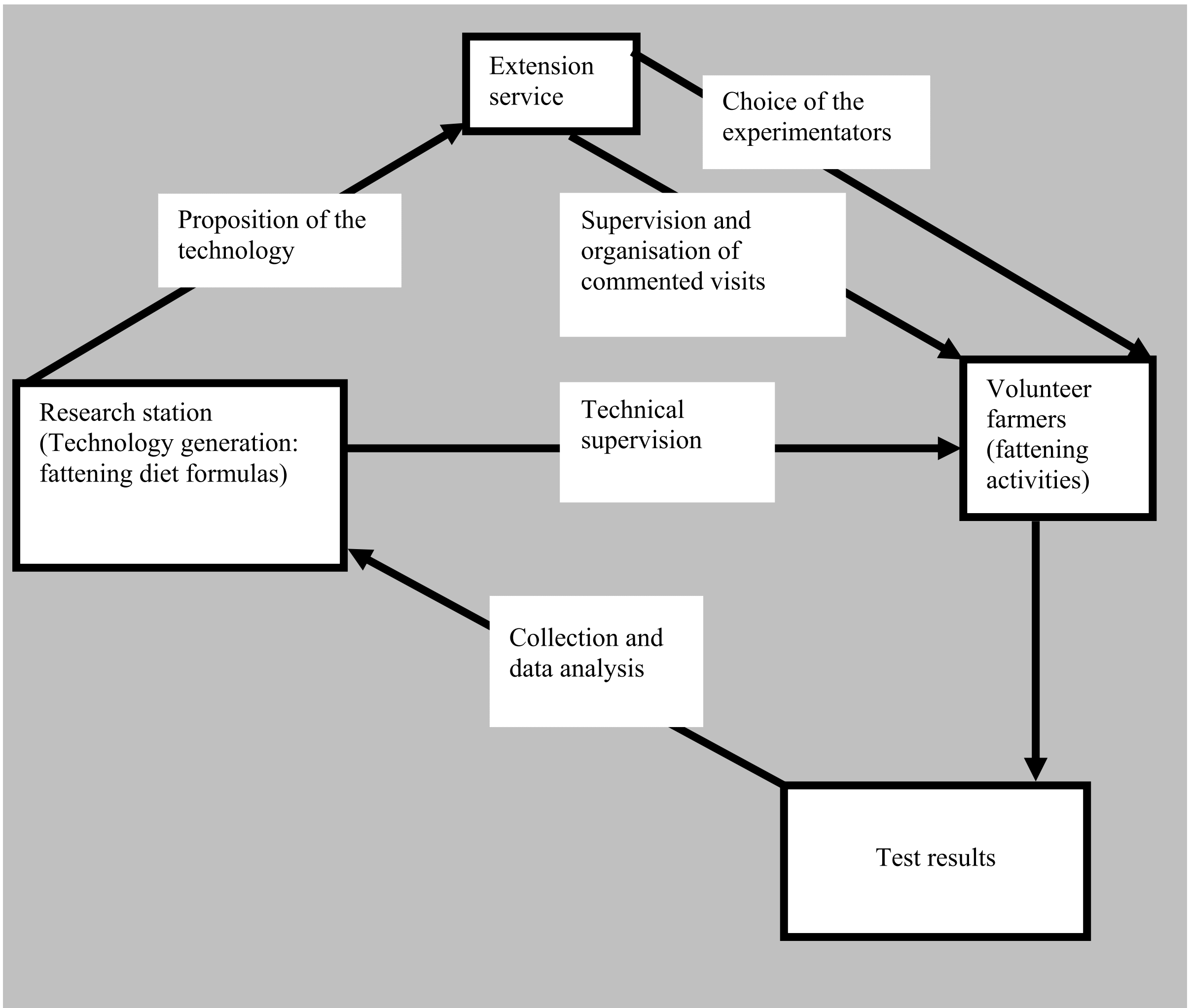

Figure 5.2.1. Scheme of the research technologies transfer approach in model I

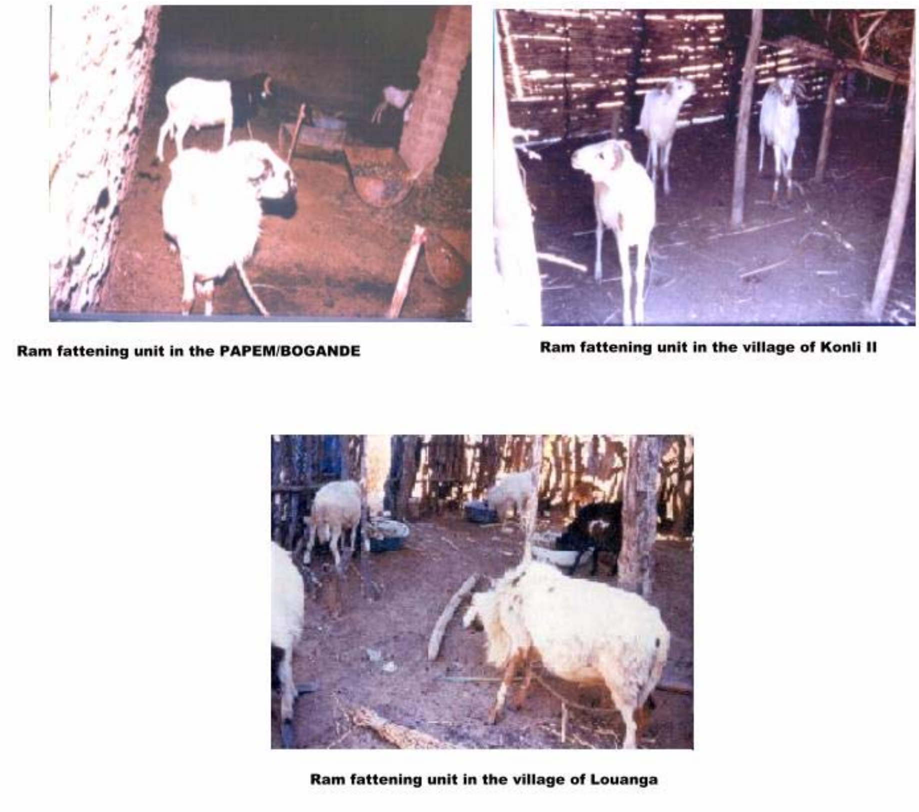

Figure 5.2.2. Ram fattening in the different sites of research with model I

The extension service identified two farmers in each of the two sites (Konli II and Louanga) for the tests. The number of replications per diet tested varied from 3 to 11 rams. They were 4 and 5 rams for the diet tested in Konli II; 10 and 11 rams at Louanga and 3 rams for each of the two diets tested in the PAPEM of Bogandé. Some sheds with pickets were used as housing of the fattening rams for the farmers whereas in the PAPEM, animals were housed in a shelter in clay. Figure 5.2.2 gives an illustration of the conditions of housing and the different breeds of sheep used. Animals used were male sheep non-castrated, purchased at the local market or taken in the flock by farmers. They were Djallonké sheep at Louanga, Fulani sheep in the PAPEM of Bogandé and crossbreed (Djalonké × Fulani) sheep at Konli II.

At the site of Konli II, rams of 30 kg mean body weight received diets I and II. In the village of Louanga, rams with 18 kg of mean body weight received diets I and IV. At the PAPEM of Bogandé, rams with mean body weight of 41 kg received diets II and III.

At each site, data of all the animals had been collected for analysis and no losses (mortality or sale) before the end of the test were registered. Duration of the test was 98 days in the village of Konli II and in the PAPEM of Bogandé. It was 56 days in the village of Louanga.

Model II

In model II, the study started with a village community meeting at the sites of research. This meeting aimed to make farmers aware of the diets tested, and to explain the design of the test. After this meeting, volunteer farmers were registered. Each volunteer farmer conducted the test in his household compound with the number of rams he could own. Allocation of a diet to a farmer was done randomly. At the same site, animals of farmers fed with the same diet constituted the replications for this diet. The scheme of model II is presented in Figure 5.2.3.

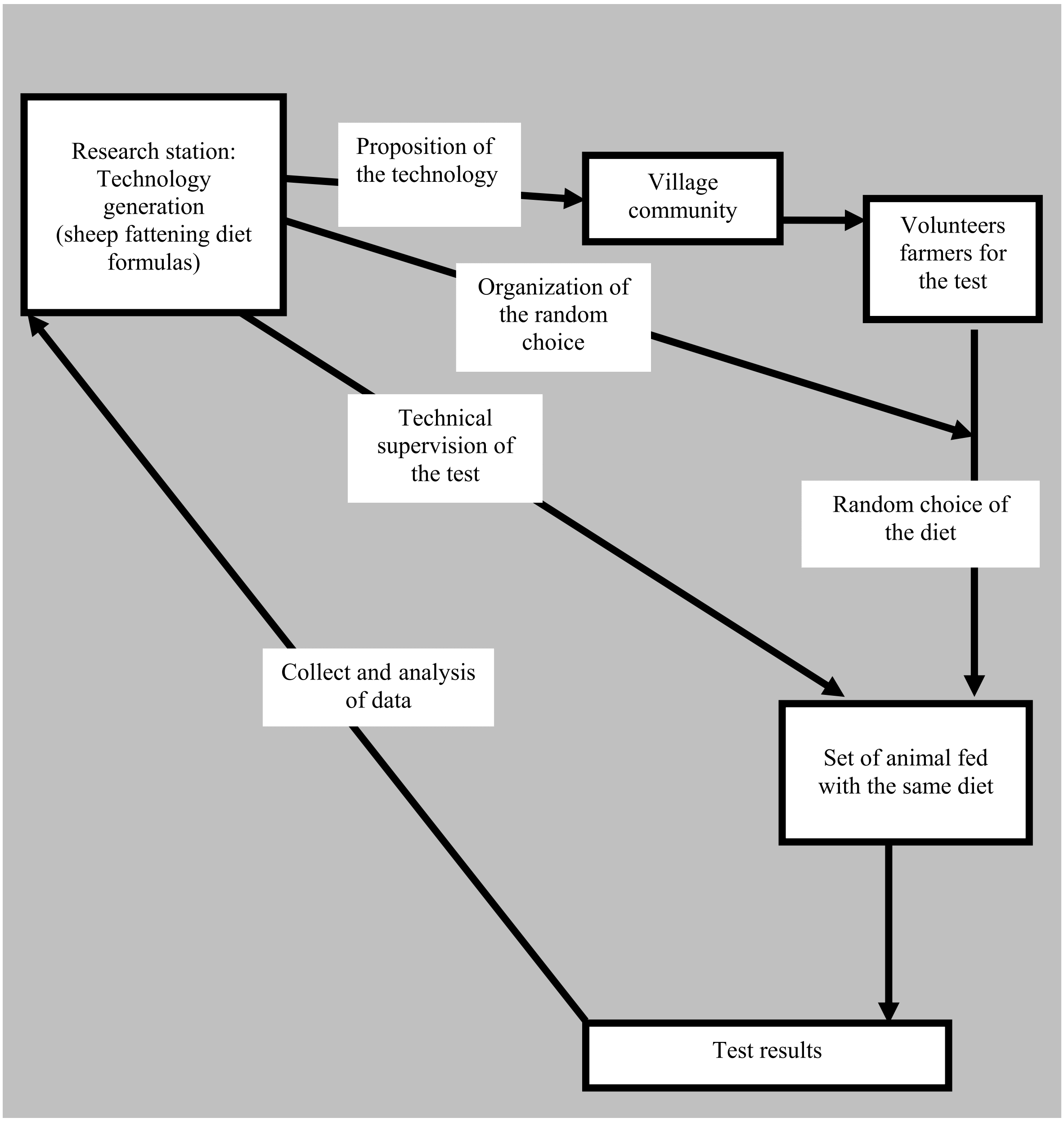

Figure 5.2.3. Scheme of the research technologies transfer approach in model II

In the current study, model II was executed at two sites (villages of Yambassé and Villy-Moukouan). Three diets were tested in Villy-Moukouan and two diets in Yambassé (Table 5.2.2).

The most available feedstuffs at these two research sites were cowpea hay, groundnut hay and sorghum straw. These feedstuffs are crop residues stored by farmers after harvesting.

The test with model II was started with 33 volunteer farmers in the two villages. After the community meeting, 27 volunteer farmers were registered for the test at Villy-Moukouan against six at Yambassé. Fattening ram numbers varied between one and three per farmer. Animals used for the test were Djallonké rams as described by Doutressoule (1947). In Yambassé, 6 and 5 replications (rams) were used for diets II and V, respectively. The mean body weights of the sheep were 21 kg for diet II and 22.5 kg for diet V. At Villy-Moukouan, 10, 16 and 15 replications (rams) were used for diets II, V and VI, respectively. At the end of the test, only 22 animals (35%) had been considered for data analysis as the other animals had died, lost or sold before the end of the test.

In the two models, recommended profile of the sheep (age, sheep breed in the site, non-castrated male) to be paid by farmers or to be taken from their flocks were indicated to farmers. So at the same site, animals had similar profile.

The substitution of a concentrate feed by another similar concentrate, or a legume by another legume, or grass by another grass was allowed. Diets were distributed in separate feeders and sheep shelters were a function of the possibility of the farmers. Shelters could be in straw or in clay.

One to two weeks of adaptation to the diets were applied before the animal received the complete diets. At the beginning of the test, the quantities of the different feedstuffs to be distributed were weighed by the researchers and then, these quantities were symbolised by marks on the recipients. These marks allowed the farmers to distribute the daily diets to the animals during the test accurately. The marks were renewed each two weeks in order to readjust the quantities of the diets at a rate of 4% of the body weight as recommended by Ouédraogo *et al.* (2001). Parameters measured were feed intake, body weight gain, socio-economical evaluation of the ram fattening for each farmer.

For any model, it is assumed that there is no need to repeat the same diet at the different sites, as the choice of the diet depended on the availability of the feedstuffs. Furthermore, the proofs of efficiency of all the diets to be tested were already done at the research centres.

Data collection procedure and analysis

Body weight gain and feed intake were obtained by recording body weights and feed refusals every two weeks.

At the end of the test, an economical assessment was done based on the following principles: the price of 1 kg of live body weight (LBW) of purchased ram was estimated to be 300 FCFA. After fattening, the price of 1 kg LBW of sheep was 500 FCFA. The purchased price of 1 kg of legumes hay (cowpea, groundnut, dolic), 1 kg of grass and 1 kg of concentrate (cottonseed, cottonseed cake, wheat bran) were set at 50, 25 and 60 FCFA during the duration of the test, respectively.

During the fattening period, a mean cost of 330 FCFA per animal for health care is necessary for prophylaxis measures. Calculations were relative to Gross Margin (GM) per animal with GM = FRP – (DC + VC + PP). FRP = fattening ram price; DC = diet cost; VC = veterinary drug cost; PP = purchased price. The fixed costs (sheep shelter, drinkers, feeders) are household dependent and were not taken into account in the calculations. With the gross margin relative to each diet, it was assumed that the farmers could adjust the number of fattening rams with regard to the fixed costs in order to make his production unit profitable.

Farmers’ opinions on the tests were collected with a questionnaire. The questions asked in the questionnaire dealt with farmers’ appreciation on the diets tested, the constraints, the number of others farmers who visited the test and their points of view, and the number of commented visits organised by the extension service.

Data were analysed with the software package STATITCF.

Results

Ram fattening results at farm level with model I

Fattening ram body weight development according to the diets tested

Body weight gains (BWG) according to the diet in model I are presented on Table 5.2.3. In the village of Konli II, rams that received diet I (66% of concentrates) gained significantly (P < 0.05%) more body weight than those receiving diet II (30% of concentrates). Although rams on diets I and IV at Louanga gained similar weights and rams on diets II and III in the PAPEM of Bogandé show somewhat similar results; it appears that there is some interaction between diet and ram breed or site of research.

Diet I generated a daily weight gain (DWG) of 147.3 g/d with young Mossi sheep in the village of Louanga, whereas in the village of Konli II a DWG of 95.9 g/d was obtained with the crossbred sheep. Furthermore, diet II in Konli II with the crossbred sheep showed a DWG of 49.7 g/d against 108.8 g/d with the Fulani sheep in the PAPEM of Bogandé. It seems that the Fulani sheep reacted favourably to diet II.

Socio-economical evaluation of the diets tested in model I

An economical evaluation of the test with model I is presented in Table 5.2.4. This evaluation confirmed the profitability of the diets formulated in the research centres. Diets with a high rate of concentrates (diets I and IV) showed higher income generation than the diets with low rates of concentrates (diets II and III). For all diets, gross margins per animal observed (1,740 to 5,095 FCFA) showed profitable sheep fattening activities with these diets at farm level.

From the interviews with farmers, it was noted that in the village of Louanga, the test received commented visits organised by the extension service for their workers. Furthermore, 22 farmers at Louanga and 10 at Konli II did some individual visits. Visitors appreciated particularly growth of the animals due to the diets and also the quantity of manure that could be produced. They were interested in the possibility to offer diets II and III. These two diets increased the value of the local available crop residues.

Table 5.2.3. Body weight development according to the diets in model I

	Site of research					
	Konli II		Louanga		PAPEM Bogandé	
	Breed used					
	Crossbreed (Fulani × Djallonké sheep)		Djallonké sheep		Fulani sheep	
	Diets used					
Parameters	Diet I n = 5	Diet II n = 4	Diet I n = 10	Diet IV n = 11	Diet II n = 3	Diet III n = 3
Initial body weight (BW) (kg)	30.2	28.1	18.7	18.3	41.0	40.7
B W at the end of fattening (kg)	39.6	33.0	26.9	25.8	51.7	47.3
Body weight gain (kg)	9.4^{a}	4.9^{b}	8.3^{a}	7.5^{a}	10.7^{a}	6.7^{a}
Daily body weight gain (g/d)	95.9^{a}	49.7^{b}	147.3^{a}	133.9^{a}	108.9^{a}	68.0^{a}

PAPEM = Extension service applied centre; n = number of rams.

At the same site, means in the same row with different superscript letters are significantly different at P < 0.05.

Table 5.2.4. Economical assessment of ram fattening according to the diets in model I (amount in FCFA)

Parameters	Site of research					
	Konli II		Louanga		PAPEM Bogandé	
	Breed used					
	Crossbred (Fulani × Djallonké sheep)		Djallonké sheep		Fulani sheep	
	Diets used					
	Diet I n = 5	Diet II n = 4	Diet I n = 10	Diet IV n = 11	Diet II n = 3	Diet III n = 3
Standard health care cost per ram	330	330	330	330	330	330
Price of 1 kg of the diet	50	50	50	45	50	45
Ram purchase Price per kg of LBW	300	300	300	300	300	300
Ram selling price per kg of LBW	500	500	500	500	500	500
Purchase price of 1 ram	9,060	8,440	5,595	5,500	12,300	12,200
Feeding cost of 1 ram fattened	6,840	5,990	2,430	2,100	8,845	7,760
Veterinary cost of 1 ram fattened	330	330	330	330	330	330
Total of the direct charge of 1 ram fattened	16,230	14,760	8,355	8,260	21,475	20 290
Income per fattened ram	19,800	16,500	13,450	12,910	25,835	23,665
Gross margin per fattened ram	3,570	1,740	5,095	4,650	4,360	3,375

FCFA = Franc de la Communauté Financière Africaine; 1 € = 655 FCFA; LBW = live body weight; PAPEM = Extension service applied centre; n = number of rams.

Advantages and disadvantages of model I

As the results indicated, model I allows to get interesting results for ram fattening diets transfer at farm level. With this model, the extension services play a key role in the identification of volunteer farmers. The extension services may organise commented visits on these tests for other farmers or extension workers. In this way, the diets that are tested reach important numbers of farmers and different localities. This way of volunteer farmer's choice assures the proper motivation of the farmers and their seriousness to be partners in the test. Collection of the data is also facilitated with this model. The risk of data loss due to animal losses, death or sale before the end of the recommended period is minimised in this model as supervision is more efficient.

The inconvenience of model I is the difficulty to obtain enough replications (animals) for the test. Only a few farmers with an acceptable economical situation can participate in the on-farm research with model I. The risks for farmers are high in this model, so some sort of compensation in case of mismanagement that lead to important number of deaths has to be taken into account by the researcher.

Ram fattening results at farm level with model II

Fattening ram body weight development according to the diets tested

Body weight gains (BWG) generated by the tested diets in model II are presented in Table 5.2.5. BWG of diet II and diet V were higher at the site of Yambassé than at the site of Villy-Moukouan. The difference in management, according to the farmers, may explain these results. At the two sites, diets with a high level of concentrates (diets V and VI) generated a higher BWG than the diets with a low level of concentrates. Diet II showed a daily weight gain of 52.7 and 86.2 g/d, similar to those registered in model I (49.7 and 108.8 g/d).

Table 5.2.5. Body weight development according to the diets in model II

Parameters	Site of research						
	Villy-Moukouan				Yambassé		
	Breed used						
	Djallonké sheep				Djallonké sheep		
	Diets tested						
	Diet II n = 2	Diet V n = 6	Diet VI n = 5	SD	Diet II n = 6	Diet V n = 3	SD
Initial body weight (kg)	22.2	22.1	22.9		21.0	22.5	
Body weight at the end of fattening (kg)	25.1	25.9	27.8		26.0	28.0	
Body weight gain (kg)	2.9	3.9	4.9	1.8	5.0	5.5	1.5
Daily body weight gain (g/d)	52.7	68.8	87.1	31.3	86.2	94.8	25.1

Socio-economical evaluation of the diets tested in model II

The economical evaluation of the ram fattening test with model II is presented in Table 5.2.6. All diets at the two sites showed similar gross margins, which ranged from 3,150 to 4,060 FCFA. Furthermore, the survey indicated that 60% of the farmers stated that (1) the test meet their expectations, (2) there is a 100% need to repeat the fattening tests and (3) they think that they are able to conduct their own fattening sheep activities. It can be noted that 20% of the farmers bought the animals for the fattening test whereas 80% took them from their sheep flocks.

Table 5.2. 6. Economic assessment of ram fattening according to the diets in model II (amount in FCFA)

Parameters	Site of research				
	Villy-Moukouan			Yambassé	
	Breed tested				
	Djallonké sheep			Djallonké sheep	
	Diets used				
	Diet II n = 2	Diet V n = 6	Diet VI n = 5	Diet II n = 6	Diet V n = 3
Standard health care cost per animal	330	330	330	330	330
Price of 1 kg of the diet	50	50	55	50	50
Ram purchase Price per kg of LBW	300	300	300	300	300
Ram selling price per kg of LBW	500	500	500	500	500
Purchase price of 1 ram	6,645	6,618	6,864	6,300	6,750
Feeding cost of 1 ram fattened	2,436.5	2,426.5	2,768.7	2,664	2,862
Veterinary cost of 1 ram fattened	330	330	330	330	330
Total of the direct charge of 1 ram fattened	9,400	9,375	9,965.7	9,295	9,940
Income per fattened sheep	12,550	12,955	13,800	13,000	14,000
Gross margin per fattened sheep	3,150	3,580	3,835	3,705	4,060

FCFA = Franc de la Communauté Financière Africaine; 1 € = 655.957 FCFA;
LBW = live body weight; n = number of rams.

Farmers reacted enthusiastically to the visible weight gain of the fattening sheep due to the effect of the diets, the higher price of the fattening rams at sale and the nice format of the rams after fattening.

Advantages and disadvantages of model II

As an advantage, model II allowed a large number of farmers to be part in the on-farm research. This large number was optimal in order to carry out a relevant formal survey on farm opinions on the test. Furthermore, the number of rams per farmer can be low so, the risks relative to the test for each farm are minimised.

The disadvantages of model II are (1) the lacking role of the extension workers and (2) the difficulties for the technical supervision due to the large number of participants to the test. There is also an increase of the risks related to ram losses, rams death or mismanagement of the test.

Discussion

The practical relevance of the ram fattening diets, formulated at the research centres, are confirmed in the current test. All the diets tested generated positive weight gains.

With model I, average daily weight gains (ADG) obtained with diet I (95.9 g/d and 140.1 g/d), diet II (49.7 g/d and 108.8 g/d) and diet III (68.0 g/d) matched with the range of those observed with the same diets during on station research. Hence, in station (Kondombo and Nianogo, 2001; Nianogo *et al.,* 1995) diets I, II, and III generated ADG's of 96 to 132.6 g/d, 81.1 g/d and 95.6 g/d, respectively. Only diet IV showed ADG on farm that were much higher (133.9 g/d) than the on-station results (68.6 g/d).

In model II, ADG observed with diet II (52.7 and 86.2 g/d), diet V (68.8 and 94.8 g/d) and diet VI (87.1 g/d), were also comparable with the on-station results observed by Kalkoumdo (1994) and Kondombo and Nianogo (2001). These authors indicated ADG's of 81.1, 73.6 and 100.9 g/d for diets II, V and VI, respectively.

Furthermore, it can be noted that all ADG are lower than those observed (128 g/d) with young Vogan sheep (Amégée, 1984). Rivière (1978) also indicated 136 g/d with the male of 'Peulh sénégalais' sheep ageing 10 to 15 months (Peulh = Fulani). Conversely, our results are concordant with those of Bourzat *et al.* (1987) with ADG of 94 to 111 g/d in 92 days of Mossi and Fulani sheep fattening.

Gross margins (3000 to 5000 FCFA/ animal) registered in the two models confirm the profitability that can be expected from the diets formulated in the research centres. It appears that the fattening of all breed and age of sheep can be profitable by using the fattening diets tested. The choice of the diet will depend of the locality and the possibility of the farmers to gather the necessary quantity of feedstuffs.

It seems also that with regard to the actual market price of fattening rams, the diet with low rates of concentrates may be more recommendable at farm level. The economical assessment indicates that the sheep fattening can be done with old sheep as well with young sheep.

The two models appear to be interesting and applicable for transfer knowledge on fattening diets to farm level. However, with regard to the advantages and disadvantages of the two models, they should be consecutively executed for a more efficient knowledge transfer. In the first stage of the transfer, model I could be applied. This will allow accurate supervision of the test and the collection of relevant data for the bio-economical analysis of the fattening diets. Then, in a second stage, model II could be applied in order to reach the maximum number of farmers and to be able to collect relevant formal survey data on farmer opinions on the test.

In conclusion, the current study gives some guidelines for the transfer of knowledge on ram fattening diets to farm level. The models described may be adapted for other research technology transfer at farm level.

5.3. Increase in the availability of forage by the combination of dolic with cereals

Abstract
A trial was conducted at the research station of Kouaré in the East of Burkina Faso, in order to identify the appropriate spatial distribution of cereals and the type of cereal thatcould be used in combination with *Dolichos lablab*. The experimental design was a cross-over with two factors in four replications. The first factor was the spatial distribution with four treatments and the second factor was the type of combination with seven treatments. None of the combinations of cereals/dolic had a negative effect on cereal yields. Forage yields for *Dolichos lablab* of up to 0.17 to 1.48 t/ha were observed with certain cereals/*Dolichos lablab* combinations. Maize and sorghum appear to be the most convenient for a cereals/*Dolichos lablab* combination. The best spatial distributions for the combination were seeding of *Dolichos lablab* in the same hole of the cereal or between two holes of the cereal both on the same line.

Keywords: Dolichos lablab, cereals, forage, combination, Burkina Faso.

Introduction

Many efforts have been undertaken by extension services to stimulate farmers to grow fodder crops. Despite the effort, its practice is not widespread yet. Causes of that are multiple but it can be noted that there is a low availability of labour and cultivable land at farm level. Indeed, according to the FAO (1983), the demographic growth, the intensification of crop production and the increase of livestock flock sizes reduce the arable lands, the time of fallow and increase the pressure on lands. Another important cause is that fodder farming cannot be valorised in the context of subsistence farming but in the context of market oriented farming.

What to do to increase qualitative and quantitative sufficiency of feed resources for livestock, especially for sheep fattening in the dry season in the Sahelian countries in general and in Burkina Faso in particular? Previous field work, mainly by FAO (1988), has been done on the development of fodder farming and ameliorated fodder in the Sudano-Sahelian zone. Fodder farming will allow obtaining high quality fodder. That will make more feed available for livestock in the dry season. To do so, and taking into account the adoption difficulties already mentioned, the combination of fodder farming, mainly dolic, with cereal production seems to be an appropriate practice. The results of former studies (FAO, 1983; FAO, 1988) showed that the combination of roughage farming together with cereal production show promises to increase the feeding status of sheep during the dry season.

This study aimed to investigate the combination of *Dolichos lablab* with millet, maize or sorghum at different spatial set ups in the field with regard to yields of both dolic and grains.

Materials and methods

The study was conducted at the experimental station of Kouaré, localised in the Department of Fada in the East of Burkina Faso, during two seasons (1994 and 1995). The station has a Sudanian climate with two distinct seasons: a rainy season of 5 to 6 months and a dry season (INERA, 1997). Rainfall varies strongly from year to year: in 1994, 836 mm of rainfall was registered in 49 days against 1024 mm in 59 days in 1995 (Table 5.3.1). The vegetation is a dense savannah bush with few big trees.

Table 5.3.1. Rainfall in the rainy seasons 1993-1994 and 1994-1995 in the department of Fada

Months	Campaign 1993-1994		Campaign 1994-1995	
	Water height (mm)	Number of days of rainfall	Water height (mm)	Number of days of rainfall
October	31.1	4	90.5	8
November to March	0	0	0	0
April	1.2	1	24	2
May	78.8	5	124	7
June	104.7	11	114.3	5
July	226.2	10	178.1	10
August	248.9	10	306.4	15
September	139.1	8	186.9	12
Total of the campaign	836	49	1024.2	59

Source: Institut de l'Environnement et de Recherches Agricoles (INERA)/ station de Kouaré/Burkina Faso

The combination was based on dolic and one out of three cereals: maize, sorghum or millet. Dolic is a fodder crop with the characteristics of annual species (quick growth and high productivity) and is adapted to the aridity. The cultivar of dolic that is mainly used in Burkina Faso is the Highworth which is easy to harvest in November-December, and widely popularised by extension workers in the country. The cereals used are millet (variety IKMP 3), sorghum (variety sariasso 9) and maize (variety KPJ). These are improved varieties developed by the agricultural research institute of Burkina Faso (INERA). The density and sowing date of the cereals were those recommended by the extension and research services in the country. Dolic was sown at the first weeding of the cereals at about 2 to 3 weeks after sowing of the cereals. Cereals were sown on July, 6 and 10 in 1994 and 1995, respectively. Dolic was sown July, 21 and 31 in 1994 and 1995, respectively.

The experimental design was a cross-over design with two factors in four replications (Figure 5.3.1a). The first factor was a spatial distribution with four treatments assigned to principal plots of 190.4 m^2 of surface each. The treatments were: (1) SD1 (one line of dolic between two lines of cereal); (2) SD2 (one line of dolic intermittently with two lines of cereal); (3) SD3 (dolic and cereals in the same hole); (4) SD4 (one line of dolic intermittently with one line of cereal (Figure 5.3.1b).

The second factor was the type of (cereal/dolic) combination with seven treatments assigned to secondary plots of 22.4 m^2 of surface area each. The associations were: (1) MID (millet/dolic); (2) SOD (sorghum/dolic); (3) MAD (maize/dolic); (4) MI (millet only); (5) SO (sorghum only); (6) MA (maize only); (7) D (dolic only).

The same design was applied in the second rainy season. Treatment SD2 was replaced by treatment SD2' (dolic between the holes of cereals in the same line). That change was made with regard to the low yield with treatment SD2 in the first year of the experiment.

The plots were fertilised according to the recommendations of the extension service. Mineral fertilisation was 100 kg/ha of NPK at sowing and 50 kg/ha of urea at growing stage for millet and sorghum. For the maize, it was 150 kg/ha of NPK at sowing and 100 kg/ha of urea at growing stage. In association with a cereal, dolic does not receive specific fertilisation, when planted alone (FD) it was fertilised with 100 kg of NPK per ha. Weeding was done at lifting and when necessary. At thinning 2 plants for dolic, 3 plants for the millet and sorghum and 1 to 2 plants for the maize were left. Dolic fodder is harvested when basal leaves turn yellow, then it is sun dried before being weighed for the determination of yield (fodder cutting was done in such a way to assure that dolic will grow against for seed production). Thereafter, grain production of cereals was measured.

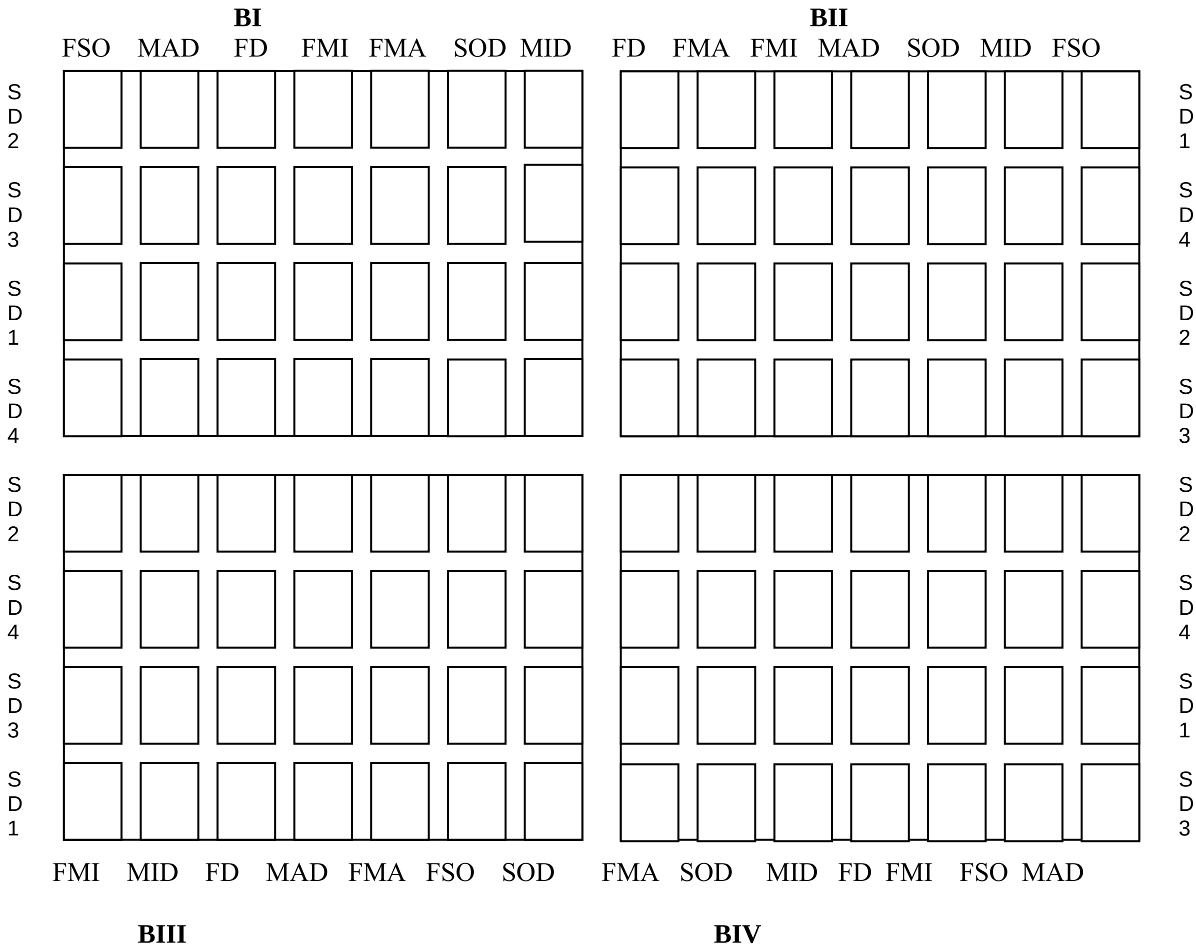

Figure 5.3.1a. Experimental plan on the field

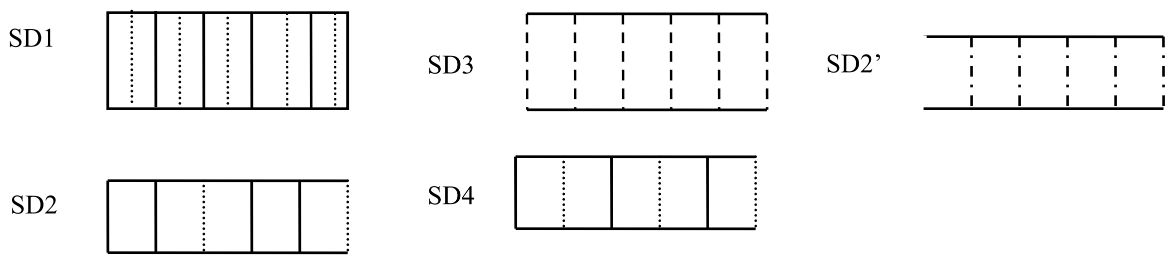

Figure 5.3.1b. Scheme of the spatial distributions of the association cereal/dolic (SD1, SD2, SD3, SD4, SD2')

——— = Line of cereal .... = Line of dolic - - - - - - - = Cereal and dolic in the same hole

-·-·-·-·-·- = Dolic holes between the hole of cereal in the same line

Distance between line = 0.8 m ; Distance between hole = 0.5 m

MAD = Maize/Dolic; FMA = maize only; SOD = Sorghum/Dolic; FSO = sorghum only; MID = Millet/Dolic; FMI = millet only; SD1 = one line of dolic between two lines of cereals; SD2 = one line of dolic for two lines of cereals; SD3 = dolic and cereals in the same hole; SD4 = one line of dolic for one line of cereal; SD2' = sowing of dolic between cereals hole on the same line; BI = block I; BII = block II; BIII = block III; BIV = block IV.

Data were analysed with the programme GENSTAT using the ANOVA analysis. The model equation used to analyse the parameters was:

$y_{ijk} = u + a_i + b_j + a_i b_j + e_{ijk}$.

With, u the overall mean effect; a_i the effect of the first factor (the spatial distribution), i = 1, 2, 3, 4); b_j, the effect of the second factor (the type of cereals/dolic combination) (j = 1, 2, 3, 4, 5, 6, 7); $a_i b_j$, the effect of the interaction; e_{ijk}, the error term; E (e_{ijk}) = 0. The significance level was 0.05. Separation of means was done by the Least Significant Difference (LSD)-test.

Results

Cereal grain yields according to the spatial distribution

In 1994, the spatial distributions SD1 and SD3 resulted in high cereal grain yields (Figure 5.3.2). During the rainy season 1995, it appeared that sowing of dolic between cereal holes (SD2') and sowing of dolic in the hole of the cereal (SD3) gave better grain yields.

Cereal grain yields according to the type of cereal/dolic combination

In 1994, the combination of dolic with maize affected negatively ($P < 0.05$) maize grain yields, although this negative influence was not observed if dolic was combined with the other cereals (Table 5.3.2). In 1995, for all cereals, there were no negative influences of any cereal in combination with dolic.

Interaction of the spatial distribution and type of combination on cereal grain yields

For the first year of the trial (1994), statistical analysis revealed significant lower yields of maize ($P < 0.05$) between maize in combination with dolic (MAD) compared to maize without dolic (MA) for the spatial distribution SD1 and SD2 (Table 5.3.3). No significant differences ($P \geq 0.05$) between MAD and MA were observed with the spatial arrangements

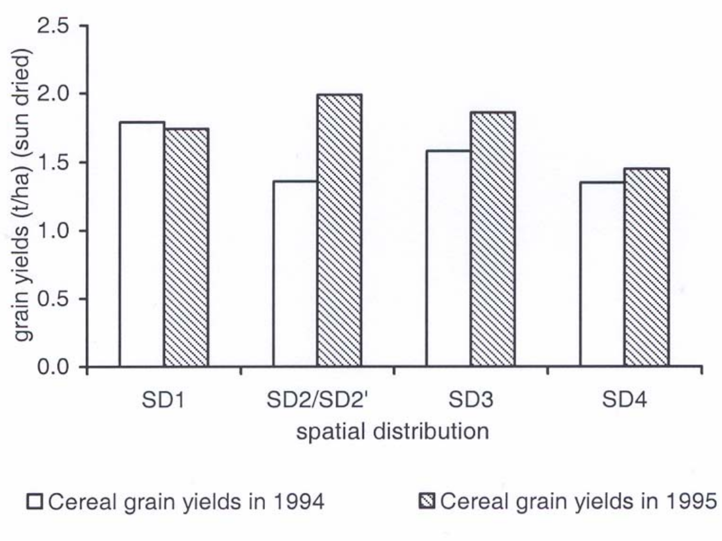

Figure 5.3.2. Influence of the spatial distribution on cereal grain yields

SD1 = one line of dolic between two lines of cereals; SD2 = one line of dolic for two lines of cereals; SD3 = dolic and cereals in the same hole; SD4 = one line of dolic for one line of cereal; SD2' = sowing of dolic between cereals hole on the same line.

Table 5.3.2. Grain yields (t/ha) (sun dried) of cereals according to type of combination

Year	Treatments							
	MA	MAD	SO	SOD	MI	MID	SE	LSD
1994	3.51[a]	3.17[b]	0.62	0.57	0.62	0.64	0.12	0.25
1995	2.55	2.35	1.65	1.69	1.15	1.16	0.15	0.63

MA = maize only, MAD = maize/dolic, SO = sorghum only, SOD = sorghum/dolic, MI = millet only, MID = millet/dolic, SE = standard error, LSD = least significant difference.

For the same cereal, the means with the different superscript letters on the same row differ significantly at P < 0.05.

Table 5.3.3. Cereal grain yields (t/ha) (sun dried) according to spatial distribution and type of combination

Year	Spatial distribution	Type of combination					
		MAD	MA	SOD	SO	MID	MI
1994	SD1	3.81 [b]	4.36 [a]	0.55	0.67	0.67	0.68
	SD2	2.38 [b]	3.07 [a]	0.54	0.64	0.80	0.75
	SD3	3.67	3.62	0.52	0.58	0.46	0.65
	SD4	2.80	2.99	0.70	0.59	0.64	0.40
	SE				0.51		
	LSD				0.25		
1995	SD1	2.40	2.59	1.57	1.56	1.10	1.22
	SD2’	2.72	3.14	1.85	1.67	1.30	1.23
	SD3	2.58	2.69	1.83	1.82	1.15	1.10
	SD4	1.72	1.78	1.51	1.56	1.10	1.04
	SE				0.31		
	LSD				0.63		

MAD = maize/dolic, MA = maize only, SOD = sorghum/dolic, SO = sorghum only, MID = millet/dolic, MI = millet only, SD1 = one line of dolic between two lines of cereals, SD2 = one line of dolic for two lines of cereals, SD3 = dolic and cereals in the same hole, SD4 = one line of dolic for one line of cereal, SD2’ = sowing of dolic between cereal holes on the same line.

For the same cereal means with the different superscript letters on the same row differ significantly at P < 0.05.

SD3 and SD4. For the second year of the trial in 1995, such differences were not observed between treatments for maize. For sorghum and millet, such effects were not observed in the two years.

Maize grain yields varied from 2.38 t/ha to 4.36 t/ha in 1994 against 1.72 t/ha to 3.14 t/ha in 1995. Sorghum grain yields varied from 0.52 to 0.70 t/ha in 1994 against 1.51 to 1.85 t/ha for 1995. For millet, grain yields ranged from 0.40 to 0.80 t/ha in 1994 against 1.04 to 1.3 t/ha in 1995.

Dolic fodder yields according to the spatial distribution

For all spatial distributions, dolic fodder yields in 1995 were much lower compared to 1994. Figure 5.3.3 reveals that for the first year (1994) of the trial the best dolic fodder yields were obtained with the spatial distributions SD3, SD4 and SD1. Especially SD3 gave favourable results. The spatial distribution SD2 gave lower (P < 0.05) forage production. For the second year (1995), the best dolic fodder yield was also observed with spatial distribution SD3.

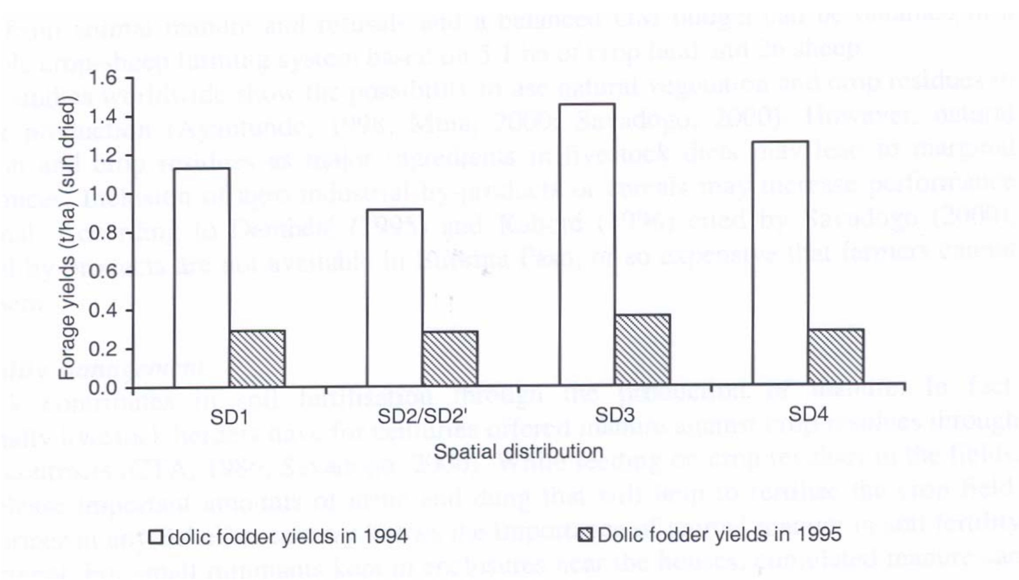

Figure 5.3.3. Influence of the spatial distribution on dolic fodder yields

SD1 = one line of dolic between two lines of cereals; SD2 = one line of dolic for two lines of cereals; SD3 = dolic and cereals in the same hole; SD4 = one line of dolic for one line of cereal; SD2' = sowing of dolic between cereal hole on the same line.

Dolic fodder yields according to the type of combination

The type of combination cereal/dolic significantly affected ($P < 0.05$) the production of dolic fodder in both years (Table 5.3.4). The farming of dolic alone (D) yielded 2.16 t/ha, significantly higher than the forage yields in combination with cereals, especially during 1994. Furthermore, during this year, there were no significant differences ($P \geq 0.05$) between dolic fodder yields obtained in a combination of dolic with maize (MAD) and sorghum (SOD). The dolic fodder yields of the combination millet/dolic (MID), however, was significantly lower ($P < 0.05$) than those with maize or sorghum. In 1995, the best dolic fodder yields in a combination with a cereal were also obtained with maize (MAD), followed numerically by sorghum (SOD) and millet (MID).

Table 5.3.4. Dolic fodder yields (t/ha) (sun dried) according to type of combination

Year	Treatments				SE	LSD
	MAD	SOD	MID	D		
1994	1.10[b]	1.06[b]	0.41[c]	2.16[a]	0.16	0.32
1995	0.23[b]	0.16[c]	0.11[c]	0.73[a]	0.03	0.06

MAD = maize/dolic, SOD = sorghum/dolic, MID = millet/dolic, D = dolic only, SE = standard error, LSD = least significant difference.

Means with different superscript letters on the same row differ significantly at $P < 0.05$.

Interaction of the spatial distribution and type of combination on dolic fodder yields
The spatial distribution did not affect dolic fodder yields in a combination with maize, sorghum or millet for both years (Table 5.3.5). However, when dolic was farmed without cereals, the spatial distribution SD3 gave the highest ($P < 0.05$) dolic fodder yields in both years.

Dolic fodder yields farmed without cereals varied from 1.51 to 2.81 t/ha in 1994, and from 0.59 to 0.93 t/ha in 1995 (Table 5.3.5). When dolic was farmed in a combination with a cereal, fodder yields varied from 0.32 to 1.48 t/ha in 1994 and from 0.08 to 0.26 t/ha in 1995. In 1995, both for dolic alone and in a combination, yields were dramatically lower than in 1994.

Discussion

The current study investigated whether the combination of forage (dolic) with a certain cereal would affect the yields of both dolic and the cereal.

The results of this study from the year 1994 reveal that the two spatial distributions: dolic between the lines of cereal (SD1) and the sowing of dolic in the same hole of the cereals (SD3) give the best cereal yields. For the production of dolic fodder, the spatial distribution of SD3 gives the best yields, followed by the fodder yields after sowing one line of dolic for one line of cereal (SD4). When considering the two aspects (grains of cereal and fodder of dolic), it appears that the best spatial distribution is the sowing of dolic in the same hole as the cereal (SD3).

In the second year (1995), the spatial distribution SD3, as in 1994, indicates to yield most dolic fodder and cereal grains. The sowing of dolic between the cereal holes (SD2' in 1995)

Table 5.3.5. Dolic fodder yields (t/ha) (sun dried) according to spatial distribution and type of combination

Year	Spatial distribution	Type of combination			
		MAD	SOD	MID	D
1994	SD1	0.98	0.87	0.54	2.12[cb]
	SD2	0.92	0.88	0.32	1.51[c]
	SD3	1.18	1.48	0.34	2.81[a]
	SD4	1.32	1.00	0.44	2.21[b]
	SE	0.33			
	LSD	0.67			
1995	SD1	0.22	0.11	0.12	0.72[b]
	SD2’	0.19	0.17	0.11	0.67[b]
	SD3	0.25	0.23	0.08	0.93[a]
	SD4	0.26	0.14	0.12	0.59[b]
	SE	0.07			
	LSD	0.13			

MAD = maize/dolic, SOD = sorghum/dolic, MID = millet/dolic, D = dolic only, SD1 = one line of dolic between two lines of cereals, SD2 = one line of dolic for two lines of cereals, SD3 = dolic and cereal in the same hole, SD4 = one line of dolic for one line of cereal, SD2’ = sowing of dolic between holes of cereal on the same line.

In the same year, means with different superscript letters in the same column differed significantly at $P < 0.05$.

appeared to be an interesting method of distribution as it allowed to maintain a high level of cereal production, even if fodder production showed relatively lower yields compared to those obtained with SD1 and SD3.

When taking into account the results of this study in the two years, the sowing of the dolic and the cereal in the same hole (SD3) and the sowing of the dolic between holes (SD2') appear to be the best spatial distributions with regard to yields of both cereals and dolic. Our results are in accordance to those of Bengaly *et al*. (1994). They indicated also that the sowing of dolic between the holes is the best spatial distribution. However, results of Scheer (cited by Bengaly *et al*., 1994) showed that the sowing in interlines was the best spatial distribution. Such results may be in accordance with our results if, in the current study, the constraints related to mechanised works were not considered

Our results reveal that the combination of dolic with cereals did not negatively influence cereal grain yields in the spatial distributions SD3 and SD2'. Similar observations were also mentioned by Bengaly *et al.* (1994): the combination of pigeon pea and sorghum in Mali did not show negative effects on the cereal grain yields. Another study in Mali indicated that sorghum yields were not influenced by the presence of dolic (CILSS /FAO, 1986). That can be explained by the fact that in the combination of a cereal and dolic, the competition for nutrients is low or limited with respect to the capacity of dolic to do the symbiotic fixation of nitrogen (CIPEA cited by Bengaly *et al.,* 1994).

The best cereal grains and dolic fodder yields are obtained with the combination maize/dolic and, at the second place, the combination sorghum/dolic. These results confirm the previous studies in Burkina Faso (FAO and CILSS, 1984) and in Mali (Bengaly *et al*., 1994).

The best combinations (maize/dolic and sorghum/dolic) in relation with the best spatial distributions (SD3 and SD2') suggest that the best interacting combinations could be MAD/SD2', MAD/SD3, SOD/SD2' and SOD/SD3. These combinations of the two factors of the study have given dolic fodder yields ranging from 0.17 to 1.48 t/ha. Such forage should be valorised in productive animal units as meat or milk production. Indeed, combination of dolic with cereals is more favourable in the perspective of market oriented productions such as sheep fattening, milk production or fodder sale. Then, farmers can produce dolic in combination with a cereal in order to increase the worth of his crop residues (cereal straws and dolic forage hay).

It should be noted that dolic fodder yields in a combination with cereals are less that those of dolic farming without cereals production. Similar observations were reported by Aloud, cited by Bengaly *et al.* (1994).

Dolic fodder yields during the two rainy seasons varied from 0.08 to 1.48 t/ha for combined farming. These yields are comparable to those of 0.13 to 0.9 t/ha registered at Sebba in Burkina Faso with the combination sorghum/dolic (CILSS and FAO, 1986). Our results are lower than those observed in Mali, where dolic forage yielded 3.92 to 9.16 t/ha with the combination cereals/dolic.

The grain yields of maize (1.72 to 3.67 t/ha), of sorghum (0.52 to 3.14 t/ha) or millet (0.46 to 1.30 t/ha) obtained in a combination with dolic do fit in the range of acceptable yields of these cereals (INERA, 1986; INERA, 2000).

Grain yields could have been affected by differences in rainfall registered in the two years, 1025.2 mm in 1995 and 839 mm in 1994, respectively. The important rainfall in 1995 may have caused temporarily floods which lead to lower fodder production. Such effects of flood were also observed in a previous study on the combination dolic/cereal in Burkina Faso, where low dolic fodder yields of 0.15 to 0.9 t/ha were obtained (CILSS and FAO, 1986).

The results provide interesting information on the technique of a cereal/dolic combination.

Such technique of fodder production can be used by small farmers who not have often the possibility to buy the concentrate feeds for the few heads of sheep that they need to grow. This technique can be a mean to increase the availability of feedstuffs for sheep fattening at farm level.

However, other investigations are indispensable to study the long term effect on soil fertility of this combination. Indeed, from the cereal/dolic combination, rural farmers sustain two opposite ideas (Bengaly *et al.*, 1994): some farmers think that the combination maize/dolic reduces soil fertility, whereas some farmers believe the contrary and a third group of farmers think that it depends on the type of soil.

Conclusion

The best fodder yields (in a decreasing order) are obtained when dolic is combined with maize, than sorghum, and than millet. The best spatial distributions for such combinations are the sowing of dolic and cereal in the same hole and the sowing of dolic between cereal holes on the same line. Hence, it appears that the combination of dolic with a cereal can be done with all the cereals.

CHAPTER 6

Relationship between village chickens and small ruminants: A design of an Integrated (village chicken/sheep fattening) Production System (IPS)

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6. Relationship between village chickens and small ruminants: A design of an Integrated (village chicken/sheep fattening) Production System (IPS)

Abstract
In developing countries, farmers are often involved in a mixed farming system. This diversification helps to avoid the risks related to the practice of one speculation. In the livestock sub-system, such strategy is also observed with regard to the ownership of different species by the same farmer. This study aimed to show how village chickens and small ruminants can both be a relevant source for livestock improvement and for income generation at farm level and how these systems can be improved. The study was done with the Rapid Rural Appraisal (RRA) method and two formal surveys in the village of Matté in Burkina Faso. The tools of RRA used were the semi-structured interviews, the Venn diagram, the resource map, the group and the individual meetings. For each formal survey, a sample of 30 households was chosen by the farmers themselves on the basis that they rear chickens and also to cover almost all the neighbourhoods of the village. A literature review helped to design an improved village chicken production system in relation with sheep fattening. The results show that nearly 80% of the households rear in addition to chicken, sheep or goats. Furthermore, there is a tendency for households to rear various animal species with 48% of the households breeding simultaneously village chicken, goat and sheep. In the households, the main source of income is the sale of village chickens and small ruminants. Up to 60% of the households never sell cereals whereas village chickens and small ruminants are frequently sold for different reasons. The most important reason for village chickens selling is the high number of chickens according to 47% of the households and the resolution of cash problem for 20% of the household. The main reasons for selling small ruminants are their high number and the solving of cash problem for respectively 53% and 37% of the households. Up to 57% of farmers perceived that the interrelation between sheep and chickens can be used to improve village chickens production. This can be done by using the same run as sheep for 27% or the income from sheep sale to invest in chicken (13%). Furthermore, the analyses of feed resources used by sheep and village chickens indicated that the interrelation between feed resources for these two species can be used as well. For the small ruminants, sheep fattening appears to be an interesting way to increase income generation from these species. An integrated village chickens/sheep fattening system can be a means of improvement of village chicken production and increase of income at farm level.

Keywords: Sheep, village chickens, integration, feeds, productivity, income, Burkina Faso.

Introduction

In developing countries in general and in Burkina Faso in particular, rural farmers have a diversity of activities such as crop production, livestock production, trade and craft. According to the possibility of each farmer, the nature of these activities can differ but for all, this diversification is designed to avoid the risk related to the practice of one activity. The cycle of production, the resistance to disease and the requirement of inputs for production are different between crop types and animal species. Farmers exploit the complementarities or the benefit of each of them to assure the sustainability of their farming system. Even in the same production system, farmers diversify the type of product. For crop production, different cereals (sorghum, millet, maize, rice) or legumes (groundnut, cowpea) may be cultivated in two, three or more combinations. For livestock production, the different species (cattle, sheep, goat, chicken, guinea fowl, duck, donkey) are reared in various combinations.

The output of the crop production activities serves firstly home consumption but rural farm households have also various sources of income: crop products, livestock products, commerce, craft and gardening. Each source has some relative importance in income generation but many authors (Sonaiya *et al.*, 1999; Guèye, 2000) agree that small ruminants and village chickens are the main source of income of poor farmers in developing countries. When we want to fight against poverty in developing countries, it is therefore firstly important to improve the output of these two production systems.

For small ruminants, sheep fattening is know as the main technology to improve the production system (Chapter 2). The available data on village chickens in Burkina Faso show that efforts have been made in research and development activities (Brunet *et al.*, 1984a,b,c; Saunders, 1984) to characterise and to improve village chicken production. Unfortunately, these actions on family poultry were short in time and space and the results are poor in terms of real improvement of village chicken production. The village chicken production system at farm level remains essentially the traditional extensive system with low productivity (Saunders, 1984; Kondombo *et al.*, 2003b). Technologies of improved houses, house equipments and sanitary health care are recommended but, how to combine all these technologies in an economical way is not yet revealed. Furthermore the problem of village chicken feeding has not yet adequate solutions (Saunders, 1984; Sonaiya *et al.*, 1999) as the use of modern complete diet is still subject to controversy. With the interventions of previous projects and extension services, some farmers try to improve village chicken production systems by sanitary interventions, rearing several poultry species, and by application of general zootechnical principles such as selection and synchronisation of the hatching (Ouandaogo, 1997). Consequently, these farmers have large flock sizes. Nevertheless, it is commonly agreed that the productivity of village chickens is still low (Djabi, 1983; Brunet *et al.*, 1984a; Wilson *et al.*, 1987; Ouandaogo, 1997; Sonaiya *et al.*, 1999; Kondombo *et al.*, 2003b). A village chicken hen has its sexual maturity at 6 months, with the body weight of the adult female and male being respectively 0.9 - 1.2 kg and 1.2 - 2.0 kg. The number of chicks per clutch is 5 to 7, egg weight is 30 g and three clutches per year are observed. In developing countries in general, the traditional poultry production remains the most important and for example in Burkina Faso, it represents 99% of poultry flocks (Ouandaogo, 1997).
So, further investigations are needed to improve the productivity of village chickens and to exploit the seasonal variation of village chickens flock size (Chapters 1 and 3) in order to improve village chicken income generation at farm level.

At rural household level, there is a necessity to identify technologies with low costs that can be adopted by every farmer. Technologies may primarily aim to reduce the losses in the flocks which needs a more controlled production system than the extensive one. Secondly, technologies may aim at optimising the use of local feed resources in addition to scavenging.
For specialised farmers, there is a need not only to increase the flock size but also to increase the production of eggs and meat per chicken. For these systems, relatively higher cost technologies in which feeding may play an important role have to be identified in relation with well-organised marketing.

The current study explores the place of small ruminants and village chickens in income generation and aims to describe how the interrelation between sheep and village chickens can be exploited to improve village chicken productivity.

Materials and methods

The study consisted of one informal and two formal surveys in a village named Matté, located in the Central Region of Burkina Faso. This village was chosen as our site of research because it benefited from projects' supports, which potentially enhanced farmers' knowledge on village chicken production (Ouandaogo, 1997). With the perspective to conduct actions aiming at improvement of village chicken production, it seemed adequate to evaluate the current state of improvement at farm level. Matté is located at about 10 km of Ziniaré, the chief town of the Province of Oubritenga.

The informal survey, realised in June 2002, was done with the Rapid Rural Appraisal (RRA) method (IISD, 1995). This RRA was organised with a research team of 5 scientists composed of 2 zootechnicians, 1 sociologist and 2 livestock technicians. The tools of RRA used were the semi-structured interviews, the Venn diagram, the resource map, the group meeting and the individual meeting. The questions dealt with farmer activities, the infrastructures and organisation in the village and the production systems in order to understand the context of the research site.

The two formal surveys were conducted in 2001 and 2002. For each formal survey, a sample of 30 crop/livestock households were chosen by the farmers themselves based on the interest of the household chief in village chicken production and also to cover most of the neighbourhoods of the village. The sample of 30 households was chosen taking into account recommendations from Udo *et al.* (1999). All households were crop/livestock households. No Fulani, livestock based households were included in the sample because in this farming system, village chicken production system is considered as marginal activity (Chapter 1; Kondombo *et al.*, 2003b). The questions asked during the survey deal with crop and livestock production systems, the flock size of the different species, the feeding of livestock in the village, the different production activities, the contribution of the different household activities in income generation. The questions also dealt with the existence of interrelations between sheep and village chickens productions, the object of the interrelation and how village chicken productivity can be improved in relation to sheep production.

The general characteristics of the household sample used in 2002 presented in Table 6.1 indicates that up to 83% have crop production as principal activity and up to 87% have livestock as second activity.

Table 6.1. General characteristic of the sample of crop/livestock farmers of the formal survey in 2002

Item	n	Number of positive response	Percentage (%) of household or mean	Standard error
Crop production as principal activity	30	25	83	-
Livestock production as secondary activity	30	26	87	-
Commerce/livestock production as secondary activity	30	3	10	-
Garden as secondary activity	30	1	3	-
Household size (averaged number)	30	30	10	4.51
Active person in the household (av. number)	30	30	5	2.18
Age of the interviewee (averaged year)	30	21	37	10

n = sample size of the households.

Village chickens and sheep are respectively monogastrics and ruminants and therefore there are some complementarities in the use of feed resources between these species. Data from literature and the survey in the village of Matté were analysed to derive how village chicken production can be improved in relation to sheep fattening.

Results

Presentation of the village of Matté

Population, infrastructures and social organisation
Matté has about 800 inhabitants according to a census in 1996 (INSD, 2000a). The village is constituted of five neighbourhoods named Rokoutin, Ropané, Loagda, Débéré and Loagkoudogo. The village consists in majority of crop/livestock farmers and few livestock (Fulani) households. These Fulani households are localised at the extremity of the village because their cattle breeding activities need space.

The village of Matté has some infrastructures (Figure 6.1) namely one primary school, one mosque, one Muslim and one French school and three functional wells. Muslim religion has great influence in village life, so households of the Muslim leaders (El Hadj) are references in the village. The village doesn't have a public health centre and a market, but has access to these infrastructures at Ziniaré, located at about 10 km.

The socio-economical organisation of the village of Matté can be observed through the Venn diagram (Figure 6.2). In the village, a Village Group of Man (VGM) and a Village Group of Women (VGW) work in close relation. A village chief and a Village Administrative focal point (VAFP) handle administration matters for the village in collaboration with the administrative service, police and gendarmerie in Ziniaré. The services of the ministries of education, agriculture, livestock and environment had important interventions through the realisation of a primary school, drilling of wells and the training and supervision of the group of farmers in the village. Commercial exchanges occur essentially through the market of Ziniaré. Many other services (forestry, livestock, agriculture, hospital, prefecture, police) are based on Ziniaré but provide services in the village.

Crop production in the village of Matté
The main crops produced in the village of Matté are sorghum, millet, rice, cowpea and groundnut. The importance of each of these crops depends on the season and the household but two main crops are produced; white sorghum and millet. Red sorghum and groundnut are marginal productions and are only noted by few farmers as important speculations in 2001. For example, in the rainy season of the years 2001 (Table 6.2), 45% of the households considered white sorghum as the most important crop followed by millet with 42% of the households. In the year 2002, the most important cereal crop on the farm was millet with 71%. Red sorghum, maize and groundnut were only considered by few households as important crops in 2001. Red sorghum has also low importance in the village because it is mainly used for local beer. Muslims, which are the main religious group in the village, do not consume alcoholic beverages. For the farmers, millet farming is important because it yields even under the conditions of degraded soil fertility present in the village. Maize is cultivated around the household compound where there is more organic matter. Sesame, rice and vegetables are sometimes cultivated in the lowlands of the village.

Constraints of crop production are the low yields, insects and bird attacks, animal devastation of the field, inadequacy of the rainfall and the lack of water for vegetable gardening.

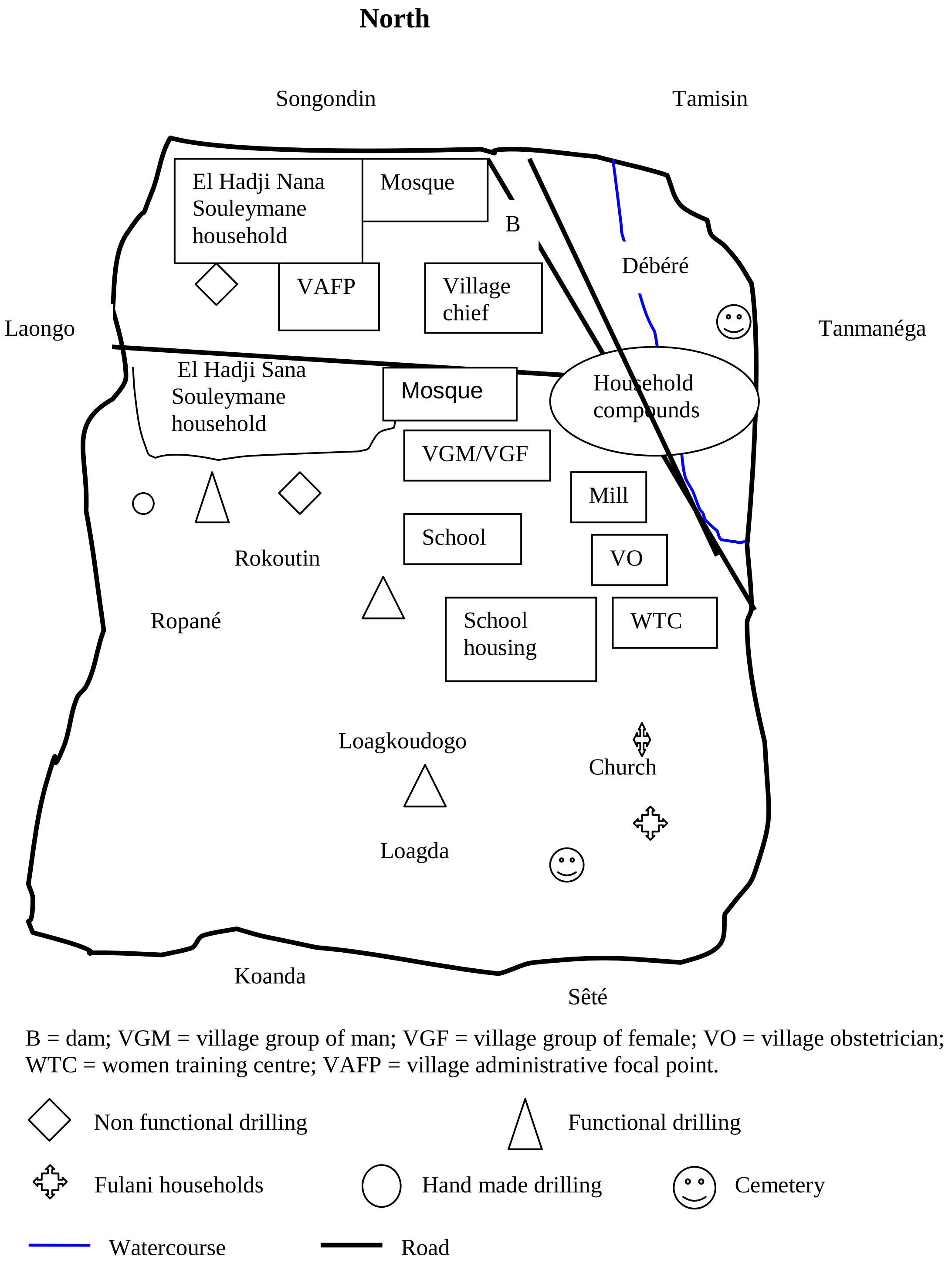
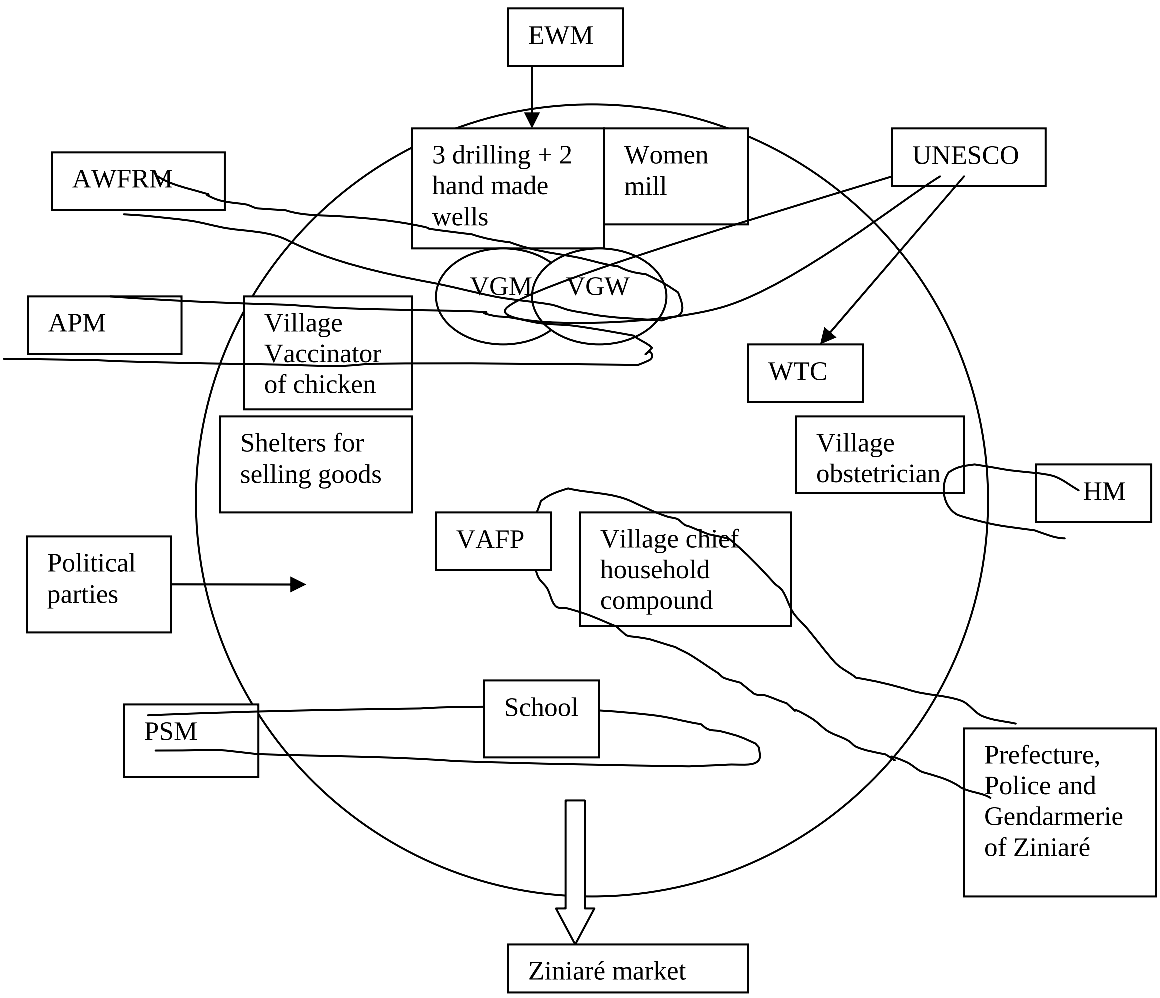


Figure 6.1. Resources map of the village of Matté



EWM = Environmental and Water Ministry, AWFRM = Water and Fishery Resources Ministry; APM = Animal Production Ministry, PSM = Primary School Ministry; HM = Health Ministry; VAFP = Village Administrative Focal Point; UNESCO = United Nation Educational Scientific and Cultural Organisation; CFF = Women training center.
→ = Intervention for all the village; WTC = Women Training Center

Figure 6.2. Venn diagram

Women participate actively in crop production by working in the common fields and in their own fields provided for by their husband. However, owning cereal fields by women and children depends of the household. In only 37% and 20% of households (Table 6.3) respectively, wives or children have their own cereal fields.

Livestock production in the village of Matté
Classification of animal species ranked by decreasing importance in the village of Matté is poultry (village chicken, guinea fowl, duck and pigeons), goat, sheep, donkey and cattle. Such a ranking takes into account, the easiness of production, the length of the (re)production cycle and income generation. Farmers simultaneously rear these different species. The flock sizes of the different species are presented in Table 6.4. Average flock size of village chickens is 51 head against 16 for guinea fowl. According to farmers, the difference is due to the fact that, in

Table 6.2. Percentage of household according to the importance of the speculation during two rainy seasons

Speculation	Rainy season 2001			Rainy season 2002		
	n	Number of positive responses	% of household citing the speculation as most important	n	Number of positive response	% of households citing the speculation as most important
White sorghum	29	13	45	28	8	29
Millet	29	12	42	28	20	71
Red sorghum	29	2	7	0	-	-
Maize	29	1	3	0	-	-
Groundnut	29	1	3	0	-	-

n = sample size of the households.

Table 6.3. Percentage of households with their wives or children owning their own cereal field in 2001

Item	n	Number of positive response	Percentage (%) of household
Women owning cereal field	30	11	37
Children owning cereal field	30	6	20
Mother of the household chief owning cereal field	30	5	17

n = sample size of the households.

Table 6.4. Average flock size of the different animal species in the village of Matté in the rainy season of 2001

Specie	n	Total number	Average flock size	Standard error
Village chicken	30	1533	51	33
Guinea fowl	23	370	16	23
Goat	23	255	1	10
Sheep	23	277	12	13
Cattle	23	88	4	9
Donkey	23	27	1	1

n = sample size of the households; Averages flock size are calculated over all responding household even those not having the species.

each household compound, different members can own village chickens whereas guinea fowl are owned only by the chief of household. This is the case in order to avoid disputes in the households with regard to the egg production of guinea fowl, as different guinea fowl lay in the same nest and the eggs represent real value as they are generally sold in the market. With their short cycle, poultry, especially village chickens, are frequently sold. Income from the sales may be used to buy goat or sheep. These two later are frequently used in socio-cultural ceremonies such as baptism or marriage. Cattle and donkeys are mainly used for traction and cattle for milk in the case of Fulani.

The results presented in Table 6.5 show that each household owns village chickens and up to 80% rear sheep or goat. Furthermore, there is a tendency (Figure 6.3) for households to rear different animal species and most households have a combination of poultry and small ruminants. 48% of the households (Type B) breed simultaneously village chicken, goat and sheep. Another important combination (Type A) is chicken, guinea fowl, sheep, goat and cattle (39% of the households). Flock sizes of village chicken are most important when several ruminant species are reared in the household (Table 6.6).

Table 6.5. Percentage of household rearing each species in 2001 (n = number of households)

Species	n	Number of positive response	Percentage (%) of households
Village chicken	30	30	100
Guinea fowl	30	20	67
Cattle	30	13	43
Sheep	30	24	80
Goat	30	26	87
Donkey	30	26	87
Duck	30	4	13
Pigeon	30	3	10
Horse	30	1	3
Rabbit	30	1	3

Table 6.6. Flock size of village chicken according to the typology of livestock

Type	n	Number of positive response	Number of village chickens per type	Flock size
Type A	23	9	559	62
Type B	23	11	602	60
Type C	23	2	85	43
Type D	23	1	16	16

n = sample size

Type A: breeding of chicken, guinea fowl, sheep, goat and cattle

Type B: breeding of chicken, guinea fowl, sheep and goat

Type C: breeding of chicken, guinea fowl and sheep

Type D: breeding of chicken, guinea fowl and goat

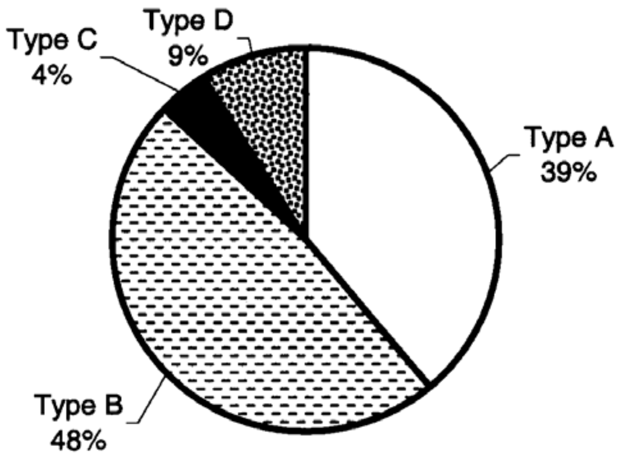


Figure 6.3. Percentage (%) of household according to the typology of the livestock

Type A: breeding of chicken, guinea fowl, sheep, goat and cattle

Type B: breeding of chicken, guinea fowl, sheep and goat

Type C: breeding of chicken, guinea fowl and sheep

Type D: breeding of chicken, guinea fowl and goat

Small ruminant's production is essentially a low input enterprise in Matté. Animals feed on natural pasture all year long, with some cowpea or groundnut hay supplementation during the dry season. Adult animals are either monitored by a herder or tied to a tree or post during the rainy season. Women in the village can own goats. They do not own sheep because according to them, sheep production needs more investment. The number of goats reared by women varies between 1 and 3. Some household heads do not allow women to own animals in order to avoid disputes between the wives in their household. It is a polygamic society.

In terms of livestock management, farmers in the village of Matté undertake a number of actions (Table 6.7). Most of the farmers put an emphasis on feeding (43%) and vaccination (37%) of village chickens. For small ruminant production, namely sheep production, the emphasis is on feeding (30% of farmers) and housing (20% of farmers).

Specific case of village chicken production system in the village of Matté

Table 6.8 presents composition of chicken flocks in the village of Matté. Proportion of hens, cockerels and pullets are more and less similar. The most important number per category is observed with chicks.

Newcastle disease appears to be the main constraint for chicken production in the village and an important number of farmers (61%) vaccinates their birds against this disease (Table 6.9).

Table 6.7. Percentage of household per action of improvement

		Village chicken improvement		Small ruminant improvement	
Item	n	Number of positive response	Percentage (%) of household	Number of positive response	Percentage (%) of household
Vaccination against Newcastle disease	30	11	37	*	*
Feeding improvement	30	13	43	9	30
Housing improvement	30	5	17	6	20
Use of best genitors	30	5	17	4	13
Sanitary care	30	*	*	4	13
Improvement of drinking feeders	30	4	13	*	*
Control of hatching	30	6	20	*	*

* = not concerned by the improvement.

n = number of households.

Table 6.8. Composition of village chickens flock in the village of Matté in the rainy season 2001

Category	n	Number of chicken of all household together	Average number per category	Standard error	Percentage (%) of the category
Cocks	30	77	3	3	5
Hens	30	367	12	7	23
Cockerels	30	346	12	13	23
Pullets	30	328	11	9	21
Chicks	30	418	14	13	27

n = number of the households.

Table 6.9. Percentage of households taking the sanitary measures in their flocks

Sanitary measures	n	Number of positive response	Percentage (%) of household
Vaccination	23	14	61
Traditional treatment	23	0	0
Vaccination and traditional treatment	23	8	35
No intervention	23	1	4

n = number of the households

Vaccination is done twice the year, just after the harvest and at the end of the dry season. Some farmers (4%) do not practice sanitary interventions in their village chickens flocks. They consider such interventions as uncertain, as there is no systematic campaign against the Newcastle disease for all the farmers. Thirty five percent of interviewers use herbal medicine in addition to vaccination in their flocks. Parts from the *Vittelaria paradoxa* tree was used for the treatment of some bursting localised on the thin part of the skin. The *Kaya senegalensis* bark, made as powder or directly introduced in the drinking water, is used against diarrhoea. The association of *Pterocarpus erinaceus, Casia sieberiana* and pepper in the drinking water is used against digestive infections. Potassium is added to drinking water against internal parasites. Against external parasites, farmers introduce the *Andropogon sp* in the housing. The parasites will use the grass as niche and the grass will be burned outside the house a few weeks later. Farmers may also use ash on the skin of chickens against external parasites.

Village chicken feeding consists of supplementation each morning with a small quantity of cereals or chaff according to the availability of these feedstuffs. Kitchen wastes are also given to chicken. In addition, termites and broken cereals are given to chicks. According to farmers, frequent use of termites and millet leads to digestive disorders.

Table 6.10 gives an overview of village chickens production materials in the village of Matté. It appears that different types of village chicken housing are observed and are owned by about 77% of households. For 70% of the households, housing consists of a roundhouse with a roof of straw. In general this type of housing does not have a window and has a small door just to allow children to enter for cleaning. About 83% of farmers in Matté use the improved drinking feeders promoted by the 'Programme de Développement des Animaux Villageois' (PDAV).

Morphology is a criterion to distinguish varieties of village chicken in the village of Matté. Three varieties are observed. The most common village chicken called in this village Noa-zaalga is observed in 56% of the flock (Table 6.11). Another variety called the Noa-kokobré is big and has a heavy format. This variety is found in 61% of the flocks. The last one is a dwarf chicken called the Noa-rigré and is found only in 4% of the flocks. According to the

Table 6.10. Percentage of household according to the type of housing and drinking feeders for village chickens

	Type of housing			Type of drinking feeders	
	Round housing	Straw housing	No housing	Type of PDAV	Others types
n	30	30	30	30	30
Number of positive response	21	2	7	25	22
Percentage (%)	70	7	23	83	73

n = number of households.

Table 6.11. Frequency of the different types of village chicken in the flock

Type of classification	Variety of village chickens	n	Number of flock owning the variety	Frequency (%)
Morphology classification	Common village chicken (noa-zaalga)	23	12	52
	Larger village chicken (noa-kokobré)	23	14	61
	Dwarf village chicken (noa-rigré)	23	1	4
Feather color classification	Noa-bengré	23	1	4
	Noa-liguidi	23	2	9
	Noa-zouglougou	23	1	4

n = number of households.

feather colour, village chickens are called black, white, or red chickens if their feathers have these colours. Chickens with mixtures of the feather colours are called Noa-bengré when black and white feathers are mixed and Noa liguidi when the feathers look like the green guinea fowl feather. The Noa-zouglougou has feathers with different colours and in disorderly arrangement on the skin.

Veterinary drugs (ITA-New vaccine, 'Vermifuge Polyvalent Volaille' (VPV), 'Vermifuge Special Pintade' (VSP)) are made available to the farmers by the extension workers. Furthermore, the Domestic Livestock Development Programme (PDAV) has trained villagers in chicken vaccination. Extension workers promote the techniques in chicken production through training, but it should be noted that there are not enough extension workers for training of all farmers. For example, the department in which Matté is located, has only 5 extension workers for all the villages of the department. An interview with the extension workers showed that 100% of the extension workers carried out Newcastle disease vaccination and 75% assured training on village chicken production. Twenty five percent sold veterinary drugs for chickens' health care. The topics of promotion are related to hygiene of housing and use of drinking feeder, treatments against internal and external parasites and genetic improvement of village chicken.

About 26% of farmers suggest (Table 6.12) that for the improvement of village chicken production one should practice supplementation and regular vaccination against Newcastle

Table 6.12. Percentage of household according to the proposition for village chicken production improvement

Suggested proposition	n	Number of households putting forward the proposition	Percentage (%) of household
Proposition I	23	6	26
Proposition II	23	3	13
Proposition III	23	2	9
Proposition IV	23	1	4

n = number of households.

Proposition I: compulsory supplementation + vaccination against Newcastle disease + improved housing;

Proposition II: compulsory supplementation, vaccination against Newcastle disease + particular care to chicks;

Proposition III: compulsory supplementation + vaccination against Newcastle disease + particular care to chicks + improved housing;

Proposition IV: compulsory supplementation, vaccination against Newcastle disease + rearing of village chicken outside the household compound.

disease and use improved housing. Another 13% suggest that supplementation, vaccination against Newcastle disease and particular care to chicks can lead to improvement of village chickens production.

Income generation at farm level in the village of Matté

In the households, income is generated through different activities or opportunities such as the sale of crop or livestock products, off-farm labour, gifts from relatives, trade of goods, small craft, and gardening. However, the major source of income in the household in the village of Matté is the sale of crop or animal products.

Cereals are very exceptionally sold by farmers and only for particular situations as shown in Table 6.13. Up to 60% of the households never sell cereals. Crop production is destined to household consumption. When sold, the main reason is to solve a cash problem or in case of surplus of cereal production for respectively 17% and 20% of the households.

Many reasons lead farmers in the village of Matté to sell chickens (Table 6.14). The most important reason is the high number of chickens according to 47% of the households and the solving of cash problems for 20%. Only 3% of the household indicated that they never sell village chickens. The most favourable period for selling of village chickens is at the feasts of the end of the year according to 67% of the households. For 82% of the households, the most frequently sold species is village chickens against 18% for which goat is most frequently sold.

Many reasons justify the sale of ruminants in the village of Matté (Table 6.15). The main reasons for selling small ruminants are their high number and the solving of punctual problems for respectively 53% and 37% of the households. The favourable periods for small ruminants' sale are the feasts of the end of the year, Tabaski and in the rainy season. In

Table. 6.13. Percentage of household according to the reason for selling cereals

Item	n	Number of positive response	Percentage (%) of households
Never sell cereal	30	18	60
To solve cash problem in any year	30	5	17
In case of surplus of cereal production	30	6	20
To solve cash problem in case of surplus of cereal production	30	4	13

n = number of households.

Table 6.14. Percentage of households according to the reason of village chicken selling

Item	n	Number of positive response	Percentage (%) of household
Never sell	30	1	3
To solve cash problem	30	15	50
In case of maturity	30	1	3
High number of chicken	30	14	47
High price in the market	30	13	13
Feast of the end of the year	30	20	67
Feast of Tabaski	30	2	7
Feast of Easter	30	3	10
Village chicken as the most frequently sold species	28	23	82
Goat as the most frequently sold species	28	5	18

n = number of households.

Table 6.15. Percentage of household stated the reason and the favourable period for ruminant selling

		Small ruminants		Cattle	
Item	n	Number of positive response	Percentage (%) of household	Number of positive response	Percentage (%) of household
Punctual problem	30	11	37	-	-
High price in the market	30	4	13	3	10
High number	30	16	53	-	-
End of the fattening	30	-	-	9	30
Mortality	30	-	-	3	10
Feast of the end of the year	30	5	17	5	17
Tabaski	30	4	13	2	7
Rainy season	30	4	13	-	-
Period post harvesting	30	-	-	4	13

n = number of households.

Table 6.16. Percentage of households according to the reason of practice or non-practice of ruminants fattening in the village of Matté

Item		Sheep fattening		Cattle fattening	
	n	Number of positive response	Percentage (%) of household	Number of positive response	Percentage (%) of household
Already practised fattening	30	11	37	11	37
No practice, lack of finance	30	11	37	13	43
No practice, lack of time	30	7	23	5	17
No practice, because of theft	30	3	10	2	7
No practice, lack of technical knowledge	30	1	3	-	-
No practice, because of mortality	30	-	-	2	7

n = number of households.

comparison, for cattle the most important reason for selling is the end of fattening according to 30% of the household and the favourable periods for cattle selling are the feasts of the end of the year.

The products of fattening (cattle and sheep) are meant to be sold. Up to 37% and 36% of the households (Table 6.16) have already practised respectively sheep and cattle fattening at least one time. For those who did not practise fattening, the main reasons are the lack of money and time.

Appreciation of the interrelation between village chickens and sheep production system by farmers

It appears that about 60% of the households recognise the existence of interrelations between chickens and sheep (Table 6.17). The subject of such interrelation is feeding for 57% of the households. However, if a relatively important number of households recognised the existence of the interrelation, only a few households (40%) were able to make suggestions as to how village chicken production can be improved by sheep production (Table 6.18). Twenty seven percent of the households indicated that the use of the same run could be a way to

Table 6.17. Percentage of household citing the type of interrelation between sheep and village chicken production system

Item	n	Number of positive responses	Percentage (%) of household
Perception of the interrelation	30	18	60
Interrelation through feeding	30	17	57
Interrelation through the income generation	30	9	30

n = number of households.

Table 6.18. Percentage of household citing how village chicken production could be improved in relation to sheep production

Item	n	Number of positive responses	Percentage (%) of household
Improvement by the use of the same run	30	8	27
Improvement by the use of income from sheep sale	30	4	13
Do not know how	30	18	60

n = number of households.

improve village chicken production by sheep production. For these farmers, from the run, small ruminants manure may be a source of insects and worms for village chickens.

Future directions for the improvement of village chicken production system

With regard to the analyse of the previous research and development activities on village chicken production systems (Chapter 1.3) and the survey at farm level, it seems that the next priority in village chicken production is to carry out systems in which the risk related to disease and predations will be minimised. To do so, combined actions of health care, feeding and housing, that will be economical in village chicken production system, need to be identified.

Many authors have demonstrated the possibility to use fibrous vegetable material to produce maggot or termites for village chickens feeding (Farina *et al.* 1991; Soukossi, 1992; Sonaiya, 1995). Furthermore concentrate feeds can be used for both chickens and sheep and Agro-Industrial By-Products already have been the subject of research (Chapter 3, Chapter 5). They were used in various combinations for livestock feeding mainly in sheep fattening (Kalkoumdo, 1994; Nianogo *et al.*, 1995; Kondombo and Nianogo, 2001; Ouédraogo *et al.*, 2001). Some of these dietary combinations can be used to optimise the utilisation of crop residues available at farm level.

Previous authors showed the possibility to use cereal grains, cereal by products, complete diets or maggots and termites for village chicken feeding (Sonaiya, 1995, Soukossi, 1992). Kayongo *et al.* (1990) demonstrated that poultry waste could be a source of nitrogen to fibrous crop residues to increase their degradability in the reticulo-rumen. Our previous studies (Kondombo *et al.*, 2003a; Chapter 4) show that feedstuffs as red sorghum, local beer malt or commercial chicken feed can be used for village chicken supplementation.

A combination of these informations makes it possible to establish a complete cycle of feed resources between fattening sheep and village chickens (Figure 6.4). Crop residues can be used in sheep fattening, and sheep will produce dung that in combination with crop residues and feed refusals will generate or supply termites, maggot, worms and insects, to village chickens. Village chickens may also feed on concentrate feeds and will produces Nrich droppings that can be used in combination with concentrate feed and/or crop residues to feed fattening sheep.

Furthermore, reinforcing the interrelation between feed resources for fattening sheep and village chickens, by keeping the animals in the same run, will allow having full control on village chickens scavenging. This will limit the risks related to diseases, predators or miscellaneous causes and has the potential to increase village chicken productivity.

Discussion

The village of Matté is a typical village in developing countries in general and in Burkina Faso in particular. It is characterised by the lack of basic infrastructures such as a market and a community public health centre and life is essentially based on crop and livestock production. Village organisation is built around moral personalities such as the village chief, religious authorities and some associative organisations. Similar characteristics are also observed in other villages in the Central Region of Burkina Faso (DPA, 1997a,b,c,d). These characteristics are however an asset for different interventions in the villages. Due to their difficult conditions and their centralised organisation, farmers are more available for the introduction of new technologies, the realisation of studies and training by extension workers.

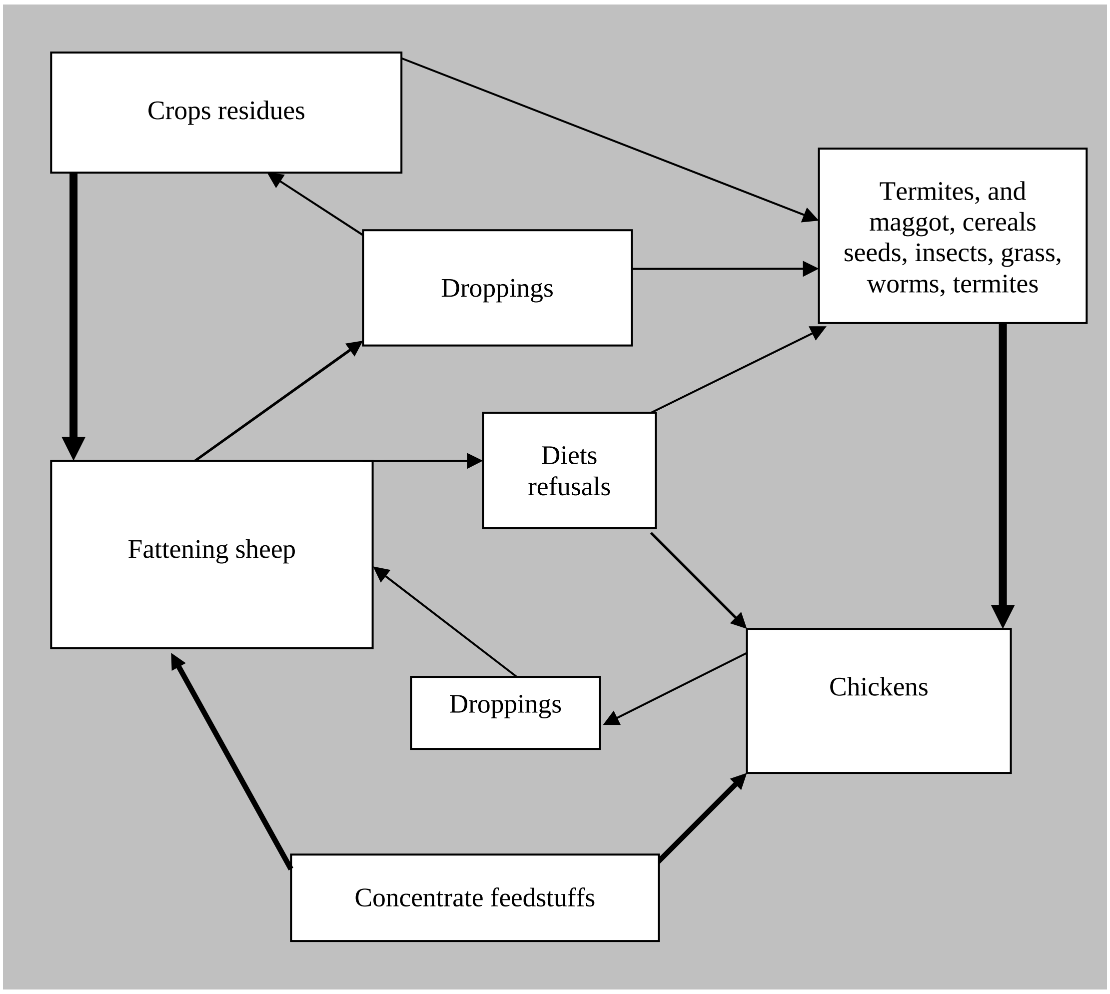


Figure 6.4. Flow layout of the feed resources between fattening sheep and village chickens. NB The thicker the arrows the more important the flow

The current study shows that crop production is the most important activity in the village with 83% having it as principal activity. Livestock is their secondary activity for up to 87%. One observes tendencies to develop livestock production in the village symbolised by the fact that a high proportion of households (39%) breed all the main livestock species in their homesteads and 48% breed a combination of poultry, sheep and goat.

This observed importance of livestock indicates a real motivation in livestock production in the village. The proportion of farmers owing multiple species (cattle, sheep, goat, poultry) is very important compared to other villages. Nianogo and Somda (1999) found a proportion of 16.6% of households breeding four species together and 15% of farmers breeding three species in two other villages in the Central Region of Burkina Faso. Such combination of livestock species at farm level may be a strategy of survival of rural household. One question is to know if the combination does have some influence on the production of each individual species. For village chicken for example, our results reveal that farmers who own multiple species have larger sizes of village chicken flocks. Furthermore, many authors (Nianogo and Somda, 1999; Kondombo *et al.*, 2003b) already noted the interdependence between livestock species in the condition of Sahelian livestock production.

It might be that those who are successful in poultry production (larger flocks) generate income to buy small ruminants or exchange them regularly against small ruminants. In this way, they can increase their possibilities to rear multiple animal species. The opposite can also be true; meaning that successful small ruminants' production may allow purchasing of village chickens.

Flock size of village chickens (51 head of chickens) in the village of Matté is higher than those indicated by previous authors (Guèye, 2000; Benabdeljebl *et al.*, 2001; Swatson *et al.*, 2001). In a same period of study (rainy season), this flock size is also higher than the one observed in our previous study in the village of Yambassé (Kondombo *et al.*, 2003b; Chapter 1.2) with respectively 51 versus 33 head of chickens. This situation can be due to the effort of projects to improve village chicken production (Ouandaogo, 1997), mainly by vaccination against Newcastle disease, in the village of Matté. The different varieties of village chickens observed in the village are similar to those indicated in the study in the village of Yambassé (Kondombo *et al.,* 2003b; Chapter 1.2) but some differences in the local names of these varieties are observed. In the current study, the bigger village chicken is called the Noa-kokobré instead of Noa-kondé and the common village chicken called Noa-kuiguiga is called Noa-zaalga. Furthermore, it can be noted that the naked neck chicken was not found in the current village and that confirms the rarity of this variety of chicken.

The improvement of livestock production in general and village chicken production in particular only occurs to a very small extend in the village. For ruminants, fattening can be cited a significant action of improvement. For village chickens, one can note the vaccination against Newcastle disease. Interventions of extension workers seem insufficient with regard to their number in the locality and the nature of the extension activities. According to INRA and SEDES (1976), extension workers conducted multiple actions of improvement in the past. Even with these actions, the level of livestock improvement is such that the suggested propositions of the farmers in the village are still relevant. The analysis of these propositions suggests that improvement of village chicken production needs a combination of improved housing, feeding and health care. Genetic improvement is not cited by farmers in their suggestions. It seems logic that, in the initial phase of improvement, the primary actions should be to improve the exploitation of the available local resources (Preston, 1987).

Our study also indicated that income generation at farm level in the village of Matté is essentially achieved with livestock products. That is obvious from the high proportion of households who never sold crop products and the fact that only few farmers were involved in trade or gardening. Many authors (Kazi, 1999; Ayatundé, 1998; Slingerland, 2000; Guèye, 2000) already indicated such role of livestock in rural household's income generation in developing countries. From livestock production, ruminants fattening and village chickens rearing appear to be the principal means for this income generation. If ruminants (cattle, sheep, or goat) are sold in relation to exceptional situations, village chickens appear to be the most frequently sold and fattened animals are in fact primarily destined to sale. As it is generally admitted that strategies for livestock improvement should be market oriented, fattening and village chicken rearing are clearly the relevant issues. However, as households have important constraints in cattle fattening (high cost of production, high risk by mortality), sheep fattening seems the option that can be realised by any rural farmer. Furthermore, village chickens can also be oriented to the option of fattening. This orientation on village chicken production will allow organising its production in such a way as to fatten the growing or mature village chicken. Such a market oriented strategy will also motivate to improving health care, feeding strategies, housing and management of village chickens and through these activities improve the entire village chicken production system.

Farmers have the tendency to associate animal species in order to exploit the complementarities between them for feed resources, space and/or income generation. Associating sheep fattening to village chicken production may be a promising way to promote the improvement of these two productions at farm level in Burkina Faso and in developing countries in general.

The previous studies so far (Brunet *et al*., 1984a,b,c; Saunders, 1984; Sonaiya *et al*., 1999; Kondombo *et al.*, 2003b) showed that improvement of village chicken production is still a challenge. It was demonstrated in the current study that the integration of village chickens and fattening sheep might be a relevant issue for improvement of village chicken production. Such an approach is also in accordance with the assertion of Sonaiya *et al.* (1999) who stated that for village chicken improvement, system approaches are needed at different system levels.

The integration will be favoured by the cross utilisation of feedstuffs and products of chickens and sheep. Feeding strategies designed at improving village chicken production systems in relation to sheep fattening need to be developed. The refusals from sheep feeding and sheep manure can for instance be used to produce termites or maggots for village chickens feeding as described by previous authors (Sonaiya, 1995; Soukossi, 1992; Farina *et al.,* 1991). Chickens can be supplemented with cereal seeds, cereal by-product or commercial feed. Village chickens can be reared in fenced yards that will allow feeding control, health care and reduction of mortality due to diseases, predation and losses. In these conditions more investments can be done and more outputs may be obtained. Furthermore the income generated by one system may be used to buy feeds or animals for the other system. The complementarities between the animals can be used to increase the value and reduce the losses of the feedstuffs available at farm level.

Furthermore, the integrated production systems may be an important source of income for small farmers in the rural area. Farmers also perceived this possible integration of the two production systems. They indicated the feeding factor as the integrative factor for improving village chicken production in relation to sheep production.

Conclusion

As the study showed, the main source of income at farm level is village chicken and small ruminants. For the small ruminants, sheep fattening appears to be the innovative way for income generation. Farmers feel that village chicken production can be improved, by vaccination, feeding and housing, preferably in combination.

Health care and housing have reliable solutions. For feeding, the problem remains but our previous study (Chapter 4; Kondombo *et al.*, 2003a) provided some options. As sheep and chicken depend on the same local feed resources but have different feed requirements, complementarities between chickens and sheep may be exploited to find solutions. Sheep and chickens do not compete for feed resources and labour. Furthermore, the income from one production can be used for purchase of inputs in the other production. It was demonstrated that the interrelation between sheep and chickens for feed resources and income at farm level can be used to design an integrated village chicken/sheep fattening production system. With regard to the survival strategy of rural farmers in developing countries which, consists of integrating different production systems in the farming system, the conclusion of the study may fit with farmers needs. The proposed integrated system may be a strategic way to improve village chickens production system and contribute to increase rural household income.

CHAPTER 7

Improvement of village chicken production by associating village chicken production to sheep fattening

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7. Improvement of village chicken production by associating village chicken production to sheep fattening

Abstract
A production system for village chicken rearing in association with sheep fattening was tested in an on-station trial in Burkina Faso. The aim of the study was to design an improved village chicken production system allowing combining village chickens with sheep. For that, an Integrated (village chicken/ram fattening) Production System (IPS) was studied through a completely randomised design with two treatments in two replicate groups. Treatment 1 (T1) was the integrated system + supplementation of local beer by-product. Treatment 2 (T2) was the integrated system + supplementation with the commercial chicken feeds. The integrated system was a fenced run in which, 2 fattening sheep of Djallonké breed are fed, improved chicken housing was provided and a dustbin was used to generate insects and worms for village chicken scavenging. Chickens can also scavenge in the fattening shelter. Results show that when the supplementation has adequate nutritive value (case of T2) daily body weight gain of 10.4 g/d can be obtained. When the nutritive value was poor (case of T1) weight loss was observed. The system did not influence negatively the performance of the sheep. A financial assessment indicates that with T2, a positive gross margin of 275 FCFA per bird can be obtained. However, when the supplement has low nutritive value (T1), a positive gross margin cannot be earned. A projection aiming at an income above the poverty line (72,600 FCFA) in Burkina Faso was made and showed that the system can be used for poverty alleviation by allowing each farmer to at least a net income of 79,030 FCFA. For this benefit two 3 month periods of sheep fattening with 4 sheep per period were needed with in each period three 1 month periods with 40 chicken each. The integrated production system investigated in the current study shows that it may be used as tool for poverty alleviation in Burkina Faso and in developing countries in general.

Keywords: Village chickens, fattening sheep, integration, nutrition, Burkina Faso.

Introduction

In developing countries, the rural population rarely has access to financial loans for their activities in general and for livestock production in particular. Sometimes, farmers receive supports from donors as the case of the 'Fonds d'Appui aux Activités Rémunératrices des Femmes[1]' (FARSF) or the 'Projet de Développement de l'Aviculture Villageoise[2]' (PDAV) in Burkina Faso. Another project supporting rural farmers is the project on family poultry in Bangladesh using poultry as tool for poverty alleviation (Kazi, 1999). Some of these projects have reported interesting results for family poultry development. However, very often at the end of the project, farmers are not able to continue the experience and return to the initial production system. So, the necessity to identify sustainable ways to improve livestock production in general and family poultry production in particular is still a major challenge.

In the case of village chickens, the major constraints are the low productivity and the mortality due essentially to Newcastle disease (Chrysostome *et al.,* 1995; Guèye, 1998; Sonaiya *et al.,* 1999). Many solutions for these constraints are available as for example, the immunisation against the Newcastle disease and the use of improved cocks. However, these

[1] Fund for the income generating activities of women
[2] Village poultry development project

solutions cannot be effective if the main feed resource for the village chicken remains scavenging. Scavenging provides low cost feeding, but hampers the improvement of village chicken production. The utilisation of commercial chicken diet as supplement to scavenging is a possible solution (Chapter 4) but may not prove profitable, if losses e.g. due to predation remain important. Thus, there is a need to identify strategies that minimise inputs, while still allowing the chicken to roam freely in somewhat controlled conditions.

A mixed production system based on the synergy of two animal species (Chapter 6), well known to farmers, might be an option. Systems where ruminants and poultry cohabite, prevail in most rural areas of Burkina Faso. How such integration can be conducted with satisfactory results in term of biological efficiency and overall profitability is the research question of the current study. Our hypothesis is that such strategy may improve village chicken productivity in term of growth, flock size and as a consequence also economic return from village chicken rearing. We used two strategies of feeding (treatments) to test the integrated scheme. These two are supplementation of village chicken in a limiting area with either a low nutritive feedstuff (the local beer by-product: see also Chapter 4.1) or a high nutritive value supplement (the commercial modern chicken diet: see also Chapter 4.2).

Materials and methods

Description of the integrated production system

The chickens were housed in a fenced run with an improved poultry house (Figure 7.1), a shelter for sheep and a dustbin. The run of 250 m^2 was delimited by a wire netting and wooden poles.

The improved housing is the one recommended by the 'Programme de Developpement des Animaux Villageois' (PDAV) of Burkina Faso: a roundhouse in clay of 3 m in diameter with 2 opposite windows, one door and roof in straw. The shelters for ram housing were made with straw and wood. The two sheep are fed with a crop residues based complete diet for fattening as described by Kondombo and Nianogo (2001) and also used in Chapter 5.1. It was assumed that the fattening operation would procure the scavenging feedstuffs through refusals, excreta of the sheep, insects and worms. The development of insects and worms was stimulated by gathering the feeds refusals and excreta in a dustbin.

Figure 7.1. The Integrated Production System (IPS) set up in the station of Saria

Treatments

The experiment was set up as a complete randomised design with 2 treatments (T1 and T2) in 2 replications with 9 or 10 experimental birds each. In addition to the Integrated Production System (IPS), in the first treatment (T1), the birds were supplemented with a low cost but low nutritive value feedstuff, the local beer by-product. In the second treatment (T2), in addition to the IPS, the birds were supplemented with high nutritive value feed (a commercial pullet feed). In both cases, supplementation was provided at 50 g per day per bird.

The experiment was done in the dry season from 29 November 2003 to the 3 January 2004. The experiment took 35 days excluding the 14 days of quarantine and a week of adaptation. Each morning, at about 7 h, birds received their respective supplement (50g/d/bird) in a common feeder and were let to roam all day in the fenced run. Water was available ad-libitum in feeders made with local material. The rams also received daily the complete diet in their shelter in separate feeders and had access to water *ad libitum*. Birds had free access to the shelter in the run and could peck directly the feedstuffs of the rams, their refusal and the excreta. The fenced run of each group was cleaned in such a way that only the excreta and feed refusals of the fattening sheep were available for scavenging.

Animals and management

The viability of the system was tested by observing the weight gain of village chicken cockerels. Cockerels of 6-7 months old, according to farmers' estimation, were purchased at farm level. The pre-experimental period included one to two weeks of quarantine, during which the animals were vaccinated and one week for the adaptation to the feeding treatments. The birds were vaccinated with the 'ITA-New' against Newcastle disease and received 'Vermifuge Polyvalent Volaille' (VPV) against internal parasites.

Fattening sheep were Djallonké ram with a mean body weight of 16.6 (se = 0.47) kg, purchased in the local market. The sheep were treated with *Berenil* against pasteurellosis and received drugs against internal and external parasites.

Data collection procedure

Body weights and feed consumption of birds were monitored weekly. Body weight of birds dead during the trial period was estimated by extrapolation from last weighing using the linear model of the Software SPSS versus 11. To measure the bird's supplement consumption, the refused supplement was weighed daily. All events (health of animals, intake and weight gain of sheep, scavenging feedstuffs generated, etc.) in the system were monitored. Three independent persons observed the behaviour of animal in the IPS. The concordant observations were consigned as the behaviour of the system.

At the end of the trial, 4 birds per replicate group were slaughtered in the morning at about 11 h (just the time for birds to fill their crops) for carcass, organs, body fat measurement and crop content analysis. Carcass was weighed after removal of the feathers, lower leg, heart, crop, pancreas, lungs, digestive and uro-genital tracts and head. Cockerel dressing was computed as carcass weight/live weight at slaughter × 100. Comb length and thoracic perimeter of birds were measured. Gizzard, liver, head and abdomen fat were weighed. Crop content was removed, air-dried and weighed successively. The different feedstuffs from this air-dried content were separated visually and each type of feedstuff was weighed. Sheep were weighed weekly for body weight and their feed consumption was appreciated by daily weighing of feed refusal. Sheep excreta were also weighed daily.

Economical assessment was done to evaluate the potential income generation of the system. The purchase price of cockerels was set at 750 FCFA (1.14 €), the price proposed by farmers. To check the sale prices we interviewed 3 village chickens sellers separately on the possible prices of the birds at the beginning and the end of the experiment. Results were concordant to 750 FCFA for the purchase price and 1,250 FCFA (1.91 €) for the sale price. We majored this sale price (1,250 FCFA) to 1,375 FCFA (2.1 €) considering mean sale prices (1,300 to 1,400 FCFA) of village chickens at town markets according to Ouédraogo and Zoundi (1999). For birds whose body weight did not change perceivably, the sale price was considered to be the same as the purchase price. The other costs included the commercial feeds (170 FCFA/kg), the vaccination (30 FCFA/bird) and the Vermifuge Polyvalent Volaille (VPV) (25 FCFA/bird).

For the sheep, we accounted a gross margin of 4,360 FCFA/animal, obtained with the fattening diet in a previous study (Kondombo and Nianogo, 2002; data from PAPEM project with diet II reported on in Chapter 5.2). For the gross margin assessment of the chicken sub-system, only expenses directly related to the animal (feed, sanitary care and animal purchased price) were accounted with the assumption that the other factors can vary greatly between farmers.

To appreciate the effect on poverty alleviation in Burkina Faso, we projected the economical return of the system over one year. For that, the minimal number of chickens and sheep to be reared was estimated, with regard to the gross margin per bird and per sheep. For that we doubled the number of chickens per rammed fatten assuming that village chickens do not have negative influence on the performance of fattening sheep (Table 7.1). These numbers are the minimum to earn a net income over the absolute poverty line in Burkina Faso. The fixed costs were set at 21,850 FCFA/year for an initial investment of about 150,250 FCFA (Table 7.2).

Table 7.1. Calendar of chickens and ram fattening in the Integrated Production System

Period of fattening	First period			Second period		
Month	1	2	3	1	2	3
Number of village chickens	40	40	40	40	40	40
Number of chicken		120			120	
Number of rams		4			4	

Table 7.2. Fixed cost of the Integrated Production System (4 sheep + 40 chickens)

Equipments	Quantity	Unity price (FCFA)	Total cost (FCFA)	Years number of depreciation	Amount of depreciation per year (FCFA)
Chicken housing	1	20,000	20,000	3	6,670
Netting ware	3	35,000	105,000	15	7,000
Wood poles	14	500	7,000	3	2,330
Feeders of chickens	5	750	3,750	3	1,250
Drinkers of chickens	2	750	1,500	3	500
Ram shelters	1	5,000	5000	2	2,500
Ram drinkers and feeders	2	4,000	8000	5	1,600
Total	-	-	150,250	-	21,850

Statistical analysis
The data were analysed statistically with the software DBSTAT developed by the chair group Animal Production System of Wageningen University. Comparison of means was done with the ANOVA analysis using the t-test. The difference was accepted as significant when $P < 0.05$.

Results

Description of the system behaviour
The birds in T2 ate the supplement straight after distribution before scavenging in the shelter of ram. In contrast to that, in T1 almost all the birds went to scavenge in the shelter before eating the local beer by-product. Birds of T2 looked healthy and became visibly mature at the end of the trial with regard to comb development. Three birds of T1 died probably due to under-nutrition in week 3, 4 and 6, respectively.

In the dustbin (Figure 7.2), termites, insects and worms were developed and could be observed visually. Cockerels pecked in this dustbin more often during the afternoon to found these termites, insects and worms.

In the two treatments, fattening ram looked healthy and lived in perfect symbiosis with cockerels when the cockerels went under the shelters or pecked feedstuffs in sheep feeders (Figure 7.2). Sheep did not show any aggressively against the cockerels in their shelters.

Growth of village chicken cockerel
In T2, the total body weight gain of 367.2 g per cockerel observed in 35 days of feeding represented an increase of 46.5% of the initial body weight (Figure 7.3). On the other hand, T1 lost 102.5 ± 28.5 g corresponding to 15% of the initial body weight. The cockerels of T2 had a daily weight gain of 10.4 ± 0.9 g/d.

Cockerel feed intake and scavenging feedstuffs production in the system
Intake of supplemental feeds was significantly different between treatments ($P < 0.05$) (Table 7.3). Almost 100% of the commercial feed was consumed by the birds, whereas only 76% of the local beer by-product offered was consumed.

Feed refusal of the ram was statistically similar in both treatments with 12.7 g/ram/day in T1 and 14.7 g/ram/day in T2. Rams produced 450 g and 490 g/day per animal of excreta in T1 and T2, respectively. Total quantities of excreta and feedstuffs refusals, being the source for scavenging were similar for both treatments.

Figure 7.2. The integrated production system behaviour

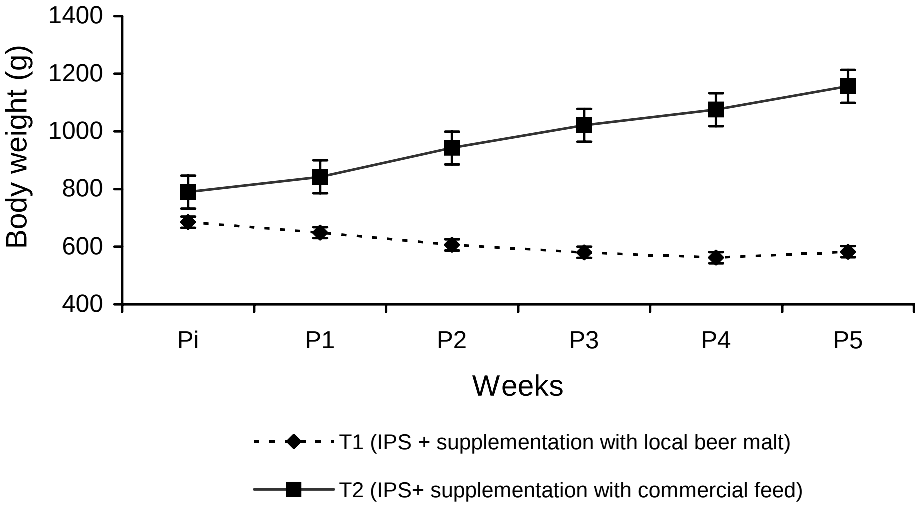

Figure 7.3. Growth curve of cockerels according to the treatment

Pi = initial cockerel body weight, P1 = cockerel body weight (CBW) at 1 week, P2 = CBW at 2 weeks, P3 = CBW at 3 weeks, P4 = CBW at 4 weeks, P5 = CBW at 5 weeks, IPS= Integrated Production System.

Table 7.3. Cockerel feed intake and quantity of feed refusals and dejections (mean ± SE) from fattening ram

		Treatment	
		T1 IPS + artisanal beer malt supplementation	T2 IPS + commercial feed supplementation
Parameters	Units		
Supplement intake	g/d/bird	37.9 ± 10.0[b]	49.5 ± 2.6[a]
Ram excreta	g/d/animal	485.3 ± 13.6	454.6 ± 10.3
Total ram excreta during 35 days	kg	34	31.8
Fattening feedstuffs refusal	g/animal/day	12.7 ± 1.1	14.7 ± 1.2
Total fattening feedstuffs refusal	kg	0.9	1.0

Means on the same row with different superscript letters are significantly different at $P < 0.05$.
IPS = Integrated Production System, number of sheep = 4 per treatment.

The crop of birds after slaughter (Table 7.4) contained almost similar quantities of local beer by-product and commercial feed respectively for T1 and T2. The other feedstuffs in the crops are mainly, groundnut cocks, cowpea seed, and sorghum seed found probably in the fattening ram diet. Amount of insects and rams faeces were found negligible in the crop. The total weight of the crop content was 2.1 times higher in T2 than in T1.

Slaughter performance of village chicken in the system
After 35 days, average carcass weight of cockerels in T2 was 800 g and in T1, 300 g. Except for dressing percentage and thoracic parameter the slaughter characteristics of T2 were almost double that of T1 (Table 7.5). However, no significant differences ($P < 0.05$) were observed between treatments for slaughter parameters probably due to the sample size.

Table 7.4. Village chicken cockerel sun dried crop content weight and relative proportion (% of DM) of available scavenging feedstuffs in the integrated system

Feedstuffs	Proportion (%) of feedstuffs in cockerel crop	
	T1 (n =8)	T2 (n=8)
Crop content weight (g) in dry matter	18.6	38.9
Groundnut pods	1.5	2.4
Stone	8.8	9.8
Local beer by-product	87.3	0
Cowpea seed	0.8	0.1
Leaves	0.4	0
Sorghum harvesting residues	0	0.2
Sorghum seed	0.1	1.4
Commercial feed	0	84.9
Insect	0	0
Natural herb	0.8	0.1
Concentrate of the fattening	0.2	0
Litter	0.2	0.9
Kaya senegalensis leaves	0	0.1
Ram faeces	0	0.1

T1= IPS + local beer by-product supplementation; T2 = IPS + commercial feed supplementation; IPS = Integrated Production System; n = number of cockerels.

Table 7.5. Slaughter performances of village chicken cockerel according to the treatment

Parameter	Treatment	
	T1 (n = 8)	T2 (n = 8)
Live bodyweight (g)	530 ± 10	1120 ± 160
Carcass weight (g)	300 ± 0	800 ± 140
Dressing (%)	56.6 ± 1.1	71.0 ± 2.4
Comb length (mm)	2.8 ± 0.2	5.4 ± 1.6
Thoracic perimeter (cm)	18.7 ± 1.3	23.4 ± 0.4
Abdomen fat weight (g)	0	0
Gizzard weight (g)	15 ± 5	25 ± 5
Liver weight (g)	12.5 ± 7.5	20 ± 0
Leg weight (g)	20 ± 0	40 ± 0
Head weight (g)	10 ± 5	25 ± 5
Crop content (g)	40 ± 20	85 ± 6

Note: T1 = IPS + local beer by-product supplementation; T2 = IPS + commercial feed supplementation; IPS = Integrated Production System.

Economical assessment of the improved village chicken production system

Considering the cockerel production, the gross margin per bird was 275 CFA for T2 (Table 7.6). For T1, a loss of 70 CFA per bird was calculated. The feed conversion ratio was about 20% with 50 g of feed needed for 10 g of growth. The feed cost for the production of 1 kg of live body weight was 803 FCFA in the case of T2.

Table 7.6. Economical assessment of the system according to treatments (amount in FCFA)

Parameters	Treatment	
	T1	T2
Bird purchased price (a)	750	750
Supplement cost/bird (b)	15	295
Prophylaxis cost/bird (c)	55	55
Gross income (d)	750	1375
Gross margin/bird (d – (a+b))	−70	275

T2 = IPS + commercial feed supplementation, 1 € = 655.957 FCFA; IPS = Integrated Production System; FCFA = Franc de la Communauté Financière Africaine.

Growth of the fattening ram

Ram growth was not significantly influenced by the presence of village chickens in the system (Figure 7.4). In the two treatments, the growth appears slow in the first week, but increases from the second week. Positive weight gains were observed throughout the study for rams. A daily weight gain of 80 ± 9.8 g/d and 78.6 ± 11.3 g/d after 35 days of fattening was observed but no significant difference (P ≥ 0.05) was observed between treatments.

Projection of the economical benefit of the integrated production system

The projected economical performance of the integrated system is presented in Table 7.7. The least optimistic projection considered 2 periods rams fattening in a year and 3 groups of cockerels fattening per period. Considering the use of feed from scavenging in T2 (Table 7.4) and the capacity of the house which can house 50 cockerels, we doubled the number of chickens to 40. Per period, 4 rams can be fattened by a farmer and a group would contain 40 cockerels. Such a system can provide to the farmer 50,440 FCFA of gross margin in 3 months. In 2 runnings the year, the system can generate a gross margin of 100,880 FCFA, allows a farmer performing the system to get a net income of 79,030 FCFA/year.

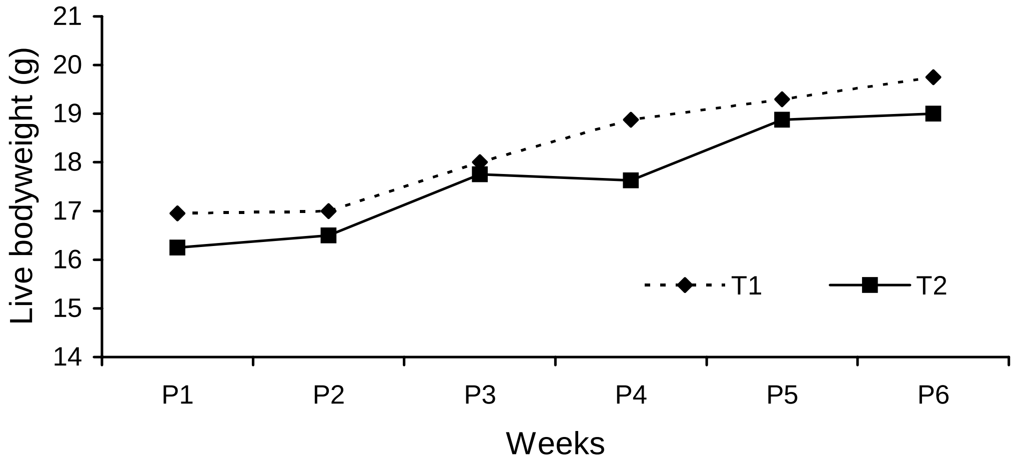

Figure 7.4. Growth curve of fattening ram in the IPS

P1 = initial body weight of rams (BWR) at week 1, P2 = BWR at week 2, P3 = BWR at 3 week 3, P4 = BWR at week 4, P5 = BWR at week 5, P6 = BWR at week 6, IPS = Integrated Production System.

Table 7.7. Economical assessment of the Integrated Production System in poverty alleviation in Burkina Faso

Parameters	Amount (FCFA)
Gross Margin/bird expected from cockerel subsystem (a)	275
Gross Margin/ram expected from the fattening subsystem (b)	4,360
Predicted total Gross Margin for 120 birds from VCS (c = 120 a)	33,000
Predicted gross margin for 4 rams from RFS (d = 4b)	17,440
Total gross margin from running the IPS (e = c + d)	50,440
Expected gross margin in one year for the IPS (f = 2e)	100,880
Estimate fixed cost per year of the IPS (g)	21,850
Net income (h = f – g)	79,030

VCS = village chicken subsystem; RFS = ram fattening subsystem; IPS = Integrated Production System.

Discussion

The body weight gain of cockerel (10.4 g/d) observed in the current study was higher than in studies indicated so far (Chapter 4). Previous village chicken feeding strategies in which, commercial feed and cereals were used in confinement conditions or in supplementation to scavenging feedstuffs at farm level (Kondombo *et al.*, 2003a; Chapter 4) showed daily weight gains of 3.7 g/d to 6 g/d. Roberts (1999) also noted a daily weight gain of 2 to 7 g/d for village chicken. Our results confirm the necessity for village chicken to run around instead of being in confinement. However, the growth performances observed in the current study are still far lower than the growth of exotic broiler chicken (50.6 to 57.5 g/d) indicated by Teguia *et al*. (2002). Furthermore, it appears that the system was not viable if local beer by-product is provided with low nutritive value due to high level of crude fibre and low level of energy was used as a low cost supplement. Value of beer by-product was 23.6% crude protein, 14.5% crude fibre, 7.3 MJ/kg of metabolisable energy (Dong and Ogle, 2000).

When high nutritive value feed is used, cockerels reach from 700 g of initial body weight to a body weight of 1120 g in 35 days. This body weight gain is similar to the mature body weight of male village chicken (1000 to 1200 g) as indicated by Guèye (1998) and Aini (1999). This maturity is also confirmed by the comb length of 5.4 cm significantly higher than the comb length in T1.

A significant difference was observed between supplement intakes of two treatments. Supplement intakes (37 to 49.5 g/d) of the cockerels in this study are still in the range of the recommendations of previous authors (Sonaiya, 1995; Ouandaogo and Ouédraogo, 1988). Hence, for Sonaiya (1995), 35 g/d of supplementation of cereals are sufficient for village chicken hens. Ouandaogo and Ouédraogo (1988) recommended 40 g of cereal/day/village chicken cockerel.

The crop analysis shows that almost all the feedstuffs from the ram fattening were effectively eaten by chickens. The negligible amount of insects and worms found in the crop is probably due to the period of analysis (the morning) whereas, bird scavenge in the dustbin in general in the afternoon for these insects and worms.

The dressing % of 71 observed in the current study was concordant with the dressing obtained in previous studies of village chicken supplementation (Kondombo *et al*., 2003a; Tadelle, 1996; Chapter 4). These studies showed dressing percentage of 61 to 68%. Furthermore, the carcass weights observed in the current study (660 to 940 g) are higher than those (559 g) noted by Tadelle *et al*. (2000), but are comparable to the 875 g reported for the White leghorns (Tekerel, 1986 quoted by Tadelle *et al*., 2000).

The obtained gross margin (275 FCFA) is higher than those (25 to 95 FCFA) in previous studies where commercial feed or local feedstuffs are used as supplements or complete diets (Kondombo *et al*., 2003a; Chapter 4). Furthermore, the system allows reducing the feed cost for the production of 1 kg of village chicken live bodyweight. However, the feed cost per kg of weight gain (803 FCFA) is higher than those of 363 to 420 FCFA for the exotic broilers reported by Teguia *et al*. (2002).

Results also show that the net income greatly depends on the cost of lean chicks and feed supplementation. Farmers are better off producing lean birds themselves rather than buying them from others. Additionally, there is need for more research to identify feedstuffs of acceptable nutritive value and low cost that might be available locally.

When considering all the system, the predicted economical assessment indicated that, when using a minimum of 4 sheep and 120 cockerels for two times one period of 3 months fattening; a net income of 79,000 FCFA (120.4 €) can be obtained in the year. This benefit is above the absolute poverty line (INSD, 2000b) in Burkina Faso (72,630 FCFA/year). To obtain the cockerels number, farmer owning 10 hens can organise chicken production in order to obtain a batch of at least 40 chicks per month as already demonstrated by Sanou (2003) and Asgedom (2000). Such batches can then be periodically fattened in the Integrated Production System (IPS) before their sale. Then, IPS can be used for poverty alleviation.

A condition for the success of the IPS is the availability of disease-free cockerels, considering the fact that most village chickens are seldom vaccinated against common disease. The system would operate in village where poultry are the subject of an appropriate health programme that includes vaccination against contagious diseases (mainly the Newcastle disease). Additionally, getting producers to create a co-operative that take care of such problems as access to loans and marketing of finished birds could be helpful in facilitating a more professional context.

Conclusion

This study showed that village chicken can be reared in controlled condition by association to the sheep fattening. However, adequate supplementation of the chickens in the system should be done. With a high quality supplement, a daily weight gain of 10.4 g/d was observed in the current study. When using a low nutritive value supplement, the system could not assure village chicken production.

The economical assessment also shows that the improved system can be efficient. The system can be used for poverty alleviation in developing countries in general and in Burkina Faso in particular. In addition to the economical aspects shown in the current study, this system opens perspectives for many studies on village chicken production improvement such as, feeding or genetic improvement.

GENERAL DISCUSSION

General discussion

Introduction

In developing countries in general and in the Sahelian countries in particular, livestock plays an important role. Livestock species such as cattle and horse are sources of prestige whereas small ruminants and poultry are frequently sacrificed for religious ceremonies or sold for income generation. Incomes from livestock are used to solve the frequent cereal shortages in Sahelian countries. Livestock participates by providing traction and manure to improve crop production thus significantly contributing to food security strategies (Ayatunde, 1998). Due to these roles, livestock production is practised in most rural households. Rearing animals appears to be an easy way for poor farmers to fit in the formal economical market. Poverty alleviation at rural farmer's level through animal production should be oriented on poultry and small ruminants' production as these are the species kept by the poorer strata of the population. Many projects already supported research and development activities in improvement of rural livestock production. However, it should be admitted that their impacts were minimal (Aini, 1999) and additional efforts are needed. In our thesis, we focused on the species poultry and sheep.

Our hypothesis in this study is that, by combining the improvements of village chicken and sheep production, we can improve income for poor rural farmers. The aim of the current thesis was first to investigate in current chicken and sheep production systems. Secondly, the study aimed to evaluate and improve feeding strategies of both village chicken and sheep production to make each of these two productions more profitable. In addition, we investigated the conditions to integrate these two productions. We designed and studied an integrated system aiming at improving village chicken production through association with ram fattening. The current section discusses the main results and highlights the main conclusions from the different studies carried out in this thesis.

The 'state of the art' of village chickens and small ruminants' production systems

The research and development activities to gather knowledge and to improve village chicken production were well documented. One can cite important studies from Gunaratne *et al*. (1993), Sonaiya (1995), Kazi (1999), Sonaiya *et al*. (1999), Guèye (2000), Maho *et al.* (2000) and Ndegwa *et al*. (2001). Particularly in Burkina Faso, reputed in West Africa for village chickens production, many activities on village chickens improvement were carried out and reviewed in Chapter 1. Unfortunately these activities did not result in significant improvement at farm level. They were limited in time and space and a real strategy for improvement of village chickens production was lacking. Village chicken production is still based on scavenging (Chapter 1; Ouandaogo, (1997); Kondombo *et al.*, 2003b) with the consequence of high mortality due to diseases and predators. An important element missing in a coherent strategy for improved village chicken production is a feeding strategy. Chickens need to be adequately fed to value other technologies of improvement such as health care, improved housing and equipment etc. So far, improvement of village chicken production consisted of genetic improvement for egg or meat production, housing and feeding as single interventions. Criticisms on such activities can be highlighted, as at the end of the different project supports for such improvements, farmers were generally not able to continue the cross breeding or the disease control and returned back to extensive production systems without these techniques. The income generated from village chicken production that is improved in only one single aspect may be to low to support the offered technologies. Farmers may also prefer chickens with different feather colours for some cultural ceremonies (SEDES, 1977) and therefore reject programs aiming at genetic improvement.

Improving village chickens production implied using inputs (labours, management, feeding) into the system. The actual village chicken production system, described in Chapter 1.2 and based on the free-range system, is not favourable for certain types of investments because 83% of the flock may be lost due to disease, predators or miscellaneous causes (see Figure 1.2.1, page 26). This system is characterised by poor housing, feeding and management conditions and as a consequence by low productivity, low hatchability and high percentage of mortality. The mentioned constraints, give the direction for improvement of the system. There is a need to have a system in which the risks of death due to diseases and predators are reduced.

It can be noted that improved housing gives possibilities to reduce health problems and decrease other sources of mortality (Saunders, 1984; Aini, 1999). There exist many valid recommendations for appropriate housing and equipment (Djabi, 1983; Saunders, 1984), but in the field of feeding and management, little has been done (Chapter 1.3). It is clear from Okitoi (1999) cited by Asgedom (2000) that when there are large number of chickens, scavenging feed resources are not sufficient to cover chickens feeding requirements. So when housing and health care successfully increase flock sizes, feeding will become the main limiting factor. In order to have an overview on composition of the scavenging feedstuffs for village chickens, these feedstuffs have been evaluated at farm level (Chapter 3.2.2). The technique used is to slaughter the animals and determine the contents of their crops. This technique is used by many authors (Tadelle, 1996; Rashid *et al*., 2005). A disadvantage of the method is that it is difficult to find the moment of sampling that is the most representative for intake of scavenging feedstuffs. Nevertheless, it gives an overview on available scavenging feedstuffs, in dry and rainy season. In the rainy season a large variety of feedstuffs were available while in the dry season, feedstuffs were essentially cereals and cereal by-products. The consequences of this seasonal availability lead to lower body weights of village chickens in the dry season compared to the rainy season. In the dry season, cocks, hens, cockerels and pullets weighed respectively 1049.4 g, 784.6 g, 658.3 g and 587.5 g. In the rainy season the weights were 1362 g for cocks, 1196 g for hens, 873 g for cockerels and 704.6 g for pullets. In the dry season it may be necessary to supplement the animals and to stimulate production of additional feed resources (insects and worms). In an integrated village chickens/fattening rams production system (IPS), chickens may have access to some additional feedstuffs which originate from fattening feed refusals and additionally produced or attracted protein sources (insects, worms, termites). This was investigated in Chapter 7. In this system chickens can improve their feed intake in a period of scarcity in scavenging. Furthermore, village chickens will roam in a limited area that will help to decrease the risks relative to contagious diseases (mainly Newcastle disease) and predators. Both aspects (more feed and less risks) of IPS will improve village chicken production in rural area based on local resources. IPS is a strategic option in the line of thinking of previous authors (Preston, 1987; Udo, 1997). According to Udo (1997), large scale-commercial production systems are of little benefit to local farmers in developing countries. Preston (1987) also noted that the primary strategy should be to make better use of locally available resources. The IPS is a way to do so.

In the case of small ruminants' production, an overview showed that the sector is also dominated by the extensive system with the result of low flock size and low income generation from the system (Chapter 2). Several researches have been conducted aiming to improve the system, particularly in Burkina Faso (Bourzat, 1983; Richard *et al.*, 1985; Bourzat *et al*., 1987; Nianogo *et al*., 1995; Ouédraogo *et al*., 2001). Most of these studies were focussed on sheep feeding and feeds. From these studies, it is clear that for small ruminants, the best way to improve their production for income generation is ram fattening. The actual attempts to improve sheep production by ram fattening are still mainly confronted with feeding constraints due to the low quantity and quality of natural pasture during the dry season, the low availability of crop residues at farm level and the high cost and low availability of the agro-industrial by-products (Chapter 3.1). In Chapter 3.2.1, it is demonstrated that only 3.7% of the crop residues produced in the fields are stored at farm level whereas the amount of available crop residues is estimated to be 36 t/ha per household (Table 1). Thus, currently farmers do not use enough crop residues for their livestock production. In the Sahelian zone of Burkina Faso, Savadogo (2000) estimated that the use of crop residues in ruminants feeding (without application of any special technology) allowed to feed 9 10^3 tropical livestock unit (TLU) each gaining 526 g per TLU per day for maximum total production or a maximum of $43 \cdot 10^3$ TLU fed at maintenance. In the first situation only 1% of all residues could be used consisting of only the best of the available legume straws while in the second situation up to 7% of all residues could be used including all legume straws. In the sub-Sahelian, north-Sudanian and south-Sudanian agro-ecological zones Savadogo (2000) calculated that 37%, 35% and 27% of the produced crop residues could be used when aiming for maximum numbers of animals fed at maintenance levels. The contribution of cereal straws in the diets in these zones were 30%, 28% and 20%, respectively. The choice between maximum production per animal or maximum numbers of animals fed at maintenance level, and the quantity and quality of the available residues is determining the possibility to use the crop residue feed resources. A promotion of sheep fattening at farm level will probably encourage storing more crop residues at farm level as the activity can add value to the feed resource. For such promotion, it should be known how much of the diets can be covered by these residues and how much live weight gain can be achieved. To carry out feeding strategies for fattening ram based on crop residues in the socio-economical conditions of farmers is still a challenge. Fattening diets based on crop residues have to be tested either on station or on farm and when established they need to be explained to all interested farmers. The best way to transfer the ram fattening techniques and diets to farmers should yet be explored.

Table 1. Available crop residues and their use at farm level in the research site of Kouaré village (Chapter 3)

Crop residues	Total available CR in the field (t)* (a)	Total quantity (t) of CR stored by household	Quantities of CR stored in % of the available CR
Maize straw	9.7	0	0
Millet straw	224	9.9	4.4
Sorghum straw	67.2	11	16.4
Groundnut hay	28.5	1.5	5.3
Cowpea hay	106.3	1.1	1
Rice straw	0.5	0.02	4
Sorghum/millet straw	211.7	0.2	0.1

CR = crop residues; * Total CR for 18 households.

On-station and on-farm researches for village chickens and fattening ram production improvement

Research on improving village chickens and sheep production should be based on the possibility of farmers to produce feed and on their economical capability to buy inputs. In the current thesis, three trials were conducted in research stations and three others at farm level. The objectives were to elaborate new technologies for improvement of village chickens and sheep fattening adapted to rural farmer's knowledge, objectives and socio-economical conditions.

Village chickens production improvement trials

At farm level, village chickens are mainly fed only on scavenging feedstuffs (Guèye, 1998; Sonaiya *et al*., 1999). Sometimes they may receive feed supplementation (Akunzuli, 2001) such as cereals or termites. In the perspective to improve the production system, more systematic feeding will be needed. It was investigated (Chapter 4.1) how the available local feedstuffs can be used for village chicken production. The performances of growth were studied in two feeding trials and the results of these trials (Table 2) were similar to several previous studies done throughout the world (Tadelle, 1996; Roberts, 1999). In the first trial, supplementation with red sorghum and/or local beer by-product generated average daily weight gains of 5 to 6 g/d for village chicken cockerels compared to 5.9 g/d without supplementation at the end of the rainy season (Chapter 4.1, Kondombo *et al.*, 2003a). So, there was no additional weight gain due to the supplementation with local beer by-product. It should be stated here that this is logical because local beer by-product contains low levels of metabolisable energy and high levels of crude fibre (Chapter 3.2.1). In addition, animals did not like to eat it. The trial showed that it makes no sense to supplement village chickens with these local feedstuffs at the end of the rainy season. However, in husbandry conditions or in a period of the year where scavenging feedstuffs are scarce, supplementation with this product may be more efficient and improve village chicken weight gains.

In the second trial of Chapter 4 in which, the supplementation of village chicken cockerels is done with commercial feed during the hot dry season and start of the rainy season, rates of

Table 2. Summary of village chickens zoo-economical performances from the feeding trials

Treatments	Source	Daily weight gain (g/d)	Gross margin (FCFA)
Scavenging + Red Sorghum (RS)	Chapter 4.1	6.1	–30
Scavenging + local beer by-product (LBBP)	Chapter 4.1	6.6	95
Scavenging + RS/LBBP	Chapter 4.1	5.5	5
Scavenging + commercial feed in S1	Chapter 4.2	2.8	55
Scavenging + commercial feed in S2	Chapter 4.2	4.4	115
Scavenging + commercial feed in S3	Chapter 4.2	3.9	130
Complete diet	Chapter 4.2	2.2	25
Scavenging at the end of rainy season	Chapter 4.1	5.9	85
Scavenging in rainy season (S1)	Chapter 4.2	0.2	160
Scavenging in hot dry season (S2)	Chapter 4.2	6.8	260
Scavenging at the beginning of the rainy season (S3)	Chapter 4.2	5.5	265

S1 = period of rainy season, S2 = period of hot dry season, S3 = period of the beginning of the rainy season; 1 € = 655.957 FCFA.

growth of 2.8 to 4.4 g/d were observed. These average daily weight gains are much lower than those of the supplementation with local feedstuffs at the end of the rainy season in the first trial. It appears that the scavenging feedstuffs highly influenced the performance of scavenging birds. As commercial feed is well balanced, it was expected to give a high weight gain but this was not the case. The period of the supplementation was the hot dry season and the start of the rainy season where the availability of the scavenging feedstuffs were poor in protein sources (insects, worms) (Chapter 3.2.2) compared to the end of the rainy season. Furthermore, in confinement conditions village chickens showed lower performances than in conditions of supplementation and free ranging. This confirms the findings of Tadelle *et al*. (2000) that scavenging for village chickens is essential to perform well.

Feeding strategies for fattening ram

In Chapter 5, we used on-station and on-farm trials to study ram fattening diets. For the on-station trial we tested the possibility to use diets for ram based on crop residues (cowpea hay, groundnut hay and sorghum straw). The study demonstrated that a diet composed of 30% of concentrates (wheat bran), 34.4% of cowpea hay, 28.4% of groundnut hay and 7.2% of sorghum straw is the combination giving the highest liveweight gain. This diet gave 81 g of daily body weight gain (DWG) (Chapter 5.1). This DWG is in the range of Djallonké growth rate indicated by Nianogo *et al.* (1995). The study showed that the available crop residues can already give interesting performance to fattening rams. As crop residues can be gathered at farm level, this diet has more chance to be adopted by farmers. Therefore, this diet should be promoted at farm level so that farmers can have better use of the crop residues produced in their fields.

In an on-farm trial, as described in Chapter 5.2, some steps for technology transfer to farm level are given. The technologies proposed for the study were diets for fattening of ram, formulated in the research stations of Burkina Faso (Kalkoumdo, 1994; Nianogo *et al.*, 1995; Kondombo and Nianogo, 2001; Ouédraogo *et al.*, 2001). The first step consisted of the approach presented in Figure 5.2.1 (page 105). In this approach, new techniques should be proposed in collaboration with extension services and a limiting number of farmers for testing in order to be able to record reliable data at farm level. At that step, the tests are supervised by researchers and extension workers. Researchers will collect and analyse the results and if they are relevant, a second approach (Figure 5.2.3, page 107) will be applied. In this second step, researchers have direct contacts with village communities and the test can be done by any volunteer farmer. At this step, the data collection procedure has a large sample size. From the results, recommendations can be made public through publication for wider diffusion of the technologies tested. The two approaches as proposed in our study emphasise that a technology should first be mastered at research level before attempting to transfer it to at farm level at a large scale.

Forage cropping to increase the availability of high nutritive feedstuffs for ram fattening

As has been demonstrated in Chapter 3, the main constraint in ram fattening is the availability of feedstuffs with sufficient nutrient density. Legume hays have a relative high nutritive value, but their availability is very low. Availability of agro-industrial by-products is low and they are also expensive. However, certain fodders have relative high nutritive values for sheep, therefore it seems important to encourage cropping of these fodders at farm level. With regard to the constraints for fodder cropping in developing countries, mainly the competition with cereal cropping for labour and arable land, new approaches for fodder cropping have to be initiated. The third study of the Chapter 5.3 aimed to give an opportunity to farmers to practice fodder cropping without additional requirements for labour and land by the identification of a fodder that can be cropped in association with cereals. The dolic (*Dolichos lablab*) fodder was chosen for the study because it was well known by farmers and also its hay has a high nutritive value with about 10.28% of crude protein (Nantoumé *et al.*, 1996). Results of the study show that maize/dolic and sorghum/dolics are possible combinations. Recommended spatial distributions for these associations are cereals and dolic in the same hole or one hole of dolic between two holes of cereal in the same line. In these conditions, dolic fodder yields from 0.17 to 1.48 t/ha may be obtained and cereal yields are higher than in any of the other spatial arrangements that were tried. Such fodder production can be used to complement the low quantity of the legume hay (cowpea and groundnut hay) stored and be incorporated in the promising fattening ram diet described in Chapter 5.1.

Necessity to integrate the production systems at farm level for improvement of livestock production in developing countries

Small ruminants and poultry are frequently used for sacrifices during traditional religious ceremonies. They can be easily sold to cover household needs for cash or be used for household consumption. Big animals as cattle or horses are only sold in exceptional cases. Poultry will be sold or sacrificed more frequently than small ruminants. Furthermore, animal manure may be used for soil fertilisation for crop production and value may be added to crop residues by using them in livestock production. Therefore, in developing countries in general and in Burkina Faso in particular, farmers integrate crop and livestock activities in their farming system.

Farmers can rear cattle, small ruminants and poultry in multiple combinations (one, two or the three species together). Such integration of production activities seems a strategy of survival as the product of one subsystem can support another one. Furthermore farmers exploit the interrelation between feed resources of the different species. This strategy of survival was well demonstrated for small ruminants and village chickens by the study described in Chapter 6. There, the interrelation between these two species in income generation at farm level and their complementarity with regard to the feed resources has been described. Nianogo and Somda (1999) also demonstrated complementary roles in livestock production. Such survival strategies of rural farmers should be taken into account when aiming at improvement of livestock production.

For small farmers, it seems that an integrated village chickens/fattening rams is appropriate as demonstrated in Chapter 6. The role of small ruminants and village chickens in rural income generation is well documented. In the studied villages, village chickens and rams also appeared to be the main issues for rural farmers in income generation. Furthermore, the production systems of small ruminants and village chickens show complementarities in the management and feeding (Chapter 6). The main reasons for selling these animals are to solve cash problems (37 to 50% of households) or the high number of animals (47 to 53% of households). In addition small ruminants' profitability can be increased with fattening (Slingerland, 2000). Chicken and sheep can be included in one feeding strategy when refusals from the feed resources from the fattening can be included in the scavenging feedstuffs for village chickens (Figure 6.4, page 139). The feed resources for fattening sheep in the case of Burkina Faso (Chapter 3) consist of crop residues, agro-industrial by-products and non-conventional feedstuffs. The integrated system will allow to control the scavenging of village chickens and to improve their productivity.

Improvement of village chicken production by an Integrated (village chickens/fattening rams) Production System

It was demonstrated in Chapter 6, that a combination of cereal residues and sheep manure can generate termites and worms. Agro-industrial by-products or local concentrate feeds can be used as fresh feed in both village chickens and fattening ram. Income from fattening ram sales may be used in village chickens production and the other way around. All these interrelations between village chickens and fattening ram production are reasons for their integration. Therefore, an Integrated (village chickens/fattening rams) Production System (IPS) was designed and studied in Chapter 7. This study was carried out in a research station as a feeding trial in order to test the profitability in term of biological and economical gain of IPS. The results of this study show that village cockerels can achieve average daily weight gains of 10.4 g in the integrated system when supplemented with a commercial pullet feed. This growth performance is higher than those indicated so far by previous studies (Chapter 4, Kondombo *et al*., 2003a; Roberts *et al*., 1999). Growth ranging from 2 to 6 g/d was reported in these studies in semi-scavenging or confinement conditions. In the IPS village chickens perform better than in the usual conditions of feeding due probably to the combined effect of scavenging and the supplementation with feeds of adequate nutritive value. Birds scavenged on feed refusal, termites, insects and worms generated by the system. They did not have to go far for scavenging which limits loss of energy and also reduced the risks related to disease contamination and predators. It can be speculated that even for village chickens egg production or chicks rearing, the conditions provided by IPS will allow better productivity than the free range system.

Furthermore, weight gains for fattening rams were not negatively influenced by the system. Growth of ram observed during the study (81 g/d) is consistent with the growth expected with the diet used (Kondombo and Nianogo, 2001; Chapter 5.1). Even when chickens use some of the concentrated feed of the ram diet, these quantities are not enough to influence ram weight gain negatively.

In economical terms, the system generated a minimum gross margin of 275 FCFA per bird. By projection it is demonstrated that the overall system (village chicken and fattening production) can be designed in such a way that it will generate a net income of 79,030 FCFA (120.5 €) per year, which is higher than the absolute poverty line of 72,600 FCFA (110.7 €) in Burkina Faso (INSD, 2000b). To achieve this benefit 4 rams and 120 growing cockerels need to be fed respectively during 3 and 1 months in the system. The system should be run at least twice the year. These conditions are feasible. Some support to rural farmers in Burkina Faso however is needed. We think that it can also work in other countries. The improved system (IPS) can thus be used for poverty alleviation in developing countries.

It should also be kept in mind that the manure produced in the system can be sold or used as fertiliser in the fields for crop production. Chicken litter may be used to increase crop residues digestibility for fattening ram (Kayongo *et al*., 1990) if it can be collected separately. Nianogo and Scott also cited by Nianogo and Somda (1999) showed the possibility to use chickens litter in goat feeding. The functions of insurance and finance of village chicken and sheep at farm level are also preserved in the system as farmers may sell birds or rams in case of cash need. One of the major advantages of IPS is the negligible loss of chickens due to bad weather or due to predators. The losses due to diseases will be greatly reduced or diseases may even be eradicated because of the control of scavenging and the possibility of adequate health care in the system.

Conclusion and recommendations

Major conclusions of the studies described in the current thesis can be synthesised as follow:
- sheep fattening and village chicken productions are the most relevant issues for poverty alleviation for rural farmer households in developing countries in general and in Burkina Faso in particular;
- supplementation in addition to scavenging is the best feeding strategy for improvement of village chicken production;
- diet incorporating 34.4% of cowpea hay, 28.4% of groundnut hay, 7.2% of sorghum straw and 30% of concentrate can be used to increase the value of crop residues at farm level through fattening of sheep;
- to transfer technologies carried out in research stations to farm level, it will be needed first to test these technologies with a limited number of farmers with the implication of the extension services before testing them at larger scale;
- village chicken production system can be improved by integrating it with sheep fattening in the Integrated Production System (village chickens/fattening rams).

As recommendations, IPS has to be tested at farm level to adapt the system according to the socio-economical context of rural farmers in each developing country.
In term of research, the system gives an appropriate design for further studies on improvement of village chicken production (genetic, feeding, health care etc.).

In conclusion, developing countries in general and Burkina Faso in particular can use IPS as a tool in their efforts for poverty alleviation. Researchers and extension workers should make efforts to apply IPS in the field.

Further research

Based on the IPS described in the current thesis, further research should be initiated to improve aspects of village chickens production. The following research subjects are proposed for further study within the concept of IPS:

- Identification of least cost supplements to be used in IPS for growth and egg production. Adequate supplements based on local feedstuffs should be studied through feeding trials in the system either for village chickens growth or egg production.
- Improvement of scavenging feedstuffs production (insect, worms, termites, vegetable) in IPS. The scavenging feedstuffs in the system were mainly feed refusals of the fattening. The availability of feeds for chicken can be improved by investigations on deliberate stimulation of protein sources (insects, worms and termites) and vegetable production in the system.
- Effects of IPS in young chicks rearing. To study how chicks (0 to 5 months of age) can be reared in the system should be studied. This will allow rearing village chickens at all age in IPS.
- Integration of further sub-systems in IPS. Guinea fowl production is strongly related to village chickens production at farm level. The possibility to associate such production in the IPS should be investigated.
- Introducing other improvements such as health care and eventually other breeds of poultry.
- The optimum number of chickens and fattening rams to be reared in IPS should be studied as well in relation to costs and benefits of inputs and outputs and optimal re-use of resources within IPS.

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Summary

Livestock play a strategic role in developing countries in general and in Sahelian traditional livelihood in particular. This strategic role was described in the 'General Introduction' of the current study. Livestock contributes in soil fertilisation by the production of manure. According to the species, cattle is considered as object of prestige and a sign of richness. Some ethnic groups have their life organised in close relation to cattle breeding. Small ruminants and family poultry are frequently used in relationships as gifts for relatives, sacrifice, marriage or religious ceremonies. According to the species, different contributions to income generation, food security and sustainability can be distinguished. Cattle contribute mainly to milk production and draught power in ploughing and transport. Small ruminants are frequently slaughtered at village level and supply the rural population with animal protein. From small ruminants, sheep are best fit for income generation. Family poultry are considered as a strategic means in income generation and food security. Among family poultry, village chickens play important socio-cultural and economical roles in developing countries. They are a source of easy and regular income for small farmers and can be reared by any farmer. Village chickens production is generally neglected in development politics which explains that its low productivity is maintained. Nevertheless, this production can be used in poverty alleviation as village chickens can be reared even by the poorest farmers. In summary, sheep and poultry (mainly village chicken) rearing appear to be the most relevant issues for income generation in Sahelian livelihood systems and therefore efforts for livestock improvement should be directed toward these two species.

The current thesis aimed to study in Burkina Faso, a West African Country, the possibilities to improve these two systems by feeding strategies. Its specific objectives were:

- To describe village chickens and small ruminants production systems;
- To identify various feeding regimens for village chickens and fattening sheep and to investigate their advantages and limitations;
- To identify which factors of each production system can contribute to the other;
- To explore an integrated village chicken-fattening sheep system (IPS) at farm level.

In Section 1.1, an overview on village chicken production systems worldwide was given based on a literature review. Three types of village chicken production systems have been reported. The first system is the free range system in which birds find the main part of their daily ration by scavenging. Such a production system is characterised by low production in terms of eggs and meat, high risk of Newcastle disease outbreaks and important losses due to predation and other causes. The second system is the backyard system. In the backyard system poultry are part-confined within a fenced yard or merely within an overnight shelter and receive regular supplementation. Sometimes, the semi-intensive system is referred to as the backyard system. The third system is the semi-intensive system which is generally observed in Asian countries. In this system the chickens are fed with formulated diets and commercial lines are used. From the several studies on village chickens, it is clear that the free range system remains the main production system for village chickens in West Africa. This production system is caracterised by low productivity and high mortality.

To appreciate the specific case of village chickens in Burkina Faso, a case study was done in a village in its Central Region (Section 1.2). The study aimed to describe and compare village chickens production in the crop/livestock farming system mainly practiced by the Mossi farmers and the livestock farming system which concerns Fulani farmers. A rapid rural appraisal preceded a monitoring study in which data were collected fortnightly for two months. The chicken production system is a free-range procedure in both farming systems, but there are differences in management. On average, the flock size was 33.5 birds, of which 57% were chicks. During the period of two months in the rainy season, the overall mortality was relatively low (8.8%), but mortality in chicks was high (31.7%). The main cause of village chickens losses was mortality that represents up to 84% of the total exits. The hatching rate and mortality in young chicks differed significantly ($P < 0.05$) between the two farming systems. Hatching rate was 70% and chick mortality 24.2% in the crop/livestock system and they were respectively 46 and 52.3% in the livestock system.

The third study of this Chapter 1 provides an overview on research and development activities on the improvement of village chickens so far in Burkina Faso (Section 1.3). Several improvements were tested and proposed regarding chicken houses and feeding and drinking equipment. Vaccination of village chickens against the Newcastle disease was reported to give an increase of 110% in the production of village chickens. Genetic improvement by exotic cock exchanges, as the Rhode Island Red chicken, and modern complete diets for feeding were proposed to improve village chicken growth and egg production. However, farmers were found not to adopt these technologies and the main village chicken production system is still essentially the traditional low-productive free-range production system. It was concluded that more integrated approaches for the improvement of village chicken production systems needed to be investigated, taking into account the proposed technologies but also the locally available resources.

In Chapter 2, small ruminants' production systems were reviewed. The dominant small ruminants' production system is an extensive system based on grazing. Small ruminants' production has low productivity characterised by low flock size, late reproductive age, high interval between parturition, high mortality, and low daily growth. The main causes of such low productivity are diseases, poor conditions of husbandry and insufficient quantity and quality of feedstuffs in the dry season. In Burkina Faso, there are 10 millions of goats and 6.7 millions of sheep and the highest concentration of small ruminants is located in its Central Region. That small ruminants are important can be derived from the fact that many studies were undertaken on these species. Two main breeds of small ruminants are observed; the Fulani and the Djallonké sheep or goat. The improvement of the system is oriented towards sheep fattening, aiming at income generation.

Chapter 3 describes the feed resource bases for fattening sheep and village chicken in Burkina Faso. Literature review and surveys (factories and market levels) were used to study the availability of concentrate feeds in Burkina Faso (Section 3.1). Feed resources for village chicken were investigated with key informants in the village of Matté and in the town of Ouagadougou. In 1998, mainly 8 factories produced agro-industrial by-products (AIBP) that can be used as concentrate feeds in Burkina Faso. Annually, the production of AIBP was 91,441 t of sugar-cane residual straw (SCRS), 59,425 t of cottonseeds (CS), 33,341 t of cottonseed cake (CSC) & cottonseed meal (CSM), 11,473 t of wheat bran (WB) and 10,697 t of molasses (M). However, only 33,341 t of CSC & CSM, 11,473 t of WB, 7,650 t of CS, 5,125 t of beer by-product and 703 t of rice bran are available for livestock feeding. The availability of AIBP could be increased by policy measures related to import and export of AIBP. Other sources of concentrate feeds need to be explored.

A second study of Chapter 3 aims to quantify the availability of crop residues at farm level and to investigate which may be available and adequate for sheep fattening in Burkina Faso (Subsection 3.2.1). A village in the east region of Burkina Faso was used as the research site, 10% of the households in the village randomly chosen were investigated. Sample field areas of 25 m^2 were used to determine the yield of each crop residue, which was afterwards extrapolated to entire fields and farms. Quantities of crop residues stored in each household were weighed and

a questionnaire on their use was submitted to farmers. This study was completed by a literature review to identity and to quantify other feed resources for sheep fattening.

Results show that with regard to quantity, the most important crop residue produced was millet straw, followed by the sorghum straw, cowpea and groundnut hay. Other crop residues from e.g. rice, peanut, cassava, and potatoes productions were negligible. The stored crop residues represented only 3.7% of the calculated crop residue production from the fields. Millet bran, sorghum bran, traditional sorghum beer by-product, pods or fruit powder of some trees as *Parkia biglobosa*, *Piliostigma reticulatum*, *Acacia albida* may be used as concentrates for sheep fattening.

The difference between the quantities of crop residues produced and stored are very large showing the need for actions to improve the use of these feed resources at farm level. One strategy is to increase the motivation for animal production as an economic activity, for instance by promoting sheep fattening. Also the means for transportation of residues need to be increased.

Chapter 3 reported also results of a study that investigated on the availability of feedstuffs for village chickens (Subsection 3.2.2). A formal survey was done in 30 households with questions that dealt with the farmers' practices in village chicken feeding. The study was completed by analysis of chickens' crop contents, after slaughtering, per category of chicken (cocks, hens, cockerels or pullets) and per season (rainy season and dry season). The results of the study showed that the most important cereals used for supplementation are sorghum (57% of the households) and millet (33% of the households). Termites are also used as supplement in 30% of households. Sun-dried crop content weight ranged from 10 to 14.7 g and no significant differences were observed between category of chicken and between seasons. Fresh crop contents ranged from 32.2 to 54 g in the rainy season and from 17.9 to 27.2 g in the dry season with significant differences between these two seasons. The most available feedstuffs for scavenging chickens are cereals, which represent 73% and 53% respectively in the rainy season and the dry season. Insects and worms are negligible in both seasons where they can represent 22% of crop content at the end of the rainy season. Means of live body weight of village chicken were 1223 g for cocks, 980 g for hens, 649 g for pullet and 771 g for cockerels. Between seasons, there are significant ($P < 0.05$) differences of village chicken body weight with the lowest body weights in the dry season.

Based on the knowledge gathered in the former chapters, trials on feeding strategies for village chickens and fattening sheep were conducted. The results of these trials are presented in Chapters 4 and 5.

In Chapter 4, a first trial was an investigation on the effects of supplementation with local feedstuffs during the end of the rainy season (from September to October) on zootechnic performances of village chicken cockerels (Section 4.1). The experimental design was a factorial design with four treatments (T1 to T4) and four blocks. In T1, birds were allowed to find their daily ration by scavenging only. In T2, T3 and T4, birds received after scavenging, supplementation with red sorghum seed, local beer by-product and the combination of both respectively. Four household compounds, in a village in the Central Region of Burkina Faso, were assigned as blocks.

The results showed that at the end of the rainy season, scavenging can support an average weight gain of 5.9 g/d for the cockerels. Sorghum appears to be an interesting supplement in conditions of scarcity of scavenging feedstuffs. When the scavenging feedstuffs are available, local beer malt or the combination red sorghum/local beer by-product gives higher body weight gains. The results of this trial suggest a strategic feeding of village chicken during the end of the rainy season.

The use of commercial feeds was also investigated in village chickens feeding in a second trial (Section 4.2). The trial was a factorial design with three factors each at three levels. The first factor was the period of feeding (beginning of the rainy season, rainy season and the hot dry season). The second factor was the availability of scavenging feedstuffs represented by the household compounds of three volunteering farmers. The third factor was the type of feeding strategy (scavenging only, scavenging + supplementation with commercial pullet feed, permanent confinement with feeding with commercial pullet feed). Ninety six cockerels with mean body weight of 432.6 g were purchased at farm level for the trial. At the end of the trial, slaughter performances were recorded and economical assessment was done. The results showed that the effect of the commercial feed is high during the first two weeks of feeding. After 35 days of feeding in confinement condition, body weight gain of village chickens is however lower than those of the other two feeding strategies. During the rainy season, the supplementation strategy showed higher chicken weight gain (97.3 g) than the scavenging only (8 g) or the complete diet in confinement (32 g). In the hot dry season, the scavenging only gives the higher weight gain with 237.5 g compared to 155.6 g for supplemented and 103 g for complete feed in confinement. In the beginning of the rainy season, no significant difference was observed between the feeding strategies after 35 days of feeding. Globally, the use of commercial feed showed more effect in the hot dry season and the beginning of rainy season after 35 days of feeding. In terms of economical assessment the scavenging only gave a gross margin of 225 FCFA followed by the supplementation with 95 FCFA of gross margin per bird. The use of complete diet gave very low gross margin with only 25 FCFA per bird. The results of this second trial suggest that if scavenging feeds are available in sufficient quantity, the best strategy of village chickens feeding is still the scavenging only. However, when this availability is not guaranteed or when going for improvement of village chicken production, supplementation of scavenging birds may be the best option. Complete diets in full confinement conditions gave poor results.

In Chapter 5, the first sheep feeding trial was conducted in a research station in the East Region of Burkina Faso, and aims to increase the value of available crop residues at farm level (Section 5.1). For that, the effect of 5 diets was studies with 25 male Djallonké rams in five repetitions for each diet. The dietary treatments were: (1) grazing (7 h/day) on a natural pasture plus a roughage diet (RD) (composed of 49.07% cowpea hay, 40.59% groundnut hay and 10.34% sorghum straw); (2) roughage diet alone; (3) 90% of RD plus 10% of concentrates; (4) 80% of RD plus 20% of concentrates and (5) 70% of RD plus 30% of concentrates. The animals were fed during a 14-day adjustment period and then, for 56 days, when feed intake and body weights were monitored. Results indicate that 20 to 30% concentrate feed in addition to a crop residues based diet notably increase weight gains. It also appears that crop residues were better utilised when fed to animals grazing on a natural pasture than as complete diet. When concentrates are available, the incorporation of 30% appears to be the most economical option.

This first trial was completed by an on-farm trial on sheep-fattening diets formulated in research centres in Burkina Faso (Section 5.2). The research question of this second trial was how to transfer such diets to farm level. Two approaches of technology transfer were tested with six diets. In the first approach (Section 5.2, Table 5.2.1), four diets were tested by volunteer farmers with the implication of the extension services. The diets tested in this approach were: diet (1) composed of 22% of cottonseed cake, 22% cottonseeds, 22% of wheat bran, 5% of *Pennisetum pedicellatum*, 20.6% of sorghum straw, 7% of groundnut hay and 1.4% of oysters shell; diet (2) composed of 30% of wheat bran, 7.24% of sorghum straw, 28.41% of groundnut hay and 34.35% of cowpea hay; diet (3) composed of 29.48% of wheat bran, 32.82% of *Panicum laetum*, 37.70% of *Dolichos lablab*; diet (4) composed of 24% cottonseed cake, 34% cottonseeds, 8% *Pennisetum pedicellatum*, 22.2% sorghum straw, 10% groundnut hay, 0.8% of oysters shell, 1% of NaCl.

In the second approach (Chapter 5, Table 5.2.2) all the farmers in the village were concerned and more than one farmer received randomly one of the diets tested. The diets tested in this approach were diet (2) again, composed of 30% of wheat bran, 7.24% of sorghum straw, 28.41% of groundnut hay and 34.35% of cowpea hay; diet (5) composed of 39.26 cowpea hay, 32.47% groundnut hay, 8.27% sorghum straw, 18% wheat bran and 2% cottonseed cake; diet (6) composed of 23.6% groundnut hay, 35.82% wheat bran, 39.18% cottonseed cake, and 1.4% oyster shell. Results show that the two approaches can be used for transfer of fattening diets to farm level, but that it is more efficient to apply the first approach before the second one. Body weight gains of 3 to 5.5 kg in 56 to 98 days of fattening were registered. The gross margin per fattening ram varied from 3,570 to 5,095 FCFA. The on-farm trial was well appreciated by farmers. The two approaches may be also useful for the transfer of similar research technologies.

Legumes have high nutritive value for sheep fattening. However their availability at farm level is low due to their low production and storage. In order to increase the availability of this kind of forage a trial was initiated to produce a forage crop, *Dolichos lablab*, in association to cereals (Section 5.3). The trial was conducted in the research station of Kouaré in the East Region of Burkina Faso. The trial aimed to identify the appropriate cereals for the cereal/dolic combination and the optimal spatial distribution of the crops in cereal/dolic farming. The experimental design was a cross-over with two factors in four replications. The first factor was the spatial distribution with 4 treatments and the second factor the type of farming with seven treatments. The study shows that the association cereals/dolic has no negative effect on cereal yields. Forage yields of 0.17 upto 1.48 t/ha were observed with the best cereal/dolic associations. Such quantities of forage may be used in diets with low rates of concentrates to feed 3 to 26 fattening sheep with 25 kg live weight during 90 days. Maize and sorghum appeared to be the best for cereals/dolic association. The best spatial distribution was seeding of dolic in the same hole as the cereal or in a separate hole between two holes of the cereal in the same line.

In developing countries, farmers are often involved in mixed farming systems. This diversification helps to avoid the risks related to the practice of one speculation. In the livestock sub-system, such strategy is also observed with regard to the ownership of different species by the same farmer. In Chapter 6, a study is presented aiming to show how village chickens and small ruminants can both be a relevant source for livestock production and for income generation at farm level and how these systems can be improved. The study was done with the RRA method and two formal surveys in the village of Matté in Burkina Faso. For each formal survey, a sample of 30 households was chosen by the farmers themselves on the basis that they rear chickens and also to cover each of the neighbourhoods of the village. A literature review helped to design how village chicken production system can be improved through a combination with sheep fattening. The results show that each household owns village chickens and nearly 80% also rear sheep or goat. Furthermore, there is a tendency for households to rear various animal species with 48% of the households breeding village chicken, goat and sheep simultaneously. The main source of income in the household is the sale of village chickens and small ruminants. Up to 60% of the households never sell cereals whereas village chickens and small ruminants are frequently sold for different reasons. The most important reason for the sale of village chickens is the high number of chickens according to 47% of the households and the solving of a cash problem for 20% of the household. The main reasons for selling small ruminants are their high numbers and the solving of cash problem for respectively 53% and 37% of the households. Up to 57% of farmers perceived that the interrelation between sheep and chickens can be used to improve village chickens production. This can be done by using the same run as sheep for 27% or using the income from sheep sales (13%) for investments in village chicken production.

Furthermore, the analyses of feed resources used by sheep and village chickens indicated that the interrelation between feed resources for these two species can be used as well. For the small ruminants, sheep fattening appears to be an interesting way to increase income generation from this species. An integrated village chickens/sheep fattening system can be a means of improvement of village chickens production and increase of income at farm level.

The results of the previous studies and trials were analysed and used to design an Integrated (village chickens/fattening rams) Production System (IPS). The designed IPS consist of a fenced run in which two fattening sheep are fed, improved chicken housing is provided and 20 chicken are penned. A dustbin is used to generate insects and worms for village chicken scavenging. The trial was carried out in the research station of Saria in the Central Region of Burkina Faso. This IPS was tested with a village chickens feeding trial and the results were reported in Chapter 7. The aim of the feeding trial was to study the effects of two feeding strategies on weight gains of village chicken cockerels. The experiment was set up as a completely randomise design with two treatments (the feeding strategies) in two replicate groups of cockerels. Treatment 1 (T1) was the Integrated Production System (IPS) + supplementation of cockerels with local beer malt. Treatment 2 (T2) was the IPS + supplementation with the commercial pullet feeds. Results showed that when the supplement had adequate nutritive value (case of T2), daily body weight of 10.4 g/d could be obtained. When the nutritive value was poor (case of T1), loss of weight was observed. The chicken production did not influence the performance of the rams in the system. An economical assessment indicated that with T2, a positive gross margin of 275 FCFA per bird could be obtained. Considering the entire system, a projection was made to explore whether the IPS could be used for poverty alleviation. This appeared to be possible with 4 sheep and 120 chickens per 3 months period twice a year. This number of animals in IPS allowed farmers to get at least a net income of 79,030 FCFA (120.5 €), which in itself is already higher than the absolute poverty line (72,600 FCFA equal to 110.7 €) in Burkina Faso. The conclusion can therefore be that the designed and tested integrated production system may be used as a tool for poverty alleviation in Burkina Faso and in developing countries in general.

Finally, the main findings of this thesis were discussed in the 'General Discussion' and conclusively, the thesis showed that:

1) Fattening sheep and village chickens are the most relevant issues for poverty alleviation at rural farmer household in developing countries in general and Burkina Faso in particular;
2) Supplementation in addition to scavenging is the best feeding strategy for improvement of village chicken production.
3) Diets incorporating 34.4% of cowpea hay, 28.4% of groundnut hay, 7.2% of Sorghum straw and 30% of concentrate can be used to increase the value of crop residues through sheep fattening at farm level.
4) To transfer technologies carried out in research stations to farm level, it will be needed to use first an approach including a few farmers with the implication of the extension services and secondly a village communities approach.
5) The village chicken production system can be improved by an Integrated (village chicken/fattening rams) Production System (IPS).
6) The IPS can be used for poverty alleviation in developing countries in general and in Burkina Faso in particular.
7) The IPS may be used for all research activities (genetic, feeding or health improvement) on village chickens production improvement.
8) The IPS has to be tested at farm level to adapt it to the socio-economical context of rural farmers.

Résumé

L'élevage joue un rôle stratégique dans les pays en développement en général et dans les systèmes de subsistance des pays Sahéliens en particulier. Ce rôle stratégique a été décrit dans une 'Introduction Générale' de la présente étude. En effet, l'élevage contribue à la fertilisation des sols par la production du fumier. Selon les espèces, on note que les bovins sont considérés comme objet de prestige et signe de richesse. Des groupes ethniques comme les Fulani ont leur vie entièrement organisée en étroite relation avec l'élevage notamment celui des bovins. Les petits ruminants et l'aviculture sont fréquemment utilisés dans les relations sociales ou les cérémonies religieuses. Sur le plan économique et de la sécurité alimentaire, les bovins contribuent essentiellement à la production du lait et à la traction animale. Les petits ruminants sont une source de protéines animales facilement accessible aux populations rurales, à l'échelle du village. Parmis les petits ruminants, les ovins sont ceux qui se prêtent les mieux à la génération de revenues monétaires. L'aviculture est aussi considérée comme un moyen stratégique dans l'obtention de revenus et dans la sécurité alimentaire en milieu rural. Dans l'aviculture traditionnelle, les poulets villageois jouent le plus important rôle socio-culturel et économique. Son élevage est une source de revenus facilement accessible et régulière pour les petits producteurs. Malheureusement, cet élevage est le plus souvent négligé dans les politiques de développement. Aussi, a-t-il toujours un caractère aléatoire avec des fréquentes fortes mortalités liées notamment à la maladie de Newcastle. Cependant, cette production pouvait être utilisée dans la lutte contre la pauvreté car étant l'élevage à la portée de toutes les couches sociales. L'analyse de ces contributions par espèce animale au niveau de l'exploitation fait ressortir que l'aviculture (notamment les poulets villageois) et les ovins sont les points d'entrée appropriés pour la génération de revenus dans les systèmes de subsistance Sahélienne. Aussi, les efforts d'amélioration de l'élevage devraient s'orienter prioritairement vers ces deux espèces.

La présente thèse avait pour but d'étudier, prenant le cas du Burkina Faso en Afrique de l'Ouest, les possibilités d'améliorer ces deux systèmes de production sur la base de stratégies d'alimentation. Ses objectifs spécifiques étaient:

- De décrire les systèmes de production des poulets villageois et des petits ruminants,
- D'identifier les contraintes d'alimentation des petits ruminants et des poulets villageois,
- D'identifier différents régimes alimentaires pour les poulets villageois et les ovins d'embouche et d'investiguer sur les limites de ces régimes,
- D'identifier lesquels des facteurs de chaque système de production pourraient être bénéfiques à l'autre,
- De tester des stratégies d'alimentation devant permettre d'améliorer l'élevage des poulets villageois en relation avec l'embouche ovine.

Dans le Chapitre 1.1, un aperçu de l'élevage des poulets villageois à travers le monde a été fait par une revue de littérature. Trois systèmes de production sont rapportés. Le premier système est le système extensif basé sur la divagation. Dans ce système, les poulets trouvent l'essentiel de leur nourriture quotidien par la divagation. Ce système est caractérisé par une faible productivité en terme de ponte et de croissance, beaucoup de mortalité due à la maladie de Newcaslte, et des pertes importantes dues aux prédateurs et à des causes diverses. Le deuxième système est le 'backyard' système. Dans ce système, les poulets sont partiellement confinés dans des enclos ou simplement un abri de nuit et reçoivent systématiquement un supplément. Très souvent ce système est aussi appelé système semi-intensif. Le système semi-intensif est le troisième système qui est généralement observé dans les pays asiatiques. Dans

ce système, les poulets sont nourris avec des aliments complets et ce sont les poules de races exotiques qui y sont utilisées. Des différentes études, il apparaît clairement que l'élevage extensif demeure le plus important système de production pour les poulets villageois. Ce système est caractérisé par une faible productivité et de fortes mortalités.

Afin d'apprécier quelle est la situation actuelle de l'élevage des poulets villageois au Burkina Faso, une étude de cas a été faite dans un village dans sa Région Centre (Chapitre 1.2). L'étude avait pour objectif de décrire et de comparer les systèmes de production des poulets villageois dans deux types d'exploitation familiale. Ces deux types d'exploitation étaient le système mixte agriculture/élevage et le système pastorale. La Méthode Accélérée de Recherche Participative (MARP) a été utilisée pour cette étude suivi d'un monitoring pour lequel, les données ont été collectées toutes les deux semaines durant deux mois. Le système de production des poulets villageois était le système extensif basé sur la divagation dans les deux types d'exploitation familiale. Toutefois, certaines différences sont observées dans la conduite de l'élevage. En moyenne, les effectifs des élevages étaient de 33.5 poulets desquels il y a 57% de poussins. Durant la période de deux mois dans la saison pluvieuse, la mortalité totale était relativement faible (8.8%), mais celle des poussins était élevée (31.7%). La cause principale des pertes dans les élevages des poulets villageois était la mortalité qui représentait jusqu'à 84% de toutes les sorties dans les élevages. Les taux d'éclosion et de mortalité des jeunes poussins étaient significativement différents ($P < 0.05$) entre les deux types d'exploitation familiale. En effet, ils étaient respectivement de 70% et de 24.2% dans le système mixte agriculture/élevage et 46% et 52.3% dans le système pastoral.

Une troisième étude de ce chapitre (Chapitre 1.3) donne à travers une revue de littérature, un aperçu sur les activités de recherches ou de développement qui ont été menées afin d'améliorer l'élevage des poulets villageois au Burkina Faso. Cette revue de littérature a montré que plusieurs activités de développement et de recherche ont été conduites afin d'améliorer le système de production des poulets villageois. Ainsi, on retient que la vaccination contre la maladie de Newcastle pouvait permettre d'améliorer de 110% la production des poulets villageois. Des tests d'amélioration génétique par les échanges de coqs améliorateurs d'espèce exotique comme la Rhode Island Red et l'utilisation de rations complètes ont étés menés pour améliorer les potentialités de croissance et de ponte des poulets villageois.

Ce Chapitre 1.3 fait ressortir essentiellement que les producteurs n'ont pas pu maintenir et adopter les technologies proposées. En effet, le système de production des poulets villageois reste essentiellement traditionnel sans des actions significatives d'amélioration. Ce système de production est sans conteste moins coûteux mais, il est caractérisé par sa faible productivité, des apparitions fréquentes de la maladie de Newcastle et des pertes importantes dues aux prédateurs et aux intempéries. D'autres nouvelles orientations pour l'amélioration du système de production des poulets villagois ont besoin d'être investiguées tout en prenant en compte les acquis antérieurs.

Le Chapitre 2 basé sur une revue de littérature donne un aperçu sur le système de production des petits ruminants. Ce système de production est essentiellement extensif, basé sur le pâturage naturel. Ce système est caractérisé par des effectifs faibles des troupeaux, des faibles performances de production (croissance, reproduction) et des fortes mortalités. Les principales causes de ces faibles performances, sont les maladies, les mauvaises conditions d'élevage et l'insuffisance quantitative et qualitative des aliments surtout en saison sèche. L'importance de ces petits ruminants au Burkina Faso est telle qu'ils ont déjà fait l'objet de plusieurs études. On a recensé environ 10 millions de têtes de caprins et 6.7 millions d'ovins dans le pays en 1994. En fonction des régions de recherche au Burkina, la Région Centre possède les effectifs les plus élevés de petits ruminants. Deux races de petits ruminants sont observées dans le pays. La race Sahélienne et la race Djallonké tant pour les ovins que les caprins. Le système de production des petits ruminants demeure essentiellement extensif et l'amélioration de ce système est orientée vers l'embouche ovine. Pour une telle amélioration la contrainte principale est l'alimentation.

Afin de préciser les contraintes pour l'amélioration des deux systèmes (élevage des poulets villageois et embouche ovine) il a été étudié dans le Chapitre 3, les ressources alimentaires disponibles pour les moutons d'embouche et les poulets villageois au Burkina Faso. Une revue de littérature et des enquêtes formelles au niveau des usines de fabrication et des marchés a permis d'étudier la disponibilité des sous-produits agro-industriels (SPAI) au Burkina Faso (Chapitre 3.1). Au moment de l'étude, dans l'année 1998, essentiellement 8 usines produisaient les SPAI au Burkina Faso. Annuellement, la production des SPAI était de 91441 t de bagasse de cane de sucre (BCS), 59424.7 t de graines de coton (GC), 33340.5 t de tourteaux de coton/aliment bétail (TC/AB), 11472.9 t de son cubé (SC) et 10697.3 t de mélasse. Cependant, seulement 33340.5 t de TC/AB, 11472.9 t de SC, 7649.7 t de GC, 5124.7 t de drêche de brasseries, et 703.4 t de son de riz étaient disponibles pour l'alimentation du bétail.

Une seconde étude de ce chapitre avait pour objectif de quantifier la disponibilité des résidus de récolte au niveau des producteurs et d'investiguer quels types d'aliments sont disponibles et adéquats pour l'embouche ovine au Burkina Faso (Chapitre 3.2.1). Pour cela, un village dans la Région Est du Burkina Faso (le village de Kouaré) a été utilisé comme site de recherche. Un échantillon de 10% des ménages du village, choisi au hasard, a été utilisé. Les surperficies de tous les champs de chaque membre de l'échantillon ont été calculées en utilisant une programmation linéaire. Des carrés de rendement de 25 m^2 ont été utilisés pour déterminer les quantités de résidus de récolte produites au niveau des exploitations. Les quantités de résidus stockées dans chaque ménage ont été pesées et un questionnaire sur leur utilisation a été administré à chaque ménage. Une revue de littérature a permis d'identifier d'autres types d'aliments locaux disponibles pour l'alimentation des animaux.

Les résultats de ces investigations montrent qu'une classification par ordre d'importance quantitative des résidus de récolte produits était la paille de petit mil, la paille de l'association sorgho/mil, la paille de sorgho, les fanes de niébé et enfin les fanes d'arachide. Les autres résidus de récolte comme la paille de riz, les fanes des patates ou des vouandzou sont négligeables. Les quantités stockées représentent seulement 3.7% du potentiel de production des résidus de récolte des champs. Par ailleurs, alternativement aux SPAI(s), des ressources alimentaires locales comme le son de mil, le son de sorgho, la drêche de dolo, les gousses ou la poudre des fruits de certains arbres comme *Parkia vittelaria*, *Piliostigma reticulatum*, *Acacia albida* peuvent être utilisées comme aliments concentrés dans l'alimentation du bétail. En conclusion de cette étude, il ressort que les quantités de résidus de récoltes produites et stockées sont telles que des actions d'amélioration sont nécessaires pour accroître l'utilisation de ces ressources alimentaires chez les producteurs. Pour cela, il faut motiver les producteurs à faire l'élevage à des fins économiques comme l'embouche ovine.

Le Chapitre 3 présente également des résultats d'une investigation sur la disponibilité des aliments et les performances à l'abattage des poulets villageois au niveau de l'exploitation (Chapitre 3.2.2). Pour cela, une enquête formelle a été faite auprès de 30 ménages sur des questions portant sur leurs pratiques en matière d'alimentation des poulets villageois. Cette enquête formelle a été complétée par l'analyse du contenu des jabots des poulets villageois. L'analyse des contenus des jabots a été faite après l'abattage des poulets villageois selon l'âge et le sexe (coq, poule, coquelets ou poulette) ou la saison (saison sèche, saison pluvieuse). Les résultats de l'étude ont montré que les plus importantes céréales utilisées pour la supplémentation des poulets villageois sont le sorgho et le petit mil. Les poids des contenus des jabots séchés au soleil variaient de 10 à 14.7 g et aucune différence significative n'a été observée selon l'âge des poulets. Les vers et les insectes étaient négligeables dans les jabots durant les deux saisons alors que lors d'une investigation en fin de saison pluvieuse ils représentaient 22% du contenu du jabot. Les poids vifs moyens étaient de 1223 g pour les coqs, 980 g pour les poules, 649 g pour les poulettes et 771 g pour les coquelets. Entre saisons, les poids vifs des poulets villageois étaient significativement inférieurs ($P < 0.05$) en saison sèche qu'en saison pluvieuse.

Avec les résultats des études des chapitres ci-dessus, il a été entrepris des essais de stratégies d'alimentation des poulets villageois et des moutons d'embouche dont les résultats sont reportés dans les Chapitres 4 et 5.

Les essais sur l'alimentation des poulets villageois sont présentés dans le Chapitre 4. Le premier essai a porté sur l'effet de la supplémentation des aliments locaux sur les performances zootechniques des poulets villageois à la fin de la saison pluvieuse (Chapitre 4.1). Il s'agissait d'une étude factorielle avec 4 traitements (T1 à T4) et 4 blocks. Dans T1, les poulets trouvaient leur ration alimentaire uniquement par la divagation. Pour T2, T3, et T4, les poulets recevaient après la divagation, un supplément du sorgho rouge, de la drêche de dolo, et la combinaison des deux aliments respectivement. Les résultats suggèrent qu'à la fin de la saison pluvieuse, la divagation puisse supporter un gain de poids moyen de 5.9 g/j pour les coquelets des poulets villageois. En terme économique, l'utilisation de la drêche de dolo (aliment à faible coût) seule ou en combinaison avec le sorgho permet d'obtenir une marge brute positive. La supplémentation avec le sorgho donne un gain de poids appréciable (170.8 g en 28 jours de supplémentation) comparé aux autres gains (155.2 g à 184.8 g) mais, à cause de son coût, il réduit considérablement le gain économique. Le sorgho pourrait être un complément alimentaire intéressant pour les poulets villageois, au cas où il y a une possibilité de réduction de son coût. Quand les aliments de divagation sont disponibles, la drêche de dolo ou l'association drêche de dolo/sorgho donne les meilleurs gains de poids.

Dans un second essai, l'utilisation de l'aliment commercial dans l'alimentation des poulets villageois a été étudiée (Chapitre 4.2). L'essai était une étude factorielle avec 3 facteurs à 3 niveaux chacun. Le premier facteur était la période d'alimentation (début de saison pluvieuse, saison pluvieuse proprement dites et saison sèche). Le deuxième facteur était la disponibilité des aliments de divagation symbolisée par les ménages de 3 volontaires du village de Matté. Le troisième facteur était la stratégie d'alimentation (divagation sans supplément, divagation plus un supplément avec un aliment chair commercial et l'élevage en claustration avec l'offre de l'aliment chair commercial uniquement). Quatre vingt seize coquelets avec un poids moyen de 432.6 g ont été achetés dans le village pour l'essai. A la fin de l'essai, les performances à l'habillage, ont été enregistrées et une évaluation économique des stratégies d'alimentation a été faite. Les résultats de l'étude montrent que l'effet positif de l'utilisation de l'aliment commercial sur les gains de poids est nettement perceptible pendant les deux premières semaines de l'alimentation lorsque les oiseaux sont en claustration. Après les deux semaines, cette stratégie d'alimentation est moins favorable dans l'alimentation des poulets villageois. En effet, après 35 jours d'alimentation, le gain de poids obtenu avec cette stratégie d'alimentation en claustration est inférieur à celui de la supplémentation ou de la divagation sans supplémentation. Durant la saison pluvieuse, la stratégie de la suplémentation donne un meilleur gain de poids (97.3 g) que la divagation sans supplémentation (8 g) ou la claustration (32 g). Dans la saison sèche chaude, la divagation donne le meilleur gain de poids (237.5 g), alors qu'au début de la saison pluvieuse, aucune différence significative n'a été observée entre les stratégies d'alimentation.

En terme d'évaluation économique, il apparaît que la stratégie d'alimentation la plus économique est la divagation sans supplémentation (225 FCA) suivie de la stratégie de la supplémentation (95 FCFA de marge brute par poulet). La stratégie de l'élevage en claustration donne une marge brute très faible (25 FCFA par poulet) comparé aux autres stratégies. Les résultats de l'étude suggèrent que lorsque les aliments de divagation sont disponibles la meilleure stratégie d'alimentation des poulets villageois demeure la divagation. Cependant, quand cette disponibilité n'est pas garantie ou dans l'optique d'une amélioration de l'élevage des poulets villageois, la supplémentation apparaît être la meilleure option.

Dans le Chapitre 5, une première étude a porté sur un essai d'embouche à la station de recherche de Kouaré dans la Région Est du Burkina Faso (Chapitre 5.1). Elle avait pour objectif de mettre au point des rations valorisant les résidus de récolte dans l'embouche ovine. Pour cela, les effets de 5 rations ont été étudiés avec 25 ovins mâles Djallonké en 5 répétitions. Les rations testées étaient (1) une ration constituée par 7 heures de pâture par jour au pâturage naturel plus une supplémentation avec une ration à base de fourrage (RF); (2) la ration à base de fourrage (RF) composée de 49.07% de fanes de niébé, 40,59% de fanes d'arachide, et 10,34% de paille de sorgho; (3) une ration composée de 90% de RF plus 10% de concentrés; (4) une ration de 80% de RF plus 20% de concentrés et (5) une ration composée de 70% de RF plus 30% de concentrés. Les animaux ont subi une période d'adaptation de 14 jours. Ils ont été alimentés avec les rations alimentaires durant 56 jours au cours desquels l'ingestion et les gains de poids ont été mesurés. Les résultats indiquent que 20 à 30% de concentrés en plus de la ration à base de résidus de récolte augmentaient de manière notable les gains de poids. Par ailleurs, les résidus de récolte sont mieux utilisés quand les animaux les reçoivent en complément du pâturage que sous forme d'une ration exclusivement constituée de ces fourrages.

Le second essai reporté dans ce Chapitre a consisté à étudier les possibilités de transfert en milieu réel des rations d'embouche formulées dans les stations de recherche (Chapitre 5.2). Pour cela, deux approches de transfert ont été testées avec 6 rations d'embouche formulées dans les stations de recherches de l'INERA. Dans la première approche, chaque ration a été testée par un producteur volontaire dans 3 localités différentes avec l'implication des agents de développement. Les rations testées étaient (2) une ration composée de 22% de tourteaux de coton, 22% de graines de coton, 22% de son de blé, 5% de *Pennisetum pedicellatum*, 20,6% de paille de sorgho, 7% de fanes d'arachide et 1,4% de coquille d'huître; (5) une ration composée de 30% de son de blé, 7,24% de paille de sorgho, de 28,41% de fanes d'arachide, 34,35% de fanes de niébé; (6) une ration composée de 24% de tourteaux de coton, 34% de graines de coton, 8% de *Pennisetum pedicellatum*, 22,2% de paille de sorgho, 10% de fanes d'arachide, 0,8% de coquille d'huître et 1% de sel (NaCl).

Dans la seconde approche, plus d'un producteur dans un site de recherche ont reçu au hasard une des rations à tester. Les rations testées dans cette approche étaient (1) une ration composée de 30% de son de blé, 7,24% de paille de sorgho, 28,41% de fanes d'arachide et 34,35% de fane de niébé; (2) une ration composée de 39,26% de fanes de niébé, 32,47% de fanes d'arachide, 8,27% de paille de sorgho, 18% de son de blé et 2% de tourteaux de coton; (3) une ration composée de 23,6% de fanes d'arachide 35,82% de son de blé, 39,18% de tourteaux de coton et 14% de coquille d'huître.

Des gains de poids de 3 à 5.5 kg pendant une opération d'embouche de 56 à 98 jours et des marges brutes de 3570 à 5095 FCFA/bélier ont été obtenus. Les résultats montrent que les deux approches peuvent être utilisées pour le transfert des rations d'embouche en milieu réel. Cependant, il semble plus efficient d'utiliser consécutivement la première approche suivie de la seconde dans tout processus de transfert. Les tests ont été bien appréciés par les producteurs. Les deux approches pourraient aussi être utilisées pour le transfert d'autres technologies de recherches.

Les fanes de légumineuses par leur valeur nutritive élevée sont des aliments de choix en embouche ovine. Malheureusement leur disponibilité est faible du à leur faible production et aux difficultés de fanage. Aussi, pour améliorer la disponibilité de ce type de ressource fourragère chez les producteurs, il a été investigué dans la présente étude la possibilité d'associer une des plantes fourragères les plus connues des producteurs Burkinabé aux cultures céréalières. Les résultats de cette étude sont reportés dans le Chapitre 5.3. L'étude avait pour but d'aider à résoudre les contraintes de disponibilité de main d'œuvre et de temps qui limitent la pratique de la culture fourragère par les producteurs alors que celle-ci leur permettra de disposer de fourrage de très bonne qualité pour les animaux. L'essai a été conduit dans la station de recherche de Kouaré dans la Région Est du Burkina Faso. L'essai avait pour objectif d'identifier les distributions spatiales et les types de céréales appropriés pour l'association céréales/dolique. Le protocole expérimental était un criss-cross avec deux facteurs en 4 répétitions. Le premier facteur était l'arrangement spatial avec 4 traitements et le second facteur le type d'association avec 7 traitements. L'étude a montré que l'association céréale/dolique n'a pas des effets négatifs sur les rendements des céréales. Des rendements en fourrage allant de 0.2 à 1.5 t/ha ont été observés avec les meilleures associations céréale/dolique. Ces quantités de fourrage peuvent être utilisées dans une ration à 30% de concentrés pour engraisser 3 à 26 ovins d'embouche de 25 kg de poids initial pendant 90 jours. Le maïs et le sorgho se sont montrés les meilleurs pour l'association céréale/dolique. Les meilleurs arrangements spatiaux étaient le semis de la dolique dans le même poquet que la céréale ou le semis de la dolique entre deux poquets de la céréale et sur une même ligne de semis.

Dans les pays en développement, les producteurs ruraux ont des systèmes mixtes de production où plusieurs productions sont simultanément pratiquées. Une telle diversification de la production permet d'éviter les risques liés à une seule spéculation. Dans le domaine de l'élevage, une telle stratégie est observée par l'élevage de plusieurs espèces dans les exploitations. Aussi, se basant sur ce principe, une étude décrite dans le Chapitre 6 avait pour objectif de montrer que les poulets villageois et les moutons d'embouche étaient les principales issues pour l'amélioration de l'élevage et des revenus dans de tels systèmes de production. En plus, comment ces deux systèmes de production pouvaient être améliorés en étroite relation, a fait l'objet d'investigation. L'étude a été faite par une enquête informelle et deux enquêtes formelles dans le village de Matté situé dans la Région Centre du Burkina Faso. L'enquête informelle a été faite par la Méthode Accélérée de Recherche Participative (MARP). Pour chaque enquête formelle, un échantillon de 30 ménages a été utilisé. Les résultats montrent qu'en plus de l'élevage des poulets villageois, près de 80% élèvaient des ovins et/ou des caprins. Par ailleurs, il y a une tendance pour chaque ménage à élever plusieurs espèces animales. Ainsi, 48% des ménages élèvaient simultanément des poulets, des caprins et des ovins. Dans les ménages, les revenus sont générés par plusieurs opportunités. Cependant, la principale source de revenus dans les ménages était la vente des poulets villageois et des petits ruminants. En effet, 60% des ménages n'ont jamais vendu des céréales alors que les poulets et les petits ruminants sont fréquemment vendus pour différentes raisons. Les plus importantes raisons pour la vente des poulets villageois sont les effectifs élevés selon 47% des ménages et les besoins ponctuels d'argent selon 20% des ménages. Seulement 3% des ménages disent n'avoir jamais vendu des poulets villageois. Les principales raisons de la vente des petits ruminants sont aussi les effectifs élevés et les besoins ponctuels d'argent respectivement pour 53% et 37% des ménages. Cela confirme que les poulets villageois et les petits ruminants sont les principales sources de revenus pour les producteurs ruraux. Pour les petits ruminants, l'embouche ovine apparaît la plus intéressante pour l'amélioration des revenus monétaires des producteurs ruraux. En se basant sur la stratégie d'intégration des systèmes de productions de ces producteurs, il est clair qu'une intégration de l'élevage des poulets villageois et de l'embouche ovine, serait la meilleure manière d'améliorer significativement leurs productivités, particulièrement celle des poulets villageois.

Dans ce sens, près de 57% des ménages sont d'avis que les interrelations entre les ovins et les poulets villageois peuvent être utilisées pour améliorer la productivité des poulets villageois. Cette amélioration pourrait être faite par l'utilisation d'un parcours commun selon 27% des ménages ou par l'utilisation des revenus de la vente des moutons d'embouche selon 13% des ménages enquêtés. En outre, l'analyse des ressources alimentaires pour les ovins et les poulets villageois, indique que les interrelations entre ces ressources peuvent être également utilisées.

Sur la base des résultats des différentes études et essais (Chapitre 1 - Chapitre 6), il a été conçu un Système de Production Intégré (poulets villageois/ovins d'embouche) (SPI) qui a été testé avec un essai d'alimentation à la station de recherche de Saria dans la Région Centre du Burkina Faso. Le SPI était constitué d'un parcours clôturé par un grillage dans lequel, 2 moutons d'embouche étaient engraissés. Un poulailler amélioré abrite les poulets d'expérimentation. Une poubelle servait de lieu de dépôt des fèces et des refus d'aliments des animaux d'embouche. Les poulets pouvaient aussi faire la divagation dans l'atelier d'embouche. Les résultats de cet essai sont présentés dans le Chapitre 7. L'objectif de cette étude était de tester deux stratégies d'alimentation (traitements) des poulets villageois dans le système intégré. Le dispositif expérimental était un dispositif complètement randomisé avec deux traitements alloués au hasard à deux bandes de 9 ou 10 poulets chacune. La première stratégie d'alimentation (T1) était le Système de Production Intégré (SPI) + une supplémentation avec la drêche de dolo. La seconde stratégie d'alimentation (T2) était le SPI + une supplémentation avec un aliment chair commercialisé sur le marché. Les résultats montrent que quand l'aliment utilisé comme supplément a une valeur nutritive adéquate (cas de T2), un gain de poids journalier de 10.4 g/j pouvait être obtenu. Quand la valeur alimentaire du supplément est pauvre (cas de T2), des pertes de poids sont observées. Le système n'influence pas négativement les performances des moutons en embouche dans le système. Une évaluation économique indique qu'avec T2, une marge brute positive de 275 FCFA par poulet peut être obtenue. Quand on considère tout le système, une projection des résultats économiques indique que le SPI pourrait être utilisé pour la lutte contre la pauvreté en permettant à un producteur d'avoir au moins un bénéfice net de 79.030 FCFA (120.5 €). En effet, ce bénéfice net est supérieur au seuil de pauvreté qui est de 72.600 FCFA (110.7 €) au Burkina Faso. Ainsi, le SPI peut être utilisé comme un moyen de lutte contre la pauvreté au Burkina Faso et d'une manière générale dans les pays en développement.

Enfin, les principaux résultats de la présente étude ont fait l'objet d'une 'Discussion Générale'. De cette discussion, des conclusions et des recommandations ont été formulées dont il ressort les points essentiels suivants:

- Les moutons d'embouche et les poulets villageois sont les plus importants points d'entrée pour la lutte contre la pauvreté des populations rurales au Burkina Faso et dans les pays Sahéliens en général.
- La supplémentation après la divagation est la meilleure stratégie d'alimentation des poulets villageois.
- Une ration incorporant 34,4% de fanes de niébé, 28,4% de fane d'arachide, 7,2% de paille de sorgho et 30% de concentrés est prometteuse pour la valorisation des résidus de récolte au niveau des producteurs.
- Pour le transfert en milieu rural des technologies mises au point dans les stations de recherches, il est nécessaire dans un premier temps de les tester avec un nombre limité de

producteurs avec l'implication des services de développement, puis dans un second temps à l'échelle de la communauté villageoise.

- Le système de production des poulets villageois peut être amélioré par un Système de Production Intégré (poulets villageois/mouton d'embouche) (SPI).
- Le SPI peut être utilisé dans la lutte contre la pauvreté dans les pays en développement en général et au Burkina Faso en particulier.
- Le SPI pourrait être utilisé dans toute activité d'amélioration (génétique, alimentation, santé, etc.) de l'élevage des poulets villageois.
- Enfin, le SPI devrait être testé en milieu réel afin de l'adapter éventuellement avec le contexte socio-économique des producteurs ruraux.

Samenvatting

Veeteelt speelt een strategische rol in ontwikkelingslanden in het algemeen en in de traditionele levenswijze van de Sahel in het bijzonder. De diverse diersoorten dragen op verschillende wijze bij aan voedselzekerheid, duurzaamheid en het genereren van inkomen. Het vee draagt bij aan de bodemverbetering via de mest. Voor sommige etnische groepen zijn runderen een status symbool en een teken van rijkdom en staat het sociale leven in het teken van de koe. Kleine herkauwers en pluimvee worden veelal gebruikt als geschenk aan familie, als offerande, en bij huwelijken en religieuze ceremonies. Runderen produceren melk en leveren trekkracht voor transport en akkerbouw. Kleine herkauwers worden regelmatige geslacht en leveren dierlijke eiwitten voor de plattelandsbevolking; schapen lijken beter geschikt voor het genereren van inkomen mede gezien hun waarde in religieuze ceremonies. Het houden van pluimvee door boerenfamilies is een strategisch middel in de strijd voor inkomen en voedselzekerheid; de kippen spelen ook een belangrijke sociaal-culturele en economische rol in ontwikkelingslanden. Pluimvee levert een gemakkelijke en regelmatige bron van inkomsten voor de kleine boer en kan door elke boer worden gehouden. In het ontwikkelingsbeleid wordt de dorpskippenhouderij vaak niet vermeld, hetgeen de voortdurende lage productiviteit deels zou kunnen verklaren. Desalniettemin kan pluimvee gebruikt worden in de strijd tegen de armoede, juist omdat elke boer een aantal dieren kan houden. Samenvattend is het houden van schapen en kippen relevant voor het genereren van inkomen in de Sahel en daarom lijkt het belangrijk aandacht aan deze twee vormen van kleinschalige veehouderij te besteden.

Deze studie onderzoekt de mogelijkheden om de productiviteit van de kippen- en schapenhouderij in Burkina Faso, West Afrika, d.m.v. een aangepaste voeding, te verbeteren. De specifieke onderzoeksvragen waren:

- Het beschrijven van de productie systemen van kippen en kleine herkauwers op dorpsniveau;
- Het identificeren van verschillende voederregimes van dorpskippen en mestschapen en het onderzoeken van de specifieke voor- en nadelen van deze regimes;
- Het identificeren van de wederzijdse bijdrage van de twee systemen;
- Het onderzoeken van de mogelijkheid om te komen tot een geïntegreerd dorpskippen-mestschapen productiesysteem.

Literatuuronderzoek geeft aan dat wereldwijd drie typen dorpskippenhouderij worden onderscheiden (Sectie 1.1):

(1) In het extensieve vrije uitloop systeem scharrelen de kippen het grootse deel van hun voeding zelf bijeen.
(2) In het semi-extensieve erfdierhouderij systeem worden de dieren deels binnen omheiningen gehouden,'s nacht opgehokt en regelmatig bijgevoerd.
(3) De semi-intensieve systemen, erg frequent in Azië, onderscheiden zich door het gebruik van industrieel samengestelde diervoeders en commerciële kippenlijnen.

Het meest toegepast bij dorpskippen in West Afrika is het vrije uitloop systeem. Het kenmerkt zich door een lage productie van eieren en vlees, en een hoog risico op sterfte o.a. ten gevolge van Newcastle epidemieën en op verliezen ten gevolge van o.a. roofdieren.

M.b.v. participatieve onderzoeksmethoden en het 2-wekelijks verzamelen van productiegegevens gedurende vier maanden werd de dorpskippenhouderij in de Centrale Regio van Burkina Faso bestudeerd (Sectie 1.2). De studie was eveneens bedoeld om de

kippenhouderij op de gemengde bedrijven van de Mossi en de veehouderijbedrijven van de Fulani te vergelijken. Beide bevolkingsgroepen houden de kippen in een enigszins vergelijkbaar vrij uitloop systeem. Het gemiddelde aantal kippen per boer was 33,5 waarvan 57% kuikens. Gedurende de twee regenrijke maanden was de gemiddelde sterfte laag (9%), maar van de kuikens stierf dan nog altijd zo'n 32%. Sterfte was de belangrijkste verliespost en betrof 84% van alle dieren die het systeem verlieten. De broedresultaten waren significant beter (70 vs. 46%) en de sterfte significant lager (24 vs. 52%) binnen het gemengde bedrijf t.o.v. het veehouderij bedrijf pur sang.

Het overzicht van reeds ondernomen onderzoek en ontwikkeling m.b.t. de dorpskippenhouderij in Burkina Faso laat een verscheidenheid aan activiteiten zien (Sectie 1.3). Naast proeven met huisvesting en drinkplaatsen werden volledige voederrantsoenen en verbeterde rassen geïntroduceerd en een vaccinatieprogramma tegen Newcastle Disease (NCD) opgezet. De vaccinatie van de dorpskippen tegen NCD gaf een productieverhoging van 110%. De voorgestelde rantsoenen en de ingezette Rhode Island Red hanen werden slechts beperkt overgenomen door de lokale kleine boeren en de dorpskippenhouderij bleef veelal beperkt tot de laag productieve vrije uitloop. Concluderend werd besloten onderzoek te doen naar meer geïntegreerde systemen waarvan de technologieën rekening houden met de lokale beschikbaarheid van voeders.

Het meest voorkomende productiesysteem van de kleine herkauwers is gebaseerd op weidegang (Hoofdstuk 2). De kleine kuddes kenmerken zich door laatrijpe dieren, lange tussenlam-intervallen, een hoge sterfte en een lage groei. De belangrijkste oorzaken van deze lage productie zijn ziekte, slechte huisvesting, matig management en onvoldoende voeding van te lage kwaliteit. In Burkina Faso zijn twee rassen, de Fulani en Djallonké schapen en geiten, regelmatig bestudeerd en er zijn vooral proeven gedaan naar het verbeteren van het afmesten van de schapen ten behoeve van een inkomensverhoging.

D.m.v. literatuur en marktonderzoek werd de beschikbaarheid van krachtvoer in kaart gebracht (Sectie 3.1). De beschikbaarheid van voer voor dorpskippen werd in het dorp Maté en de stad Ouagadougou bestudeerd m.b.v. informanten. In 1998 werden acht producenten van agro-industriële bijprodukten bezocht. Zij produceren suikerrietstengels, katoenzaad koek en meel, tarwe- en rijst-voermeel, en melasse. Daarvan is slechts en deel beschikbaar voor het vee, omdat de suikerrietstengels worden verbrand en vooral veel katoenzaad koek wordt geëxporteerd. Door de beperking van de export en onderzoek naar andere lokale voederbronnen kan de beschikbaarheid worden vergroot.

De beschikbaarheid van potentieel belangrijke oogstresiduen voor schapen is in kaart gebracht voor een dorp in de Oostelijke Regio van Burkina Faso (Sectie 3.2.1). Bij 10% van de boeren werd op veldjes van 25 m^2 de opbrengst gemeten en nadien geëxtrapoleerd naar het gehele veld en de boerderij. De hoeveelheid opgeslagen oogstresiduen werd bepaald en de boeren werden geïnterviewd m.b.v. een vragenformulier. Een literatuurstudie gaf informatie over eventueel andere lokaal beschikbare voeders. De best beschikbare oogstresiduen waren achtereenvolgens: stro van millet en sorghum, en hooi van bonen en pinda's. Rijstestro en hooi van zoetaardappelen en vouandzou komen weinig voor. Slechts 3,7% van alle oogstresiduen werd opgeslagen. Het verschil tussen het geproduceerde en het opgeslagen deel van de oogstresiduen laat zien dat acties ter verbetering van het gebruik nodig zijn. Verder kunnen als krachtvoer voor de schapen worden gebruikt: voermeel van millet en sorghum, borstel van traditioneel gebrouwen bier, en peulen of poeder van bomen als *Parkia biglobosa, Piliostigma reticulatum* en *Acacia Albida*.

Om de beschikbaarheid van voer voor de dorpskippen te kwantificeren werd bij 30 boeren de dagelijkse praktijk van de kippenhouderij geïnventariseerd en werd de kropinhoud van enkele kippen geanalyseerd (Sectie 3.2.2). Na slachten beoordeelden we de inhoud van het krop van hanen, hennen, jonge hanen en jonge hennen in het regen- en het droge seizoen. De belangrijkste bijvoeders zijn sorghum en millet graankorrels, respectievelijk voor 57% en 33% van de huishoudens; 30% van de huishoudens voerde termieten aan de kippen. De zongedroogde kropinhoud woog tussen de 10 en 15 gram en was niet significant verschillend voor de categorieën pluimvee en de seizoenen. De verse kropinhoud was in het regenseizoen veel groter dan in het droge seizoen: respectievelijk 32 tot 54 en 18 tot 27 gram. De kropinhoud bestond voor 73% en 53% uit granen, respectievelijk in het regen- en het droge seizoen. Insecten en wormen waren alleen belangrijk aan het einde van de regentijd (22% van de kropinhoud), maar voor de rest van het jaar waren de hoeveelheden verwaarloosbaar klein. De hanen hadden een gemiddeld lichaamsgewicht van 1223 g, de hennen 980 g, de jonge hanen 771 g en de jonge hennen 649 g. Tussen seizoenen was er een opmerkelijk verschil in gewicht: in het droge seizoen waren de dieren significant lichter.

Een andere proef (Sectie 4.1) betrof het effect van het bijvoeren van lokale producten in september en oktober (einde van de regentijd) op de groei en de sterfte onder hanen (Hoofdstuk 4). In een 4 × 4 factoriele proef vergeleken we (1) scharrelen, (2) scharrelen en bijvoeren met zaad van rode sorghum, (3) scharrelen en bijvoeren met bierborstel, en (4) scharrelen en bijvoeren van beide producten. De proef werd uitgevoerd in 4 huishoudens (herhalingen). Met scharrelen alleen groeiden de dieren 6 g/d en dat verschilde niet wezenlijk van de bijvoederrantsoenen. Nadere studie is hier vereist.

In een 3 × 3 proef (Sectie 4.2) met 96 kippen van gemiddeld 433 g met de factoren: seizoen, veehouderijstrategiëen (huishouden) en type bijvoedering werd het belang van het commerciële voer gewogen. Aan het einde van de proef werden uitslachtingspercentages bepaald en de economische efficiëntie berekend. Het commerciële voer had alleen in de eerste twee weken een meetbaar gunstig effect bij de dieren zonder vrije uitloop, maar na vijf weken gaven een vrije uitloop (scharrelen) met of zonder bijvoeding een beter resultaat. Tijdens het regenseizoen bleek de groei van dieren die slechts konden scharrelen 8 g te zijn, scharrelen inclusief bijvoedering 97 g, en gevoerd op een commercieel voer 32 g. In het droge seizoen gaf scharrelen de hoogste groei (238 g) maar aan het begin van het regenseizoen verschilden de drie behandelingen niet significant van elkaar. Het bruto economische rendement was het hoogst voor scharrelen alleen (225 FCA) ten opzichte van bijvoederen (95 FCA) en het ophokken met alleen commercieel voer (25 FCA). Alhoewel scharrelen de economisch beste optie is, lijkt uit het oogpunt van de introductie van andere verbeteringen het scharrelen met bijvoeren te prefereren, mede in het licht van het slechte groeiresultaat met scharrelen alleen in het regenseizoen.

Vijf rantsoenen voor het afmesten van schapen zijn op het onderzoekstation Kouaré in de Oostelijke Regio van Burkina Faso getest met 25 schapen in 5 herhalingen (Sectie 5.1). De behandelingen waren: (1) 7 uur weidegang met een complement van ruwvoer samengesteld als in behandeling 2; (2) 100% ruwvoer, samengesteld uit 49% bonenhooi, 41% pindahooi en 10% sorghumstro; (3) 90 % ruwvoer als in (2) met 10% krachtvoer; (4) 80% ruwvoer als in (2) en 20% krachtvoer; (5) 70% ruwvoer als in (2) met 30% krachtvoer. Na een adaptatieperiode van 14 dagen werden opname en groei gedurende 56 dagen gemeten. Rantsoenen 4 en 5 gaven significant betere groeicijfers te zien. Het bijvoeren met krachtvoer verbetert het gebruik van het rantsoen meer dan indien slechts ruwvoer werd gevoerd (naast weidegang). Vervolgens zijn zes van dergelijke rantsoenen in drie regio's van Burkina Faso door boeren getest (Sectie 5.2). In eerste instantie testten drie boeren in drie regio's, drie in eiwit en energie gelijkwaardige rantsoenen: (1) 22% katoenzaad koek (KZK), 22% katoenzaad (KZ), 22% tarwevoermeel (TVM), 5% hooi van *Pennisetum pedicellatum*,(PP), 7% pindahooi (PH), en 1,4 % schelpen (S); (2) 30% TVM, 33% hooi van *Panicum laetum*, en 38% hooi van *Dolichos lablab*; en (3) 24% KZK, 34% KZ, 8% PP, 22% SS, 10% PH, 0,8% S en 1% NaCl. In tweede instantie kregen meerdere boeren per regio willekeurig één van de volgende rantsoenen toegewezen. (1) 30% TVM, 7% sorghum stro (SS), 28 % PH, en 34% bonenhooi (BH); (2) 39% BH, 32% PH, 8% SS, 18% TVM en 2% KZK; (3) 24% BH, 36% TVM, 39% KZK en 14% S. De schapen groeiden 3 tot 5.5 kg in 56 tot 98 dagen en het bruto rendement varieerde van 3570 FCA tot 5095 FCA per dier. De boeren waardeerden de resultaten positief en het gebruik van beide methoden lijkt interessant voor de voorlichting aan boeren over betere afmestrantsoenen.

Het hooi van vlinderbloemigen als pinda, bonen en *Dolichos lablab* geeft de beste economische resultaten bij het afmesten, maar de beschikbaarheid van deze ruwvoeders is beperkt op bedrijfsniveau (Hoofdstuk 6). Om dit laatste te verbeteren is op het station van Kouaré een proef in 4 herhalingen uitgevoerd met 2 factoren: 4 zaai-afstanden en 7 behandelingen van 3 graansoorten, elk in combinatie met *Dolichos lablab*. Dolichos werd ongeveer twee weken later ingezaaid dan het graan en de combinatie had geen negatief effect op de opbrengst van één der granen. De opbrengst van dolichos varieerde van 0,2 tot 1,5 t/ha. De combinatie met sorghum of maïs waren beter dan die met millet. Voor wat betreft de zaai-afstand, bleek het zaaien van dolichos in hetzelfde zaaigat of tussen twee zaaigaten van graan in dezelfde lijn optimaal.

Kleine boeren in ontwikkelingslanden hebben meestal gemengde bedrijfssystemen met verscheidene gewassen om de risico's te spreiden. Ook op bedrijven met een veeteeltcomponent worden veelal om dezelfde reden meerdere diersoorten gehouden. Om een analyse te maken van de mogelijkheden tot het verbeteren van het gezamenlijk houden van dorpskippen en mestschapen hebben wij een open en twee gesloten enquêtes gehouden in het dorp Matté. De gesloten vragenlijsten bij 30 boeren bevestigden de gewoonte om meerdere diersoorten op één bedrijf te houden. Naast pluimvee hield 80% van deze boeren schapen of geiten en 48% hield beide kleine herkauwers naast de kippen. Het houden van deze dieren was de belangrijkste bron van inkomsten: 60% van de huishoudens had nooit graan verkocht, terwijl slecht 3% nooit kippen had verkocht. De belangrijkste redenen om dieren te verkopen zijn de te grote aantallen (47% en 53%) en de behoefte aan contant geld (20% en 37%) voor respectievelijk kippen en schapen. Het afmesten van schapen lijkt de meest lucratieve bron van inkomsten te zijn. Van de boeren is 57% van mening dat de relatie tussen schapen en kippen beter kan worden uitgebuit, bijvoorbeeld d.m.v. het gezamenlijk gebruiken van de uitloop (27%) of de investering van de opbrengst van de verkoop van de schapen voor een verbetering van de kippenhouderij (13%). Een participatieve analyse liet zien dat er relaties zijn op het gebied van de voeding die gebruikt kunnen worden.

Op basis van voorgaande resultaten hebben we een geïntegreerd productiesysteem dorpskip-mestschaap in 2 herhalingen getest op het onderzoeksstation Saria in de Centrale Regio van Burkina Faso (Hoofdstuk 7). Binnen een omheining van kippengaas stonden zowel een kippenhok, een afdak met 2 mestschapen alsook een composthoop voor mest en voerresten. De kippen hadden overdag vrij toegang tot afdak en composthoop. Binnen elke herhaling werden groepen van 9 of 10 kippen in de ochtend bijgevoerd met lokaal bierborstel of met commercieel krachtvoer. De bierborstel leidde tot gewichtsverliezen en sterfte bij de kippen terwijl de groei in de krachtvoergroep ruim 10 g/dag was en het bruto rendement 275 FCA per kip. Een dergelijk systeem, indien vrijwel continue uitgevoerd met 40 kippen, kan een netto resultaat van 79.030 FCA (120,5 €) behalen, hetgeen hoger is dan de armoede grens (110,7 €).

Na de algemene discussie zijn de volgende conclusies en aanbevelingen geformuleerd:

- Mestschapen en dorpskippen zijn belangrijk in de strijd tegen de armoede onder de plattelandsbevolking van Burkina Faso in het bijzonder en van de Sahel in het algemeen.
- Het bijvoeren met lokale gewassen of commerciële voeders is een goede voerstrategie voor vrij loslopende (scharrelende) dorpskippen.
- Een rantsoen met 34% bonenhooi, 28 % pindahooi, 7% sorghum stro, en 30% krachtvoer is veelbelovend voor het afmesten van schapen.
- De productie van dorpskippen kan worden verbeterd d.m.v. een integratie met mestschapen.
- De verbeterde integratie van dorpskippen met mestschapen
    - kan een hulpmiddel zijn bij de armoedebestrijding in ontwikkelingslanden en speciaal in Burkina Faso.
    - kan als uitgangspunt dienen voor velerlei veehouderijverbeteringen (genetisch, voeding, gezondheid).
    - dient op dorpsniveau te worden getest om het eventueel te kunnen aanpassen aan de sociaal-economische context van de kleine boerenbedrijven.

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Salam Richard KONDOMBO

Curriculum vitae

Kondombo Salam Richard was born on 22 September 1965 in Nanoro, Burkina Faso. He finished high school in 1986 at the 'Lycée Yadéga' in Ouahigouya where he obtained his Bachelor degree in Mathematique and Natural Sciences. After 2 years at the 'Institut des Sciences Naturelles' (ISN) of the University of Ouagadougou/Burkina Faso, he continued his study at the 'Institut du Développement Rural (IDR)' of the same university. In this university, he obtained the Master degree in Rural Development Techniques in 1990 and the Engineer degree of Rural Development in 1991, both in the specialisation of animal production. During his training at IDR, he conducted several farm surveys on animal production and conducted on-station research on sheep fattening.

After his graduation of Engineer, he did his National Service from July 1991 to June 1992 in which, he taught Mathematics and Natural Sciences in the secondary school of the town of Manga in Burkina Faso. From July 1992 to January 1993, he conducted for the NGO 'Fondation pour le Développement Communautaire/Save the Children' a study in order to formulate a project on the livestock sector for the villages involved in the activities of this NGO. In February 1993, he was employed in the Animal Production Research Programme of the 'Institut de l'Environnement et de Recherches Agricoles' (INERA) of Burkina Faso. Since then, he works in this Institute as zootechnician in the field of animal nutrition, and production. In 1998, INERA awarded him a fellowship to become an MSc student at Wageningen University. He obtained his MSc degree in Animal Science in the field of two groups (Animal Nutrition and Animal Production Systems) in January 2000. After his graduation, he enrolled in a Sandwich PhD Programme at the same university in February 2000 and got back to Burkina Faso for the field work. The current thesis reports onstudies carried out for his PhD study, in his research institute as part of the INERA research programme.

With one of the studies in the current thesis, Salam Richard Kondombo was laureate of the 'Forum National de la Recherche et des Innovations Technologiques' (FRESIT) of Burkina Faso held in Ouagadougou in May 2002 with the:

- Award of the Animal Production Minister of Burkina Faso.
- Award of the 'Director General' of the International Center for Research and Development in Sudanian Zone (CIRDES).

Salam Richard is married and has one son and two daughters.

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