EFFECTS OF SUPPLEMENTATION WITH LEAVES OF PAPER MULBERRY (*BROUSSONETIA PAPYRIFERA*) ON GROWTH PERFORMANCE AND BLOOD INDICES OF WEST AFRICAN DWARF SHEEP (DJALLONKÉ) FED NAPIER GRASS BASAL DIET

By

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DECLARATION

I do hereby declare that the work presented in this thesis is the result of my own effort and that in no previous application for a degree in this University or elsewhere has such work been presented. All sources of information have been specifically acknowledged by reference to authors.

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DEDICATION

I dedicate this work to by beloved mother – Madam Salamatu Musah, whose unending prayers and support I acknowledge with heartfelt humbleness.

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ABSTRACT

An experiment was conducted to determine the effects of supplementing Paper mulberry (*Broussonetia papyrifera*) leaves on the growth performance and blood profile of West African Dwarf (Djallonké) sheep fed Napier grass (*Pennisetum purpureum*) basal diet. Two varieties of Napier grass, the local variety and an improved variety (16798) were cultivated and used in the study. Mature leaves of Paper mulberry (a tree in the moraceae family), were used as supplement to the Napier grass basal diet. Exploration of ways of managing the recent invasiveness of Paper mulberry in the country has necessitated the assessment of its potential for feeding ruminants.

Twenty four (24) Djallonké rams weighing averagely 14kg were randomly allocated in a 2x3 factorial arrangement to six (6) treatments in a Completely Randomised Design (CRD). There were four (4) replicates. The factors were variety of Napier grass (local and improved) and level of supplementation (0g, 100g and 200g/d). This resulted in a total of six treatments: Loc0 (Local with 0g/d of supplement), Loc100 (Local with 100g/d of supplement), Loc200 (Local with 200g/d of supplement), Imp0 (Improved with 0g/d of supplement), Imp100 (Improved with 100g/d of supplement) and Imp200 (Improved with 200g/d of supplement). The grass harvested each morning and chopped into short lengths was fed to the animals and feed refusals weighed back the following morning to determine intake. The supplement was fed to each animal at 8.00 a.m prior to the grass basal diet at 9.00 a.m each morning. An adaptation period of seven (7) days was followed by twelve (12) weeks of data collection for each animal. Parameters measured included, average daily intake of

both basal diet and supplement, live weight change, haematological and blood biochemical indices.

Each of the Napier grass varieties was analysed for dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), hemicellulose and cellulose. Paper mulberry was also analysed for dry matter (DM), crude protein (CP), ash, ether extract (EE), neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemicellulose. The chemical composition of the grasses showed that the CP levels ranged from 92.98g/kgDM in the improved (variety 16798) to 96.50g/kgDM in the local variety. NDF concentrations did not show wide differences and ranged from 724.90gkgDM in variety 16798 to 729.85g/kgDM in the local variety. There were wide differences, however in ADF concentrations, from 472.66 – 531.97g/kgDM for variety 16798 and the local variety respectively. Hemicellulose and cellulose concentrations among the two varieties were also variable. The chemical composition of the supplement used (Paper mulberry leaves) compared favourably with those of other leaf supplements. The chemical compositions were: DM was 905.0g/kg, CP was 205.0gkg/DM, ash was 132.0g/kgDM, EE was 100.0g/kgDM, ADF was 340.0g/kgDM, NDF was 430.0g/kgDM and hemicelluloses 90.0g/kgDM.

Supplementation of the Napier grass basal diet with Paper mulberry leaves resulted in an increase in total intake which improved linearly as level of supplement increased from 0g/d to 200g/d in both varieties of grass consumed. Intake of supplement offered was highly significant ($P<0.001$) when expressed on the bases of both gDM/d and on metabolic body size which was indicative of a high degree of acceptability of the supplement. Final live weight gain also improved significantly ($P<0.05$) with supplementation. However, ADG observed was not significantly influenced by treatment. All ADG values obtained (50g/d, 60g/d and 70g/d for 0, 100 and 200g/d of supplementation) were however comparable to live weight gains reported earlier for sheep fed Napier grass basal diet with and without supplementation. Effects of the treatments on haematological and biochemical parameters were varied: while some were within the normal physiological ranges reported for healthy sheep, others were outside these reference values or ranges.

Records were kept on all activities undertaken during the establishment of the pasture to estimate the cost of establishing pasture and harvesting it for feeding for a given period of time. The total cost of establishing Napier grass pasture on a 1.7 acre land and harvesting daily for feeding for twelve (12) weeks stood at five hundred and sixty-five Ghana cedis (Gh¢565.0) excluding the cost of land. Based on the study, the cost of pasture per live weight gain of rams (Gh¢0.23) in kilogrammes compared to the current price of a kilogramme of mutton at the Kumasi Abbattoir (Gh¢4.0) showed that it makes economic sense to venture into pasture establishment for feeding sheep.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

Paper mulberry (*Broussonetia papyrifera*) used in the manufacture of paper was introduced into Ghana in 1969 upon the recommendation of the Forest Research Institute of Ghana, as part of the programme to identify tree species for the local production of industrial fibre. The reason for its deliberate introduction, according to Bosu and Apetorgbor (2006), was to evaluate its potential for pulp and paper production. It is known locally as 'York', the name of the Technical Officer who worked on the plots during the experimental trials of the 1970s. The plant was first introduced with fourteen seedlings which were planted at each of three research centres in three different ecological zones. These centres were Afram headwaters forest reserve in the dry semi-deciduous forest zone, Pra-Anum forest zone in the moist semi-deciduous forest zone and Asenanyo forest reserve in the moist semi-deciduous zone.

The plant has now become invasive at an alarming proportion. It is perhaps the most serious non-indigenous woody invasive plant in the closed forest zone of Ghana (Bosu and Apetorgbor, 2006). Indeed, the plant which is native to Eastern Asia has become an invasive invader on several continents and in over dozen countries. Recent studies have shown that it is one of the top alien invasives in the Pampa grasslands in Argentina (Ghersa *et al.*, 2002). The World Conservation Union also lists Paper mulberry as one of the six worst plant invaders in Pakistan (Morgan and Overholtz, 2004).

In Ghana, Paper mulberry is concentrated in the two forest reserves, namely Pra-Anum and Afram Headwaters Forest Reserves. According to the Centre for Scientific and Industrial Research, CSIR, (2006), the plant currently covers an area conservatively estimated at 80 kilometres square, and stretches from Pra-Anum Forest Reserve at Amentia in the Eastern Region, through Kumasi in the Ashanti and Sunyani in the Brong Ahafo Regions. The plant has not always been invasive in the Pacific Islands as only male clones were introduced. As a consequence, no seeds are produced and propagation is by vegetative means, using root shoot suckers.

In Ghana and other places where both fertile male and female plants were introduced, the invasive potential of the plant increases significantly. In recent times, Paper mulberry has become a nuisance in forests and farm lands in several countries especially the West African sub-region. Where the plant has established, germplasm of food crops are smothered to the disadvantage of agricultural development. The infestation by Paper mulberry is expanding at an alarming proportion beyond the forest reserve due to a number of reasons: birds, fruit bats and other vertebrates disperse its seeds over long distances, the plant has the ability to get established in open areas and to regenerate after fire and then the fact that there are no systematic efforts to manage the species.

In 2006, control of Paper mulberry was considered on a project to carry out on-farm research activities in community forest plantations as it was considered a major limiting factor to tree regeneration. The Forestry Research Institute of Ghana (FORIG) was tasked by the Forestry Commission of Ghana to evaluate management strategies for Paper mulberry. Among the objectives set for the investigations was the evaluation of various control methods. It was found that manual removal of shrubs (uprooting) and cut-and-squirt with Triploclor were effective at controlling shrubs while girdle and squirt with Triploclor was also effective at killing pole-size trees (Bosu and Apetorgbor, 2006). The CSIR, according to Bosu and Apetorgbor (2006), has warned of a serious threat to land areas, particularly in the River Afram Headwaters Forest Reserve, as a result of the invasion of this foreign plant which is fast taking over the forest reserve. The plant has been identified to be counter-productive to the activities of farming communities, where these are found.

One way of managing this plant invasion is to assess the suitability and viability of the leaves as a supplement for sheep and all other ruminants. The primary concern facing livestock production in Sub-Saharan Africa is related to shortages in quality and quantity of feed resources during the dry season (Jutzi, 1993; Larbi *et al.*, 1993). Lack of adequate year-round nutrition is probably the most important contributory factor to the low livestock productivity in Ghana. Farmers still generally use as supplement high levels of concentrates including cereal grains and oil seed meals. It is thus important to find alternative supplements (Preston, 1995) and in this regard the role of leaf supplementation in ruminant nutrition cannot be underestimated. Marjuki *et al*. (2008), for instance, found that feeding increasing amounts of cassava leaf silage as a feed supplement for sheep significantly increased digestible crude protein (CP) intake and nitrogen retention and this was associated with an increase in average daily weight gain.

Norton *et al.* (1992) have observed that leguminous tree leaves have traditionally been fed as supplements to housed and tethered animals in Asia, Africa and the Pacific islands. Species such as *Leucaena leucocephala* (leucaena) have also been grown with grasses in fodder banks to provide a source of high quality forage for ruminants raised in cut-and-carry systems. Leguminous tree leaves maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity. Legume tree foliage is therefore useful as a protein supplement. There is increasing interest, according to Norton *et al.* (1992), in the use of the foliage of these trees as sources of high quality feed for grazing ruminants and as supplements to improve the productivity of ruminants given low quality feeds.

The main vegetation formations in Ghana as described by Benneh *et al*. (1990) are the Coastal Strand and Mangrove, the Coastal Savannah, the Closed Forest, the Derived Savannah and the Interior Savannah. The growth pattern of the forages follows the rainfall pattern within the different agro-ecological zones. In the Coastal Savannah area, there is a growing season of seven months and a "non-growing" period of five months while in the Northern Savannah area, the growing season lasts for five months and the "non-growing" period for seven months. The nutritive value of the natural pasture herbage varies over the year according to the season. Protein content is high (8-12 percent DM) at the beginning of the rains but may drop to as low as 2 to 4 percent DM in the dry season. Phosphorus levels also vary ranging between 0.16 and 0.06 percent DM (Agrovets Consultancy, 1989).

Ruminant livestock production in most Sub Saharan Africa depends on forages as the major feed resource (Jones and Wilson, 1987) with that in Ghana depending mainly on unimproved native pastures and crop residues (Siaw *et al.*, 1993; Amaning-Kwarteng, 1991), which when left alone cannot sustain the ruminant livestock population.

In the tropics natural pastures in the rangelands provide more than 90% of livestock feed throughout the year. However, these grasses do not provide the requisite amount of protein to enable grazing ruminants such as cattle, sheep and goats to put on good gain and finish, and they are insufficient to cover the needs of animals especially as the composition and nutritive value of pastures vary greatly with the stage of growth or maturity at harvest (Speedy and Pugliese, 1982). According to McDonald *et al.* (1981), generally there is decline in quality of pasture and increase in quantity with increase in harvesting date. Lignin and cellulose content increase with increasing maturity making pasture more fibrous and thereby reducing the digestibility. Ranjhan (1999) has also reported that crude protein and moisture content decline with increase in maturity thereby affecting pasture quality at various stages of the year, more so during and at the end of the dry season. In such instances, the need for supplementation to enhance digestibility and improve the nutritive value of fibrous feed cannot be over-emphasised.

Most of Ghana's natural pastures are under-utilized, and the grasses are characterized by very rapid growth, with feeding value high only in the early part of the wet season, declining rapidly thereafter and becoming extremely low in the dry season. Even where the supply of dry matter is adequate in the dry season, it is seriously deficient in protein, vitamins and minerals (Oppong-Anane, 2006). The resultant inadequacy of feed, in terms of quantity and quality, negatively affects the productive and reproductive performance of grazing livestock. The major constraint to expanding smallholder pasture development according to Oppong-Anane (2006) has been encroachment by alien herds and wildlife as the pastures are not fenced. Recent increasing demand for forage seeds among both existing and emerging commercial farmers and for rehabilitation of lands that have been subjected to surface mining have been very encouraging (Oppong-Anane, 2006). However, information regarding the cost of pasture establishment as well as the variables to consider thereof over the past decade in Ghana has not been properly documented if at all available.

Small ruminants, especially sheep, can be fed without recourse to concentrates and do not compete for grains and concentrate protein foods with human beings as simple stomached animals, like swine and poultry (Johnston, 1983). Paper mulberry leaves could be considered an appropriate supplement because of the high nitrogen content for sheep fed a basal diet of Napier grass, replacing partially or totally the oil seed meals which could be used in monogastric diets. This could be an affordable source especially to the resource-constrained farmer in the tropics.

The objectives of the research were to determine;

(a) the chemical composition (DM, Ash, NDF, ADF and CP) of the leaves of paper mulberry

(b) the growth performance of sheep supplemented with Paper mulberry leaves

(c) the blood parameters of sheep supplemented with Paper mulberry leaves and

(d) the cost of establishing a Napier grass pasture.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Paper Mulberry

Paper mulberry (*Broussonetia papyrifera*) is a tree in the family Moraceae and is native to Eastern Asia. Other names of the tree include: Halibun, Kalivon, Kozo and Tapacloth tree. Paper mulberry is a fast-growing, deciduous tree that grows up to 15.2 m in height and is a very adaptable tree that is found growing in tropical climates. Its range also extends well into the temperate zone. The tree has a wide ecological tolerance and can be grown in humid tropical, sub-humid tropical and temperate climates. It can regenerate rapidly, as it readily forms new stems from the rootstocks after the stems have been harvested. Thus, the tree coppices well, and in fact, it is the main means of production of new stem shoots from the root system (Whistler and Elevitch, 2006).

According to Morgan and Overholtz (2004), Paper mulberry is an exotic invasive plant which can quickly colonize distributed areas. Its tremendous range shows its ability to thrive in various climates throughout the world. The plant spreads by means of its 1.5cm-2.0cm fruits which are spread significant distances by local wildlife. Once established, Paper mulberry then spreads from its root system, forming dense thickets which are often thirty feet across.

2.1.1 Characteristics and Identification of the Plant

Paper mulberry is a large shrub or small tree with a mounded appearance. The older, taller stems are towards the middle of the plant. Its leaf scars are in alternate pattern although on occasion they are opposite as well. The tree is dioecious and therefore male and female plants must be grown if seed is required. Male trees produce long clusters of flowers in mid-April and female trees produce bizarre ball-shaped flower clusters as shown below in Plate 2.1 and Plate 2.2. Paper mulberry is deciduous and in winter can be identified by its conical buds, prominent stipule scars and very hairy reddish brown twigs.

Plate2.1 Long cluster of flowers produced by male trees. Source: *cwcook@duke.edu*

Plate2.2 Ball-shaped flower clusters of female trees. Source: *cwcook@duke.edu*

Most revealing about Paper mulberry is its highly variable leaves. In size, they range from 8-25cm in length, the smallest of which are simple with a serrate margin. Larger leaves tend to be heart shaped or mitten-shaped, while the largest leaves are generally deeply lobed giving the leaf three large lobes and occasionally two smaller ones near the leaf base.

The fruits of the plant are generally 1.5-2.0cm in diameter and reddish purple in color, appearing in summer. The fruit (eaten raw) comprises a ball about 1.5cm in diameter with numerous small edible fruits protruding (see Plate 2.3 below). There is not much edible flesh but it has a pleasant flavour (Hendrich, 1972 ; Tanaka, 1976).

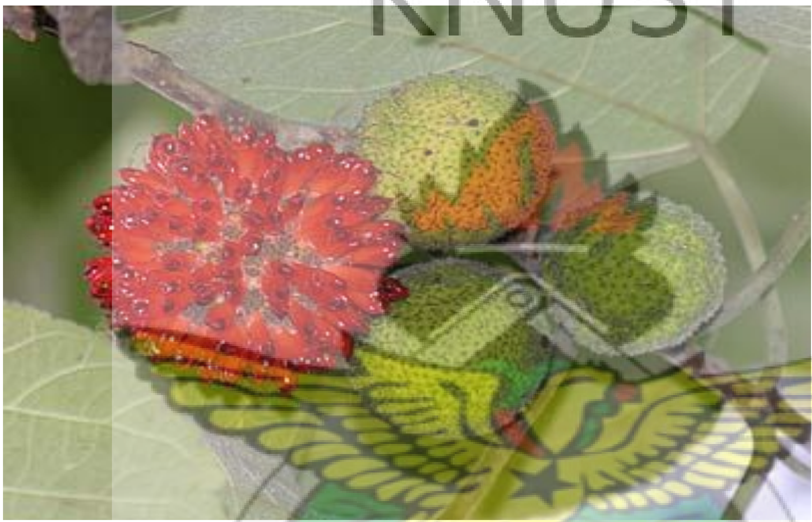


Plate 2.3 Mature red ball-shaped aggregate fruits of Paper mulberry. Source: *cwcook@duke.edu*

2.1.2 Uses, Products and Chemical Composition

For nearly 2000 years ago, the Chinese used Paper mulberry bark for the production of its paper. This was the first example of a true 'paper' being used as opposed to parchment and hides (Morgan and Overholtz, 2004). The most significant part of the paper mulberry is its strong, fibrous bark used in making native bark cloth commonly known as tapa cloth or tapa. Paper mulberry has several other uses including medicinal and as food.

Edible parts include the flowers, fruits and leaves. The fruit is edible and very sweet. Prolonged ingestion of the fruit is said to weaken the bones (Reid, 197 ; Jang *et al*,. 1997). As fodder for animals, the tender leaves and twigs can be used to feed deer. The leaves are also fed to pigs in Indochina and to silkworms in China. And in Indonesia, the steamed young leaves are eaten as a leaf vegetable (Whistler and Elevitch, 2006).

There are several uses of the bark fibre. The bark can be used to make rough rope/cordage, as can the roots. The bark is also decocted for ascites and is used to reduce swelling or oedema and used for abdominal distention. The juice is used in anuria. Medicinally, the slimy sap is a mild laxative. Thrush, a mouth disease, is said to be improved when the ash from the burned beaten sheet made from the bark is applied to the mouth. The latex is useful externally for neurodermatitis, eczema, bee sting and other insect bites. According to traditional Chinese medicine, Paper mulberry tonifies the liver and kidneys, clears heat and cools the blood and is used to stop diarrhoea (Dweck, 2002). Inthapanya and Preston (2009), have also reported that presently, the bark of Paper mulberry is used in the handicraft industry to make paper and envelopes.

In Ghana, many forest fringe communities who cannot control the spread of the Paper mulberry plant have found some uses for it. The stem is used as firewood and for making charcoal. The bark is used in strips as binding ropes for mud houses and sometimes weaved into mesh used in erosion prevention. In many areas, the leaves are fed to livestock (Owusu-Sekyere, 2006).

The wood (timber) is light coloured, soft, greyish-white, even and straight grained. It is light with a basic density of 506 kg/m^3. It is thus used mainly in the manufacture of cheap furniture, match sticks, packing cases, boxes, plywood, building boards, sports equipment and pencils (Orwa *et al.*, 2009).

The leaves of Paper mulberry have been reported to contain 16% Crude Protein in DM (Inthapanya and Preston, 2009). Oduro (2009) found that the Crude Protein content of the young leaves from three different ecological zones in Ghana ranged from 16% to 22.5% of the DM while that the mature leaves ranged from 17.50% to 19.50% of the DM. The organic matter (OM) also ranged from 87.05% to 89.04% and from 86.71% to 88.03% for the young and mature leaves respectively. The ash content of the young leaves ranged from 10.96% to 12.95 for the young leaves while that of the mature leaves ranged from11.97% to13.90% of the DM. The chemical composition of the leaves indicates it can be used to provide a nitrogen source in ruminant feeds.

2.2 Origin and Characteristics of Napier grass

Napier grass *(Pennisetum purpureum)*, also known as Elephant grass, is used as fodder crop. The plants tiller freely and a single clump may produce 50 tillers under favourable climatic and soil conditions. Unfortunately, the grass is coarse-textured, the leaf blade and sheaths hairy, leaf margins sharply toothed and stems less juicy and fibrous.

Napier grass, which used to be promoted in Uganda for soil conservation and for mulching coffee is now a commercial livestock feed. It was Colonel Napier of Bulawayo, after whom Napier grass was named, who urged Rhodesia's (now Zimbabwe) Department of Agriculture to explore the possibility of using it for commercial livestock production early in the last century (Boonman, 1993).

Accordingly the grass was later promoted as a livestock feed as farmers found it more profitable to sell Napier grass to livestock farmers or feed the grass to their livestock than to sell the Napier grass to coffee estates as it turned out that very few smallholders mulched their coffee (Acland, 1971).

Herbage yield of Napier grass may be affected by the harvesting day after planting. Generally, as grass ages, herbage yield is increased due to rapid increase in the tissues of the plant (Minson, 1990). Leaves of grass have been generally reported to contain more crude protein and cell contents than the stem (Reid *et al.*, 1973). Napier Grass has become by far the most important fodder due to its wide ecological range (from the coast to over 2,000 metres), high yield and ease of propagation and management; sometimes herbaceous legumes or fodder shrubs are associated with the grass but their use is limited and their economics poorly documented.

Napier grass, which is robust perennial forage with vigorous root system, sometimes stoloniferous with a creeping rhizome is native to eastern and central Africa and has been introduced to most tropical and sub-tropical countries. Its natural habitat is damp grassland, forest margins and riverbeds. Mature plants normally reach up to 4m in height and have up to 20 nodes (Henderson & Preston, 1977). Boonman (1997) found it growing to a height of 10m in riverbeds and recorded a harvest at Kitale of 29 tonnes/ha DM taken in one cut on a very mature stand (more than 2 years overdue).

2.2.1 Importance of Napier grass

Napier grass has been the most promising and high yielding fodder (Anindo and Potter 1994) giving dry matter yields that surpass most tropical grasses (Humphreys, 1994; Skerman and Riveros, 1990). Reported on-farm dry matter yields from different regions averaged about 16 tonnes/ha/year (Wouters, 1987) with little or no fertilizer, while according to Schreuder *et al.* (1993) yields on research stations vary between 10-40 tonnes dry matter per hectare depending on soil fertility, climate and management factors. These yields surpass those of Rhodes grass (*Chloris gayana*), Setaria (*Setaria sphacelata*) and Kikuyu grass (*Pennisetum clandestinum*) which are popular pasture grasses but which yield between 5 to 15 tonnes of DM per year (Boonman, 1993).

High DM yields for Napier grass have been recorded elsewhere in the tropics (Ferraris and Sinclair, 1980: Woodard and Prine, 1991); exceptionally high yields up to 85 tonnes DM/ha have been cited when high rates of fertilizers were applied (Skerman and Riveros, 1990), for example under natural rainfall of 2000 mm per year where 897 kg of N fertilizer were applied per hectare per year and the grass was cut every 90 days the yield was 84, 800 kg DM/year (Vicente-Chandler *et al.*, 1959). Dry matter yield alone, however, is of limited value if it is not closely related to the DM intake of the animals. At farm level, the combination of DM yield and observed DM intake can form the basis for estimating the number of livestock that can be supported by available forage.

Napier grass tolerates frequent defoliation, under good weather conditions it can be cut 6-8 weeks giving up to 8 cuts in a year, depending on fertilizer application, rainfall amount and distribution. Hay and silage can be made for dry season use. It makes good hay if cut when young but is too coarse if cut late. It is more usually made into silage of high quality without additives. In Taiwan, Napier grass is widely used for the production of dehydrated grass pellets used as supplementary stock feed.

2.2.2 Climate and soil requirements

For optimal growth, Napier grass requires high and well-distributed rainfall (more than 1000 mm per annum) although it can tolerate a moderate dry season (3-4 months) because of its deep root system. At higher altitudes (above 2100 m), growth is slowed by lower temperatures; optimal temperatures for growth are in the range 25 to 40^{o} C with high rainfall. It ceases to grow when temperatures fall below 10^{o}C (Bogdan, 1977) and the tall varieties cannot withstand frost, in contrast to the dwarf type which is frost tolerant (Legel, 1990). However, even though the herbage may be killed by frost, the underground parts remain alive as long as the soil is not frozen. Napier grass can grow in a wide range of soils, performing best in fertile and well drained soils, but cannot tolerate flooding or waterlogging (Bogdan, 1977). It establishes well in clay or sandy loam and deep, fertile loam soils produce best growth and yields (Skerman and Riveros, 1990).

2.2.3 Napier grass establishment

Napier grass is propagated vegetatively because seeds have low genetic stability and viability (Humphreys, 1994). Conventionally Napier grass is established in well-prepared land (ploughed and harrowed) from root splits, canes with 3 nodes or from whole canes. The material is planted 15-20 cm deep with splits planted upright, three node canes planted at an angle of 30-45^{o} while whole canes are buried in the furrow 60-90 cm apart. The root splits and canes are usually spaced 50 - 60 cm x 50- 60 cm , 50-60cm x 90-100 cm or 90-100 cm x 90-100cm depending on the soil moisture of the area; usually the higher the rainfall the closer the spacing. Root splits generally take more labour (Suttie, 1965) to prepare (uproot) and to plant but result in quicker establishment and earlier and higher forage yields. Once the crop is well-established the original planting material type generally has little effect on dry matter yield although some varieties such as French Cameroon may establish best from canes (NARS, 1979). Whether root splits or canes are used, they should be sufficiently mature to tiller well and produce tall and high yielding forage plants; canes should be from plants 20-28 weeks old.

Napier grass can also be established by the "Tumbukiza" method where the planting is done in round or rectangular pits 60-90 cm wide and 60-90 cm deep, filled with a mixture of topsoil and manure in the ratio of 1:2.

2.2.4 Cropping system

Napier grass is usually planted as a sole crop; however, it can also be under sown with other crops such as maize (Wanjala *et al.*, 1983) or intercropped with forage legumes (Kusewa *et al.*, 1980). It can grow as an intercrop within the same row or within alternate rows with legumes such as *Pueraria phaseoloides*, *Centrosema pubescens and Stylosanthes guianensis.* When intercropped with herbaceous legumes, cutting or grazing management is adjusted to favour the legumes in order to maintain a satisfactory mixed sward. Napier grass can also be grown as an alley crop with fodder legumes such as leucaena (*Leucaena leucocephala*), calliandra (*Calliandra calothyrsus*) sesbania (*Sesbania sesban*) and gliricidia (*Gliricidia sepium*). Legumes improve the quality of Napier grass-based feed and also increase the overall yield.

When inter-planted with maize, it is planted 12 weeks after sowing maize at a spacing of 75 x 30 cm, as this has been shown to give the best maize yield. However, if the main crop is Napier grass, delayed planting reduces its yield. When Napier grass and maize are planted at the same time, Napier grass yield is increased, without necessarily reducing maize yields. Experience shows that both Napier grass and maize compete for nutrients and it is only under high nutrient management systems that Napier grass and maize can be successfully grown on the same plots. Herbaceous legumes can give high yield when intercropped with Napier grass; those that are compatible and give high yields include: giant vetch (*Vicia dasycarpa*), silver leaf desmodium (*Desmodium uncinatum*), greenleaf desmodium *(D. intortum)*, stylo (*Stylosanthes guianensis*), glycine (*Neonotonia wightii)*, centro (*Centrosema pubescens)* and butterfly pea (*Clitoria ternatea*). Generally planting Napier grass with herbaceous legumes increases the dry matter yield and crude protein of the forage. The combined dry matter yield is greater than the yield of Napier grass alone.

2.2.5 Research work on Napier grass at the Department

Work on Napier grass done at the Department of Animal Science, KNUST, is quite extensive. Among these include an experiment conducted to evaluate the nutritive value of nine hybrids of *Pennisetum*, obtained far across Africa, and a local *Pennisetum purpureum* grown in the Ashanti Region of Ghana. The hybrid varieties were: 15743, 16786, 16791, 16798, 16834, 16835, 16837, and 16838 and16840 obtained from International Livestock Research Institute (ILRI), Ethiopia.

It was found among other things that the local variety ranked best in persistence and tiller number. The leafiness and tiller number was highest in varieties 15743, 16837 and 16838. Generally, crude protein concentration in the leaf, stem and whole plant fractions were consistently higher in variety 15743 while other varieties were similar to the local. The NDF, ADF and ADL concentrations were lower in varieties 15743 and 16838 while the rest were also similar to the local (Dzimale, 2000).

In another experiment to determine the effect of harvesting date (60, 90, 120 days) of the local Napier grass supplemented with urea multinutrient blocks on rumen degradability in Djallonké sheep. It was found that Napier harvested at 60 days had the highest degradability, followed by 120 days and then 90 days in that order (Dzimale, 2000). The author emphasized that factors that could account for such observations include the rumen environment in which degradability was determined, the placement of the bags in the rumen and the length of time the samples are incubated. Also, Napier harvested at 60 days had the highest proportion of the readily soluble or degradable portion. Napier harvested at 90 days had a higher proportion of the insoluble but degradable portion than those harvested at 60 days but lower than that of Napier harvested at 120 days (Ampofo, 2009).

In an experiment to find the herbage yield and chemical composition of four varieties of Napier grass, Ansah *et al*. (2010) found out that the Local and variety 16798 produced a significantly higher yield among the four varieties and the 120 day harvest also recorded the highest yield among the 3 harvest days (60, 90 and 120 days). However, the 60 day harvest had the highest cellulose and lowest lignin content. The balance of quantity versus quality is noted between varieties Local and variety 16798 with more cellulose but less dry matter yield on the one hand and varieties 16786 and 16840 with a greater yield but greater lignin content on the other hand. All the varieties recorded a CP level above the critical 70g/kg required for voluntary intake in ruminants and therefore could be suitable for feeding small ruminants in Ghana. Variety 16798 recorded the lowest lignin content among the four varieties. The leaf fraction recorded the highest CP compared to the stem fraction however; the stem fraction recorded the highest cellulose fraction.

2.3 Supplementation in ruminant nutrition

The primary limitations of straw for ruminant production according to Raghuvansi *et al.* (2007), are low digestibility, slow rate of breakdown of straw particles to a size that can leave the rumen, low propionate fermentation pattern in the rumen and the negligible content of both fermentable N and by-pass protein. Bondi (1987) suggested that feeds containing less than 6% crude protein promote negative N balance owing to protein malnutrition and therefore straw-based feeds require N supplementation to enhance cellulolysis in the rumen which may improve rumen microbial N supply and retention.

Supplements refer to feedstuffs that are used to improve the value of basal diets. They are feeds which are fed to ruminants only in small quantities and which supply essential nutrients. Supplements are required to correct deficiencies, thereby increasing basal feed intake and hence animal production. The most common types of supplement are: energy concentrates (for example, cereal and rice bran), protein concentrates (for example, decorticated groundnut cake), molasses, non-protein nitrogen (for example, urea), and minerals (Gatenby, 2002). Supplements, particularly concentrates, are expensive and their cost must be more than repaid by the increase in productivity.

Ruminants because of their rumen physiological adaptation can utilize inexpensive forage to meet their feed requirements for maintenance, growth and reproduction. The microbial population in the ruminant fore-stomach is responsible for the digestion of both the fibrous and soluble fraction of plant material consumed. Although most of these forages are low in nitrogen, and high in fibre, supplementation with high nitrogen feeds will help improve the rumen’s ecosystem thereby increasing the animal's ability to digest fibrous portions of these forages (Preston and Leng, 1987). This is perhaps why according to Ibrahim *et al*. (1994), the supplementation of limiting nutrients to the rumen micro-organisms to enhance their growth and increase utilization of fibrous feeds has received much attention in recent years as a way of improving tropical feed systems.

The intensity with which microbes break down food entering the rumen depends on the rate at which they are growing and reproducing. The microbes need sufficient energy to meet their nutritional requirements in order to grow rapidly. When a poor quality, highly fibrous diet is fed, the microbes can only attack slowly and the energy release will be slow and insufficient to meet the needs of the microbes. This results in very low rates of microbial growth and even slower rates of food breakdown. The addition of a small amount of material that is readily broken down may stimulate the microbes not only to actively breakdown the new material, but also to attack the original food with renewed vigour.

Fermentation results in the production of volatile fatty acids (VFA) which are the major source of energy for ruminants. Microbial cells and undigested plant proteins are the main sources of protein. Maximum fermentation rates are attained when all factors required by the ruminal microorganisms are available, namely - a source of energy (sugars, cellulose), nitrogen (N), sulphur (S) and minerals. When the rate of fermentation is restricted, feed intake decreases and nutrient availability to the animal is limited. Low quality diets (straws and mature grasses) are characterised by low animal productivity as shortage of one or more of the essential nutrients limits microbial activity.

The amount of leguminous tree foliage needed to provide effective supplementation will vary with the quality of the basal diet, the quality of the supplement and the level of animal production expected, whether maintenance or growth (Norton *et al.*, 1992).

2.3.1 Forage trees as supplement to low quality basal diet

Forage tree legumes have considerable potential as supplements to low quality diets. Whilst there is considerable information available on the supplementation value of leucaena and gliricidia for instance, less is known about other forage tree legumes. The level of supplement required will depend on the quality of the basal feed. There is an extensive and diverse literature on the effects of leguminous tree supplementation on the productivity of cattle, sheep and goats. Forage tree leaves, particularly Leucaena and *Gliricidia sepium* (gliricidia), have been used as supplements to a wide range of forages and agricultural by-products. They have been incorporated into concentrate rations as substitutes for more expensive processed protein sources, used as supplements to sisal waste in Mexico and as the major protein source for cattle fed molasses diets (Norton *et al.*, 1992).

Since basal feed intake usually increases with supplementation, practical recommendations for levels of supplement to be offered are better expressed in relation to live weight of the animal than as a percentage of a diet. The studies of Bamualim *et al.* (1984a, 1984b) with goats and sheep given leucaena as a supplement to spear grass (*Heteropogon contortus*) illustrate the common response to supplementation. These authors observed an increase in hay intake and an overall improvement in diet digestibility with supplementation. Although weight changes were not measured in these experiments, the increase in digestible dry matter intake is predictive of improved weight gain. Leucaena supplementation increased rumen ammonia concentrations, stimulated microbial protein synthesis in the rumen (from 1.6 to 2.9 g/day) and increased the amount of plant protein available for absorption. The degradability of Leucaena protein in the rumen was estimated to be 66% for fresh Leucaena and 40% for dried Leucaena. The increased protein absorption from the small intestine stimulated an increased voluntary consumption of low quality straw. Other experiments generally demonstrate similar responses, although supplementation of rice straw with leucaena generally did not increase basal intake but did increase digestible nutrient intake.

Liu *et al*. (1998), in a research to evaluate the nutritional value of mulberry leaves and their use as supplement to growing sheep fed ammoniated rice straw, concluded that the benefits resulting from supplementation with mulberry leaves included an increased intake of basal diet, less consumption of concentrate and an increased income. However the growth rate of lambs on the ammoniated straw diets in the study was not high regardless of the supplement. One of the reasons may be that the straw intakes were not high. Further study is needed to investigate the response to the increasing percentage of mulberry leaves in diets for lambs, according to the authors.

Again, in an experiment to evaluate various species of forage tree legumes with Napier grass as basal diet in goats, Van Eys *et al*. (1986) found that the basal diet was sufficient for maintenance and all three fodder tree species increased weight gain to some extent.

The effect of drying of tree foliage on response to supplementation is clearly shown in the studies of Robertson (1988). Dried foliage promoted higher weight gain than fresh foliage for all species, with no species being superior. It is possible that drying may have a number of different effects. It may increase the amount of protein bypassing the rumen and decrease the content of anti-nutritive factors. Drying has been reported to improve palatability in some species. Robertson (1988) found that all leaf supplements were avidly consumed, so differential palatability was not the cause.

Paper mulberry is one tree species that has a great potential for use as a leaf supplement. Oduro (2009) found the leaves and fruits of the plant to contain the following ranges of feed quality values (1.89-3%, 0.58-1.04%, and 0.18-0.36%) for nitrogen, potassium and phosphorus in that order. This indicates the suitability of Paper mulberry for meeting the nutrient requirements for ruminants. Oduro (2009) called for the use of the plant as a forage and consideration given to its use in combination with other feeds.

Mulberry leaves are relished by sheep and goats and have high nutritive value with protein content of about 20 % of dry matter (DM) (FAO, 1998). Roothaert (1999) observed that dairy heifers had higher voluntary intake, and thus higher potential of milk production, when consuming mulberry fodder than with cassava tree (*Manihot glaziovii*) and leucaena *(Leucaena diversifolia*).

2.3.2 Supplementing Protein and Energy

Cattle, sheep and goats, being grazing and browsing animals, grow and reproduce well on quality pasture alone. Adequate quantities of green forage can supply most-if not all- the energy and protein a ruminant needs. However, forage nutritional composition changes depending on plant maturity, species, season, moisture and grazing system (Rinehart, 2008). Besides, an intensive and industrial agricultural production philosophy has dictated that crops and animals should be raised faster, larger and more consistently than a pasture system can deliver. Also, few feedstuffs meet the nutrient requirements of the animals to which they are fed when used alone and in their natural state.

The major operational expense confronting the livestock industry, according to Rinehart (2008), in most parts of the United States and for that matter other parts of the world is for supplemental feed. In temperate regions of the country that experience adequate rainfall and a lengthy grazing season, supplementation on green, growing, vegetative, well-managed pastures should not be necessary. Well-managed grass-legume pastures can be highly digestible with protein concentrations approaching 25% while vegetative. Such pastures can supply the protein needed to raise lambs, kids, heifers or steers, or support lactating cattle, sheep or goats. The problem on high-quality pastures often becomes one of inefficient protein use. Supplementing energy with digestible fibre in these situations can make the animals utilize protein more efficiently.

In conclusion, Rinehart (2008) contends that supplementing energy is helpful on vegetative, well-managed pasture for more efficient utilization of forage protein (for high producing animals) and supplementing with protein is necessary on low-quality pasture and rangeland or when continuously grazing temperate warm-season pastures. It is worth noting, according to Rinehart (2008), that supplementation of protein on low-quality forages will increase forage intake and therefore increase energy intake. However, excessive supplementation may reduce the ability of the rumen microbes to use forage.

2.4 Economic Importance of sheep

Sheep are reared in almost all villages in West Africa and are of great economic importance to the communities (Oppong, 1965). Unlike cattle, they can be kept as backyard animals due to their small size. Their ability to graze close to the ground ensures that they can utilize forage more effectively than cattle. They have shorter gestation period and are more prolific than cattle (Robert and Ralph, 1988). Sheep have the ability to convert plant carbohydrates and proteins for human use, and therefore render productive vast portions of otherwise unusable land (Rinehart, 2008).

Sheep are kept for meat (lamb, hogget or mutton), milk, wool or hair, skin and manure. Ovine meat is called lamb when from younger animals and mutton when from older ones. Sheep continue to be important today for meat and wool and are also occasionally raised for pelts, as dairy animals or as model organisms for science. Thus, although the primary function is meat production, in temperate countries milk has become important and skins a valuable product especially in countries with large sheep population. Sheep are therefore a way of converting poor quality food into desirable products (Gatenby, 2002).

Ruminant livestock play an important role in the socio-cultural life of the farming communities in Ghana. Livestock is a partial determinant of wealth and is also used as part of bridal dowry. Their value as readily convertible liquid asset is equally important. Sheep, goats and pigs are frequent generators of cash required by households (MOFA, 1997). Davendra and Mcleroy (1987) have reported that for pastoralists and agricultural subsistence societies, sheep and goats may be kept as a source of investment and as insurance against disaster. They are also used in ceremonial feasts like the Muslim Eid-ul-Adha as sacrificial animals.

Sheep will eat more variety of plants than any other livestock, making them excellent weed destroyers; a class of livestock that can turn waste into profit and at the same time improve the appearance of many farms (Horlacker, 1950).

Gatenby (2002) has catalogued a number of advantages of keeping small ruminants such as sheep which include among others the following:

i. sheep survive and often even thrive on low-quality food, they are found in marginal arid areas, are used for weed control in plantations and live on rubbish in peri-urban areas

ii. sheep can survive periods of poor nutrition, animals lose weight and cut down production when food is inadequate, but when it becomes plentiful again appetite is very high and there is compensatory growth

iii. sheep can survive infrequent watering; breeds adapted to arid environments can tolerate watering every three days although reduced water intake causes reduced food intake

iv. sheep thrive on a wide range of thermal environments

v. sheep are adaptable and can be reared in a variety of management systems including free range, shepherding, tethering and confinement

vi. sheep can graze on steep slopes unsuitable for cattle and other large animals

vii. sheep are economical of labour because they stay together while grazing; one shepherd can look after two hundred sheep in an open grazing system, more if the land is fenced

viii. keeping sheep and consuming mutton are activities free from cultural and religious barriers; this is untrue of pork, which is forbidden to Muslims and Jews, and cattle, which Hindus do not slaughter.

2.4.1 The West African Dwarf Sheep (Djallonké)

This breed is known as the West African Dwarf and the Forest type in Ghana. It is referred to as Nigerian Dwarf in Nigeria and Djallonké in French speaking countries (Gatenby, 2002). It is a small breed but not dwarf in the genetic sense: true dwarfs are genetically weak and poor reproducers, whereas the sheep of West Africa have notable physical and sexual vigour and a robustness that enables them to withstand the stresses of the climate, disease and irregular feeding (Charray *et al.*, 1992).

The breed is relatively small with height measuring 40-60cm at the withers. Ewes weigh 20-30kg and the rams 25-35kg. There are considerable variations, however, sometimes even within one country as size increases in regions with a marked dry season and decreases in wet forest areas (Charray *et al.*, 1992).

The coat varies widely in colour, ranging from pure white to brown and deep black, but with a clear tendency to pied types, where the fore part of the animal is black or brown and the rear part completely white. Only the rams have horns, which in adulthood form a forward-inclined spiral with a one-and-a- half turns (Plate 2.4a). Hornless rams are also frequently found. The tail is slender and short, without any fat deposits. The ears are short and usually in a horizontal position, only being erected when the animal's attention is aroused. In most ewes, the udder is poorly developed. Plate 2.4 'b' shows a Djallonké ewe with a lamb.

Plate 2.4 A Djallonké ram Plate 2.5 A Djallonké ewe with a lamb

Source: Fitzhugh, H.A. and G.E. Bradford, G.E., A Winrock International Study, (1983), Oklahoma State University.

The West African Dwarf sheep is kept exclusively for meat, as the ewe's milk yield barely suffices to feed the lambs. They can be bred at the age of 7 to 8 months. They tend to have a short lambing interval. Lamb mortality is high and growth rates are low under village conditions, but basic disease control and improved husbandry practices can reduce losses and allow a weight of 20-22kg to be attained in 6-8 months, compared with 2-3 years under traditional husbandry conditions (Charray *et al.,* 1992).

Observed performances of sheep indicate that dry savannah-like are more suitable for sheep husbandry than hot humid regions. This is not the case with the West African Dwarf breed of sheep which thrive and breed in the tsetse fly-infested hot humid regions of West Africa (Mason, 1951; Hill, 1960). The West African Dwarf sheep has been observed to cycle and ovulate throughout the year (Jollans, 1960), are prolific and have a high twinning rate (Adeleye, 1982). Osaer *et al.*, (1998) have confirmed that the breed is known for its adaptation to the tropical hot and humid environment of West Africa and is considered tolerant to trypanosomiasis infections.

2.5 Systems of sheep production in Ghana

Systems of sheep production in Ghana include the extensive, intensive, semi-intensive and tethering.

The main type of sheep production in Ghana is the extensive system. With this system, animals fend for themselves, find their own food, scavenge around the house and feed on fallow land and/or kitchen waste left for them (Gatenby, 1985). During the main cropping season, owners are obliged to provide the animals with food and water in order to protect their crops (Charray *et al.*, 1992). Productivity is low in this system since there is no control over pasture and work on crop farms takes precedence over keeping animals. This however, makes the system easy to manage.

In the intensive system, large numbers of animals are kept on limited land in confinement. There are two types of the intensive system. The first involves the use of cultivated pastures divided into paddocks. Animals are grazed from one paddock to another. Shade trees are used as shelter. An example is the Ministry of Food and Agriculture sheep breeding farm at Ejura in the Ashanti Region.

The second type is where forage is cut and fed to sheep in their stall or pens known as zero grazing or 'cut and carry'. This system, according to Gatenby (1985), is well developed in Muslim West Africa. It is common among Muslim communities in Ghana for fattening rams for festivals like Eid-ul-Fitr. In this system, there is the tendency for the animals to be underfed. It is also capital and labour-intensive as time taken to collect and carry fodder is considerable. There is however higher return on investment as productivity is higher if well-managed.

The third common system is the semi-intensive – a compromise between the extensive and intensive systems. The system is characterized by a combination of limited stall feeding and grazing. The animals are housed at night in simple structures and released during the day to graze.

Tethering is also practised in small communities. In this system, sheep are tied by a rope to pegs, posts or trees during grazing. The length of the rope determines the area available for grazing. This restricts the movement of the animal (Addo, 2007). It requires a relatively little labour but sheep should be tethered on areas of good quality fodder and should be moved two or three times each day so they can eat enough vegetation (Gatenby, 1991).

2.6 Feeding behaviour and nutrient requirements for sheep

The primary function of the livestock industry is the conversion of edible as well as inedible raw materials surplus to the requirements of human beings, such as feed grains, processing by-products, protein concentrates, fodder and pasture grass, into animal products such as meat, and milk. This conversion takes place within the bodies of farm animals (Tweneboah, 2000). Ruminants are adapted to use forage because of the microbes in their rumen. To maintain ruminant health and productivity therefore, the rumen microbes must be fed, which in turn will feed the ruminant.

According to Schoenian (2003), feed is the single largest cost associated with raising small ruminants, typically accounting for 60% or more of total production costs. It goes without saying that nutrition exerts a very large influence on flock reproduction, milk production and lamb and kid growth. Animals receiving inadequate diet are more prone to disease and will fail to reach their genetic potential. Gimenez (1994) also contends that feed whether purchased or produced on the farm, makes up a large part of the expenses incurred in sheep production. For profitable production, proper feeding and year-round management are essential. Without proper nutrition, it is impossible to produce a high-percentage crop, wean heavy animals, and develop satisfactory flock replacements.

Many factors affect the nutritional requirements of small ruminants namely: maintenance, growth, pregnancy, lactation, fibre production, activity and environment. Maintenance requirements increase as the level of the animal's activity increases. In cold and severe weather, sheep and goats require more feed to maintain body heat. The added stresses of pregnancy, lactation and growth further increase nutrient requirements. As a general rule sheep and goats will consume 2 to 4 per cent of their body weight on a dry matter basis in feed. The exact percentage varies according to the size (weight) of the animal (Shoenian, 2003).

Traditional systems have developed to take advantage of the available feed, and sheep generally eat low quality feed that is not eaten by pigs, poultry or man. Attention must be paid to the feeding habits of ruminants so that they will be properly cared for when confined (Okello, 1993). Sheep are not free to display their natural feeding behaviour when housed and allowed to consume the same type of feed all the time. Major nutrients needed by sheep, according to Schoenian (2003), are energy, protein, minerals, vitamins, fiber and water.

2.6.1 Energy

The most common limiting factor in small ruminant nutrition is energy (defined as the ability to do work). Energy strictly is not a nutrient but a characteristic of nutrients that describe their ability to promote the functions (maintenance and production) that animals have to perform. An energy shortage will result in decreased production, reproductive failure, increased mortality, and increased susceptibility to diseases and parasites. The most plentiful feeds available are the best sources of energy. However, sheep and goats are often underfed. Poor-quality pastures and roughages or inadequate amounts of feed are the primary causes of energy deficiency. The major sources of energy for small ruminants are usually pastures and browses, hay, and grains (Gimenez, 1994).

Energy from food is used for maintenance (that is, the essential processes which keep the body functioning) and production (growth, lactation and pregnancy). The lowest energy density (amount of metabolisable energy in each kilogramme DM of food) at which sheep does not lose weight according to Gatenby (1991) is between 8 and 10 MJ/Kg DM. This energy density is found in reasonable quality grass or in straw with small quantity of energy supplement. If the energy density of the diet is above minimum level for maintenance, the sheep has surplus energy which it uses for production (Gatenby, 1991).

2.6.2 Protein

Proteins are complex molecules which contain nitrogen. In small ruminants, the amount of protein is more important than the quality of protein. Animal's requirements are usually expressed as requirements for crude protein where: crude protein = nitrogen x 6.25. Much of the crude protein requirement of sheep can be supplied as non-protein nitrogen (such as urea) but some must be true protein (Gatenby, 1991).

As a rule of thumb, the minimum crude protein level required for maintenance is about 8% in the dry matter, while the most productive animals such as rapidly growing lambs and lactating ewes need about 11%. These levels are considerably higher than the average values found in natural pastures; sheep manage to survive and reproduce because they select vegetation with a better than average feeding value (Gatenby, 1991).

It does not harm sheep to eat more than enough protein, but as high protein foods are expensive, it is unlikely they will be fed to sheep in large quantities. Often a deficit of crude protein can be rectified by feeding a small quantity of urea, say 20g/day. Sheep should not be given more than a very small quantity of urea as even moderate amounts are poisonous (Gatenby, 1991).

Proteins are usually the most expensive part of diets of livestock. If we ignore fats, then the proteins comprise the largest part of the dry matter in animal's carcass. This protein is very important because it is the part of the animal that the consumer wants (Chesworth, 1992). Protein is used to repair old tissues and to build new tissues. Protein deficiency is more detrimental to the young animal, so an adequate amount of protein must be supplied if rapid growth and high production are to be obtained. On the other hand, excessive feeding is expensive (Gimenez, 1994).

2.6.3 Minerals

Animals need several minerals (both macro and micro) in their diet. Macro-minerals important in animal nutrition include; calcium, phosphorus, potassium, sodium, chlorine, sulphur and magnesium. Micro-minerals on the other hand include: iodine, copper, cobalt, selenium, fluorine, iron, manganese, molybdenum, nickel and zinc (Gatenby, 1991).

Problems such as low growth rate and poor fertility arise if there are insufficient minerals in the diet. Mineral deficiencies in grass or other vegetation are caused by mineral deficiencies in the soil. In general, few problems are seen in sheep in extensive production systems. It is only when intensive systems of husbandry are developed that mineral deficiencies become a noticeable problem.

According to Gatenby (1991), in practice only chronic symptoms of mineral deficiencies are seen rather than the acute symptoms described in physiology textbooks. These chronic symptoms include: low growth rate, poor fertility, low appetite, loss of hair and diarrhoea. It is however worth noting that, these symptoms are also caused by many other problems such as low energy intake, low protein intake and internal parasites, and so it is almost impossible to say that a flock is suffering from mineral deficiency by looking at the sheep. The most common way to detect a mineral deficiency according to Gatenby (1991) is to take a blood sample and analyse its mineral content.

If sheep are in an intensive system and are fed concentrates, mineral deficiency can be rectified by adding a commercially available mineral to the feed. Where animals do not receive concentrates, minerals can be supplied in salt lick. If there is too much of any mineral in the diet, toxicity occurs. The symptoms of mineral toxicity are similar to those of mineral deficiency. Sheep are particularly intolerant of copper and so concentrates should not contain high levels of copper (Gatenby, 1991).

Rumen micro-organisms require both macro and trace minerals for their normal cell function and metabolism (Ørskov, 1982). Sulphur is required by rumen micro-organisms for the synthesis of sulphur-containing amino acids, methionine, cystine and cysteine (Preston and Leng, 1987). The sulphur-containing amino acids constitute a constant proportion of microbial amino acids and therefore, the requirement for sulphur by the rumen micro-organisms is related to the requirement for nitrogen (Ørskov, 1982). The ratio of nitrogen to sulphur for efficient microbial growth has been reported to range from 10 to 14:1 for sheep (ARC, 1980). Sulphur from micro-organisms generally comes from the degradation of dietary protein and therefore a deficiency in sulphur is likely to occur if there is also a deficiency in protein (Ørskov, 1982), although inorganic sulphur such as sodium sulphate (Na_2SO_4) can be utilized.

Phosphorus is a constituent of nucleotides and co-enzymes such as flavin phosphates and pyridoxal phosphates. Phosphorus forms an essential part of the structure of DNA and RNA, helping to build the nucleic acid into the helix. It is also essential for all energy transactions within microbial cells in the formation of adenosine di- and tri-phosphates (ADP and ATP) and guanine triphosphate (GTP) (Ørskov, 1982).

Cobalt is required by micro-organisms in the rumen for synthesis of vitamin B_{12} (Maynard *et al.*, 1976). McDonald *et al.* (1981) reported that if cobalt is deficient in the diet, then vitamin B_{12} cannot be produced in the rumen in amounts sufficient to satisfy the animal's requirements and symptoms of 'pining' (emaciation, anaemia and listlessness) occur.

According to Mackie and Therion (1984), the provision of diets containing a high amount of mineral salt such as sodium and potassium can result in hypertonic rumen fluid causing increasing osmolarity which may have an inhibitory effect on rumen fermentation and consequently bring about a reduction in feed intake.

2.6.4 Vitamins

Vitamins are complex organic compounds that are required in minute amounts by one or more animal species for normal growth, production, reproduction and/or health. The most important attributes of vitamins, according to Chesworth (1992) are that: the material is essential for the normal metabolism of the animal, it cannot always be synthesized in sufficient quantities within the animal's body and therefore some supply from the gut may be necessary, and that it is required in only small quantities.

The major vitamins in animal nutrition are vitamins A, B1, B2, B6, B12, C, D2, D3, E and K. Small ruminants require many vitamins, just as other animals do. However, their dietary vitamin requirements are relatively simple because of the nature of the feeds they ordinarily consume and the synthesis of vitamins by microbes in the rumen.

For sheep, vitamin deficiencies are rare compared with deficiencies of energy, protein and minerals. Generally, the only vitamin deficiency seen in adult sheep in commercial systems is vitamin A deficiency. This can arise when the diet is based on straw or when the grass and other vegetation are of very low quality, such as at the end of the dry season or in a drought. Vitamin A deficiency can be rectified by feeding green fodder or synthetic Vitamin A (Chesworth, 1992).

2.6.5 Fibre

Crude fibre is higher in grasses and edible tree leaves as well as the bulky food classed as ‘roughage’ and fodder crops such as hay, straw, silage and dry grasses. It is also high in milling offal such as bran and other cereal by-products. Much of the crude fibre is indigestible but it adds bulk to the ration and thereby satisfies the appetite. It does not only stimulate and assists digestion, but also necessary to maintain a healthy rumen environment and prevent digestive upsets. A certain amount of fibre is therefore necessary in the feed of all animals after they have been weaned.

The rumen and reticulum of ruminants are particularly equipped to deal with crude fibre content of feeds during digestion. They contain innumerable micro-organisms such as fungi, bacteria and protozoa which are able to breakdown cellulose into the lower fatty acids such as acetic, propionic and butyric acids and also gases chiefly carbon dioxide, methane and hydrogen. The gases are eliminated but the fatty acids are absorbed into the blood from the rumen, reticulum and large intestines in which they are produced, and make a major contribution to their nutrition (Tweneboah, 2000).

2.6.6 Water

Water is the cheapest feed ingredient, but often is the most neglected. Water and feed intake are positively correlated. Inadequate water intake can cause various health problems. Animals should have access to clean, fresh water at all times. A mature animal will consume between three-quarters to one and a half gallons of water per day. Water requirements and intake increase greatly during late gestation and during lactation. Water requirements also increase substantially when environmental temperatures rise above 70° Fahrenheit (21°C) and decline with very cold temperatures (Schoenian, 2003). Grazing sheep, particularly in the cooler seasons of the year, can require relatively little additional water beyond what they receive through forage. Hot, drier weather, however, will result in increased water intake.

The actual amount of water an animal needs will depend on a number of factors: the breed of the animal, the climate, the amount and type of feed eaten, and the type of production in which the animal is involved. Sources of water to ruminants include: intake through feed and drink, metabolic water and water storage (in rumen which can act as water storage organ). Water supplied to livestock needs to be of reasonable quality in terms of the quantity of dissolved solids (salts, chlorides, sulphates and nitrates of metals) and contamination with bacteria and algae especially for young stock without the benefit of a functioning rumen to act as a barrier (Chesworth, 1992).

During water deprivation, there is the discomfort of a dry mouth in the early stages followed by a reduced secretion of digestive juices and ultimately a comprehensive disruption of bodily function. Lack of water results in reduced food intake and eventually completes anorexia. In one study, the food intake of sheep declined noticeably by the second day without water (Gordon, 1965). This was attributed to the difficulty of transporting the more viscous digesta through the digestive tract.

Water is used in six important ways, according to Chesworth (1992): as a means of transport for nutrients to body tissues, as a medium for digestion, as a vehicle for excretion, as a means of cooling, to supply necessary minerals and as a major component of milk.

2.7 Feed intake and growth of sheep

Sheep are often permitted to eat as much feed as they want although they are not always given the type of feed they like best. Intake of nutrients depends on the type of feed available, the amount eaten and the energy density in the diet (Gatenby, 1991). Sheep will eat more of fine feeds than coarse feeds and for this reason straw is sometimes chopped. As a rough guide, the daily DM intake of a coarse diet varies from about 1.5% of body weight for a poor quality diet to about 3.0% for a high quality diet (Gatenby, 1991). Factors that influence feed intake in ruminants according to Chesworth (1992) include: physiological factors, nutrient deficiencies, digestibility, food bulkiness, processing, level of production, pregnancy, environmental temperature, photoperiod, state of health, distribution or density of herbage and animal factors (type and age).

Growth is the increase in size and change in body composition as a lamb gets older. Potential growth rate increases with age until the maximum is seen when a lamb is about 5 months old. After this growth slows down until the animal reaches its adult weight. Growth rate of lambs varies from 20g to 200g per day depending on feeding level, genotype, sex (and castration), health and management (Gatenby, 1991). During periods of low quality feed, sheep only grow very slowly or may even lose weight. After the period of under-feeding, sheep grow faster when feed is improved. This faster-than-normal growth is known as compensatory growth. Growth promoters (substances which increase the growth rate of animals and decrease fatness) may be implanted into the tissues of the ear or may be mixed with feed (Gatenby, 1991).

2.8 Constraints to sheep production in Ghana

The primary concern facing livestock production in Sub Saharan Africa is related to shortages in quality and quantity of feed resources during the dry season (Jutzi, 1993; Larbi *et al.*, 1993). It is therefore evident that lack of adequate year-round nutrition is probably the most important contributory factor to low ruminant livestock productivity in Ghana. Grasses grow very vigorously in the rainy season but turn fibrous by the time the rains are over. The rate of lignification in very high in the tropics and is common knowledge that lignified herbage has low nutritive value. The situation is worsened by bush fires in places where these are common.

Crop residues which abound to be used for supplementation are known to be of relatively poor feeding value due to high fibre and lignin contents and low contents of important nutrients such as crude protein, minerals, vitamins and easily fermentable carbohydrates (Nour, 1986). In seasonally dry environments, according to Jones and Wilson (1987), the main limitations to livestock production are the lack of green feed at least for half of the year coupled with low nutritive quality of forages during most of the period of active pasture growth.

In the northern parts of Ghana, there are very dry and hot weather conditions (November/December through to March/April). This period is marked by very poor feed quality low in nitrogen, inadequate grazing material and inadequate drinking water for ruminant livestock on natural pasture (Alhassan and Karbo, 1993). Animals lose quite a considerable amount of their live weight as a result. Again, in the urban centres where smallholders are found, grazing areas are fairly restricted, comprising areas around villages, on the sides of roads and crop growing lands after harvest or fallow lying land (Charray *et al*., 1992).

2.9 Blood indices or profile

Evaluation of the blood profile of animals may give some insight as to the potentials of a dietary treatment to meet the metabolic needs of the animals. According to Church *et al.* (1984), dietary components have measurable effects on blood constituents such that significant changes in their values can be used to draw inference on the nutritive value of feeds offered to the animals. Changes in the concentration of blood components of ruminants have been used both as criterion of nutrient status (Russell and Wright, 1983) and as an index of metabolic disturbance or toxicity (Puoli *et al.*, 1992).

2.9.1 Haematological indices

Haemoglobin (Hb) is the iron-containing oxygen-transport metalloprotein in the red blood cells of all vertebrates (with the exception of fish family – channichthyidae) as well as the tissues of some invertebrates (Maton *et al.*, 1993). Hb in the blood carries oxygen from the respiratory organs to the rest of the body where it releases the oxygen to burn nutrients to provide energy to power the functions of the organism and collects the resultant carbon dioxide to bring back to the respiratory organs to be dispensed from the organism. A low Hb or 'blood count' is known as anaemia. The normal physiological range of Hb for healthy sheep reported by Greenwood (1977) and Pratt (1998) is 8 – 16g/d*l*.

Haematocrit (HCT) or packed cell volume (PCV) is a measure of the ratio of the volume occupied by the red cells to the volume of white blood cells in a sample of capillary, venous or arterial blood. PCV is an easily obtained measure for detecting anaemia or polycythemia and can be useful in estimating changes in hemodilution and hemoconcentration (Bull *et al.,* 2000). Normal physiological range of PCV for healthy sheep is 27 – 45% (Jain, 1993).

Red blood cells (RBC) are the most common type of blood cell and the vertebrate organism's principal means of delivering oxygen to the body tissues via the blood flow through the circulatory system. RBC's cytoplasm is rich in haemoglobin, an iron-containing biomolecule that can bind oxygen and is responsible for blood's red colour. Anaemia is a disease characterized by low oxygen transport capacity because of low red cell count or abnormality of RBC or haemoglobin. Fadiyimu et al., (2010) have reported a normal physiological RBC range of 7.87 – 11.29 x 10^{12}/L. White blood cells (WBC) or leucocytes are cells of the immune system involved in defending the body against both infections and foreign materials. The number of WBCs in the blood is an indicator of diseases. Normal physiological values for healthy sheep according to Fadiyimu *et al.,* (2010) is 6.93 – 12.66 x 10^{9}/L .

Mean cell volume (MCV) is the measure of the average red blood cell size reported as part of standard complete blood count. It allows the classification of anaemia as either microcytic anaemia (MCV below normal range) or normocytic anaemia (MCV within normal range) or macrocytic anaemia (MCV above normal range). According to Borjesson *et al.,* (2000), the normal physiological MCV range for sheep is 35.3 – 43.7f*l*. Mean cell haemoglobin (MCH) is the average mass of haemoglobin per red blood cell in a sample of blood. MCH value is diminished in hypochromic anaemias. Normal physiological MCH for healthy sheep, according to Borjesson et al., (2000), is 11.3 – 14.1pg. Mean cell haemoglobin concentration (MCHC) is a measure of the concentration of haemoglobin in a given volume of packed red blood cells. It is calculated by dividing the haemoglobin by the haematocrit. Normal physiological range of values for MCHC is 30.3 – 34.3g/d*l* (Borjesson, 2000).

2.9.2 Biochemical indices

Cholesterol is an organic chemical substance classified as a waxy steroid of fat. It is an essential component of the mammalian cell membrane and is required to establish proper membrane permeability and fluidity Sadava *et al.,* (2011). It is also an important component for the manufacture of bile acid, steroid hormones and vitamin D. Cholesterol is synthesized predominantly in the liver. Cholesterol exists in the blood as a free sterol in an esterified form. Knowledge of the plasma levels of lipids (cholesterol and triglycerides) together with lipoproteins of high and low density aids in the detection of many conditions bound to metabolic disorders of soaring risk. The imbalance in the level of lipoproteins in plasma leads to hyperlipoproteinemias, a group of disorders that affect lipid levels in serum causing coronary disease and atherosclerosis, conditions in which the cholesterol levels are important tools in their diagnosis and classification. Low total serum cholesterol values with normal ester fractions are noted mainly in hyperthyroidism and malnutrition. Abnormally low levels of cholesterol are termed hypocholesterolemia (Lewington *et al.,* 2007). Normal range of total cholesterol levels reported for healthy sheep by Cox-Ganser *et al*. (1994) is 1.33 – 1.95mmol/*l*.

Total protein is a biochemical test for measuring the total amount of protein in blood plasma or serum. The serum content of soluble proteins, those circulating in extracellular and intracellular fluids, has been used as a marker to aid clinical diagnosis. The main diagnostic tests are those measuring serum total protein and serum albumen. Collectively, serum total protein including albumen is mainly involved in: the maintenance of normal water distribution between tissue and the blood, responsible for maintaining the pressure of plasma and is used to transport many substances including macromolecules (Rastogi, 2008). The concentrations of plasma proteins remain constant even during dietary variations and normal conditions. Prolonged malnutrition, however affects the protein concentration. Normal physiological range of total protein values for sheep is 60 – 93g/*l* (Borjesson *et al.*, 2000).

Protein in plasma is made up of albumen and globulin. Albumen is made mainly in the liver. It helps to keep the blood from leaking out of blood vessels. Albumen also helps to carry some medicines and other substances through the blood and is important for tissue growth and healing (WebMD, 2009). In certain abnormal conditions the albumen content of the plasma is lowered. Concentrations below 2g/100ml, according to Rastogi (2008), are associated with oedema. Milne and Scott (2006) have reported a normal physiological range of 30 – 38g/*l* for albumen content in ovine blood. Globulins are made up of different proteins called alpha, beta and gamma types. Some globulins are made by the liver while others are made by the immune system. Certain globulins bind with haemoglobin and other transport metals such as iron in the blood and help fight infection (WebMD, 2009). Rastogi (2008) has also reported that globulins carry the lipid fraction of proteins and contain antibodies for generating immune response. The albumen/globulin ratio in the blood according to Singh (2003) is 1.2 – 1.5.

2.10 Pastures

A pasture is an area of land covered with forage crops usually grass and legumes, used for grazing. Forage crops are grasses or legumes grown mainly for feeding ruminant livestock. In Ghana, grasses used for establishing pasture include: Guinea grass (*Panicum maximum*), Bahama grass (*Andropogon gayanus*), elephant grass (*Pennisetum purpureum*), giant star grass (*Cynodon plectostachyus*) and carpet grass (*Axonopus compressus*). Leguminous plants suitable for pastures include: centrosema (*Centrosema pubescens*), stylo (*Stylosanthes graccilis*), tropical Kudzu (*Pueraria phaseoloides*) and pigeon pea (*Cajanus cajan*) (Addo, 2007). Good pasture management is crucial in animal production since differences between a well-managed and poorly-managed forage programme often show up in animal performance, milk production, conception rates and fewer days of feeding stored forage (Arseneau, 2010).

Characteristics of good pasture species, according to Addo (2007), include:

i. should be highly productive with a high forage yield per hectare
ii. must persist under various environmental conditions, for instance, should be able to withstand drought
iii. should be able to withstand grazing and recover after grazing
iv. should be easy to propagate and establish
v. should be fast growing
vi. should be highly palatable and nutritious
vii. must have a good associative ability and be able to mix well with other pasture species.

2.10.1 Types of pasture

There are two main types of pasture namely natural/native pasture and artificial/man-made/cultivated pasture.

Natural pasture/rangeland is an area of land covered with forage crops planted by nobody. The forage species may be annual or perennial. It is grazed upon any hour whether the forage is in its groom or not. Overgrazing is common as no proper maintenance is done. The nutritive value is usually low. The forage species are those that can tolerate fire and are more adapted to the environment. Examples in Ghana are Coastal savanna, Guinea savanna and Derived savanna. Natural pastures can be improved by the application of manure or the introduction of legumes to improve the nitrogen status of the soil.

Man-made pastures, unlike natural pastures, are planted and taken care of by man. Management practices like weed control, fertilizer application, irrigation, reseeding, rotational grazing and using the correct stocking rate during grazing are adopted. Types of man-made pasture include: annual pastures, perennial pastures, irrigated pastures and ley/rotational pastures. Annual pastures are those with species that complete their life cycle in one growing season. Such pastures need to be replaced from time to time. Pastures with species that survive vegetatively from year to year are known as perennial pastures. Irrigated pasture refers to legumes or fodder crops grown in arid areas to supplement dry season grazing for high producing stock such as dairy animals. Ley/rotational pasture refers to grasses and legumes for feeding livestock grown in rotation with arable crops (Addo, 2007).

2.10.2 Pasture establishment

Quality pastures are the powerhouse of any livestock enterprise. Healthy pastures mean healthy animals, an important goal for landholders of any scale. Successful pasture establishment needs proper preparation and planting which should start at least 12 months before the pasture is sown. To offer pastures the optimal conditions for establishment, the soil needs to be in the best condition possible before planting. Seeding is not the end of pasture establishment; newly established pastures need regular monitoring for pests and weeds. Ongoing pasture management in terms of grazing and fertilizer management will then determine the longevity and continued quality of the pasture (Department of Agricultural Farm note, 2008).

A farm's forage needs must be evaluated before establishing new pastures. It is important to reflect on how the forage will be used (grazing versus hay), what species might be adapted to the area and what resources (equipment, money, time) are available (Lemus, 2008). Steps involved in establishing or renovating include in chronological order: soil testing and correcting soil nutrient deficiencies, selecting the desired mixture of plant species adapted to a specific area, selecting seeding method, using proper management to maintain a productive stand (Arseneau, 2010).

A soil test should be taken to determine the nutrient status of the soil followed by fertilization to correct deficiencies. If soil pH is not in the appropriate range, nutrients may not be available for plant uptake. Moreover if legumes are a part of the forage programme, lime may need to be added to correct a low pH. Nutrients like nitrogen, phosphorus, potassium, sulphur and boron are the main nutrients considered in a pasture fertilization programme. They can be supplied as commercial fertilizer mix or composted manure spread evenly on the pasture. Legumes offer many advantages when included in a pasture mix. Among these are nitrogen contribution to grasses, increased production (during summer months) and increased forage quality.

Generally the seeding method is influenced by plant species, seed bed, and availability of equipment and site conditions. Turning the soil can lead to erosion, loss of soil organic matter and also creates a favourable environment for weeds. Certain situations, however, warrant the use of tillage. If tillage must be done, the objective should be to prepare smooth, firm, clod-free seed bed to provide for optimum seed placement and good seed-to-soil contact.

Grazing should be planned such that maximum forage production and quality will concur with the herd's maximum nutritional needs, such as during calving and breeding season. There are essentially two types of grazing systems namely continuous and rotational. In continuous grazing system, there are no subdivisions of pastures. This type of grazing requires less management skill and lower set-up costs (water systems and fence) but results in less beef produced per acre. Legumes, however, will generally not keep it up under continuous grazing. Stocking rates in continuous grazing system should be chosen to guarantee adequate forage availability during low production periods after the year.

In rotational grazing system, animals are rotated to different pastures or paddocks. Compared to continuous grazing, rotational grazing can increase the productivity of pastures which can lead to more pounds of beef per acre. It also gives plants a rest period to grow plant tops (leaves), be more competitive with weeds and regrow more quickly after grazing. Consequently, the real advantage of rotational grazing is healthier, fast growing and more productive pastures.

Animals can be moved to a new pasture when forage is at a predetermined height say 10 inches and let the animals graze it down to a certain height for example 4 inches. The animals can also be rotated when the forage in the next paddock is ready to be grazed which means getting the animals on that paddock while the forage is in a lush, vegetative state so that it does not overly mature and become low in quality. Throughout periods of swift grass growth, animals are rotated frequently between paddocks to keep up with the fast forage growth. If there is too much forage growth in a paddock before it can be grazed, it can be taken for hay. However, rotational grazing requires a higher degree of management, labour and increased costs for fencing and water supplies (Arseneau, 2010).

2.10.3 Fertility Management

Pastures should be soil tested every 2-3 years to find out their nutrient status and be fertilized according to soil test results to preserve yield. If legumes are a chief component of pastures, then soil pH and phosphorus and potassium levels should be the main focus of the fertilization programme because phosphorus and potassium are essential for legume persistence. Conversely, if grasses are the main component of a stand, yields can be significantly improved by fertilizing with nitrogen.

2.10.4 Weed management

Failure to effectively control weeds before seeding new pasture appreciably increases the risk of poor pasture establishment. Numerous pasture species, particularly grass species, will fail to compete successfully with weeds. Comprehensive weed control also considerably increases the number of perennial pasture species that can establish (Department of Agricultural Farm note, 2008). If weeds do become a problem, they can be chemically controlled or clipped before they develop seeds.

2.10.5 Problems of pasture establishment

A number of problems are associated with pasture establishment in Ghana. These, according to Addo (2007), include:

i. high cost of establishment

ii. unavailability of improved grass and legume seeds

iii. communal ownership of land which discourages farmers from investing in pasture establishment

iv. low interest in pasture establishment due to the fact that there is abundant natural grassland

v. inadequate knowledge and technical know-how with regard to pasture establishment

vi. seasonal damages by uncontrolled bush fires to natural and sown pastures

vii. weed encroachment and poor pasture management.

2.10.6 Cost of Pasture establishment

In the past few decades, there has been a tremendous amount of research dedicated to understanding, in scientific terms, the ways in which animals use feed and for that matter pasture species to maintain life, to grow, to reproduce and to produce all of the animal products which man uses. However, not much has been done, if anything at all, in the area of determining the cost of establishing pasture per acre of a given area of land. This is perhaps due to the fact that in tropical countries of which Ghana is no exception, animal production is often a secondary activity linked to growing crops or to the production of meat for special, perhaps religious, occasions.

Numerous indigenous and exotic species of grasses and legumes, according to Oppong-Anane (2006), have undergone trials at the agricultural research stations and the promising ones established as pastures on state owned and a few commercial and small holder farms. About 2,750 ha of forages have been established as pure grass and legume stands or as mixed pastures at these state-owned, few commercial and smallholder farms, while a further 110 ha of intensive fodder plots comprising mainly forage trees, and averaging 0.1 ha per plot, have been set up close to dwellings for zero grazing. Ghana has about 8,500 ha of sown pastures according to Oppong-Anane (2006), including rangelands over-sown with *Stylosanthes hamata* and *Andropogon gayanus* as well as forages introduced into plantation crops. Although the rate of establishing pastures in the country has generally been low, the role of sown pastures in supplementing grazing from natural pastures, and in particular during the dry season, is well acknowledged by both commercial and smallholder farmers. Reports on the cost of establishing pasture on a given area of land however are either difficult to come by or not available.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Location of experiment

The experiment was conducted at the Livestock Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, between May, 2009 and February, 2010. The experimental site lies between Latitude 06˚43'N and Longitude 1˚36'W. The trial site falls between the moist semi-deciduous forest belt of Ghana with a bimodal pattern of rainfall. The annual rainfall averages about 1193.6mm. The major wet season extends from late March to July with peak rainfall in April and May. After a relatively short dry spell in August, the minor wet season begins in September and tails off in November. This is followed by the major dry season in December through January to February (Osafo, 1976). Temperatures are generally high throughout the year. The mean maximum monthly temperature of about 34.0 ˚C occurs in February and March whilst the mean minimum monthly temperature of about 21.4 ˚C is recorded in August (Osafo, 1976).

3.2 Experimental animals and their management

Twenty four (24) Djallonké rams with an average weight of 14kg, were purchased from livestock open markets at Bantama, Ayeduasi and Kotei in the Kumasi Metropolis for the experiment which lasted for twelve (12) weeks after an adaptation period of 7 days. The animals were housed in individual well-ventilated and properly illuminated pens which had slatted floors. The housing unit was roofed with corrugated iron sheets. Each animal was identified by the number of pen in which it stayed as well as the treatment and replication numbers. The rams were individually housed in pens of dimensions: 3m x 1m. The pens which had slatted floors were identified by pen number, treatment and replicate number.

The pens were thoroughly cleaned and disinfected prior to the introduction of the animals. Feed and water troughs were also washed and disinfected. Each pen had two wooden feeding troughs (one for the basal diet and the other for the supplement) designed to minimize spillage and one plastic water trough. All animals were dipped and dewormed with Albendazole[1] 10%, a broad-spectrum antihelmintic, against external and internal parasites respectively.

3.3 Sources of feeds and preparation

Two varieties of Napier grass, the local variety and 16798, an improved hybrid variety obtained originally from the International Livestock Research Institute (ILRI), Ethiopia which had been maintained in a herbarium at the Department of Animal Science, KNUST were cultivated. The field measuring 94m x 73m (1.7155 acres) was ploughed and harrowed in early May, 2009. It was then left for four (4) weeks for the vegetation ploughed in to decompose to add organic matter to the soil. It was then divided into two halves with a walkway of two (2) metres in between.

Matured stems of both varieties were procured from previously established pastures at the experimental site (Department of Animal Science) for the preparation of the planting materials

[1]Albazol 10% - Pyvet Holland. Contains 100mg albendazole/1ml.

(cuttings). Each cutting had at least three (3) nodes. The cuttings or canes were planted 15-20 cm deep and inclined at an angle of about 30-45^{o} at a spacing of 60cm x 60cm after the field had been lined and pegged. The two halves of the field (which had received the same preparation) were used for the two varieties. Weeding was manually done with hoes twice after the fourth and eighth week to eliminate competition from weeds.

The supplement, Paper mulberry leaves, was harvested from mature trees at Abofour in the Offinso South District of Ashanti Region. The leaves were bagged and transported fresh soon after harvesting to the experimental site and air dried for two weeks. During drying the leaves were turned daily to curb mouldiness. The leaves were bagged after the drying process and stored for use during the feeding trial.

3.4 Experimental design

All the twenty four (24) rams were randomly allocated to the six treatments which were replicated four times. The experimental design was a 2x3 factorial in a Completely Randomized Design (CRD). The factors were two varieties of Napier grass (the Local variety and Improved) and three levels of Paper mulberry leaf supplement (0g, 100g and 200g/d). There were a total of six treatments which were: Loc0 (Local with 0g/d of supplement), Loc100 (Local with 100g/d of supplement), Loc200 (Local with 200g/d of supplement), Imp0 (Improved with 0g/d of supplement), Imp100 (Improved with 100g/d of supplement) and Imp200 (Improved with 200g/d

of supplement).

3.5 Diet and feeding

The grasses were harvested each morning, chopped into short lengths (5-10cm) with cutlass, weighed and offered to each animal individually at the rate of 50g/kg live weight. The feed troughs and drinkers were cleaned every morning prior to the supply of fresh feed and water for the day. The feed refusals were weighed back the following morning for each animal and the difference between quantity offered and quantity not eaten was the amount of feed eaten. Sample of the grasses were taken and dried in an oven for dry matter (DM) which was used in calculating the amount of DM offered.

The leaf supplements (which were well-dried to a moisture content of 9.5%) were also weighed each morning and fed to each animal (either 100g/d or 200g/d depending on the treatment) individually except the control groups that were offered none of the supplement. The refusals were weighed back the following morning to determine the amount eaten in a similar manner as was done with the grass basal diet. The supplements were offered at 8.00 a.m in the morning, an hour earlier before the basal diet at 9.00 a.m. Salt lick[1] was provided in each pen. Water was also provided ad libitum. All animals were weighed weekly prior to feeding in the morning. Medication was given when necessary.

[1]Mineral salt lick, Frankatson Ltd, Accra. Contains per 10kg: sodium 38.00%, calcium 1.00%, magnesium 0.50%, zinc 290mg/kg, manganese 180mg/kg, iodine 40mg/kg, iron 40mg/kg, cobalt 28mg/kg and selenium 6mg/kg.

3.6 Chemical Analysis

3.6.1 Sample Preparation

Dried samples of both varieties and that of the supplement (which had been previously air-dried) were dried at 60^0C for 48 hours and ground using a laboratory mill (Wiley mill) to pass through 1mm sieve screens for laboratory analyses. Chemical analysis to determine the dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemicellulose of the grass and crude protein (CP), crude fibre, ether extract, ash, acid detergent fibre (ADF) and neutral detergent fibre (NDF) of *Broussonetia papyrifera* were performed. The Proximate analysis (DM, CP, ash, ether extract and crude fibre) were performed according to the Association of Official Analytical Chemists (A.O.A.C, 1990). The NDF and the ADF fractions were determined following the technique described by Goering and Van Soest (1970).

3.6.2 Dry matter (DM)

Moisture or water is usually determined by the loss in weight that occurs in a sample upon drying to a constant weight in an oven. Moisture can or crucibles were weighed. Two (2) g of granular samples were also weighed and allowed to dry overnight in an air oven at 110^oC for 24 hours. The crucibles plus samples were cooled in a desiccator and re-weighed to determine the dry matter.

3.6.3 Ash

Ash, the inorganic residue, was obtained by burning a sample at 500^o C -600^o C. Ashing of a feed sample burns off all organic constituents, leaving behind the non-volatile mineral elements. Ash crucible was removed from oven, placed in desiccator, cooled and weighed. Then 2.0g of sample was weighed into porcelain crucible in duplicate and put into furnace for 2 hours at 600°C. Furnace was allowed to cool below 200°C and maintained for 20 minutes. Crucibles were placed in desiccators with stopper top, cooled and then weighed to determine the ash content.

3.6.4 Crude Protein

Two grams (2g) of the sample was weighed and transferred to a 500ml digestion flask. A spoonful of $CuSO_4$-$NaSO_4$ mixture (to act as catalyst) and 15ml of concentrated H_2SO_4 were added to the digestion flask. Boiling chips were added and the sample digested till the solution became colourless. The digest was cooled, diluted with a small quantity of distilled ammonia-free water and transferred to the distillation apparatus. The Kjeldahl flask was rinsed with successive small quantities of water. A 100ml conical flask containing 25ml of boric acid solution with a few drops of mixed indicator was placed and 50ml of 40% sodium hydroxide solution added to the test solution in the apparatus. The ammonia on boric acid was distilled and collected.

The solution was titrated against the standard acid until the first appearance of pink colour, i.e. the end-point. A reagent blank was ran with equal volume of distilled water and the titration volume subtracted from that of sample titration volume to determine the nitrogen content and subsequently the crude protein as:

% Crude Protein (CP) = Total Nitrogen (N_T) x 6.25(Protein factor)

3.6.5 Ether extract

A piece of filter paper was folded in such a way to hold the sample. It was wrapped around a 2nd filter, left open at the top like a thimble. A piece of cotton wool was placed at the top to evenly distribute the solvent as it dropped on the sample during extraction. The sample packet was placed in the butt tubes of the Soxhlet extraction apparatus.

The extraction flask was placed in an oven for about 5mins at 110 °C then cooled and weighed. The sample was extracted with petroleum ether for 2-3 hours without interruption by gentle heating. It was allowed to cool and the extraction flask dismantled. The ether was evaporated on a steam until no odour of ether remained and then cooled at room temperature. The extraction flask and its extract were re-weighed and recorded to determine the ether extract.

3.6.6 Neutral detergent fibre (NDF)

Neutral detergent solution was added to a 2.4 g sample placed in a refluxing beaker and refluxed for 60 minutes. The resultant solution was filtered and the residue washed with hot water. This was repeated three times and was followed by washing with acetone to remove any remaining plant pigments. The residue was transferred to a pre-weighed crucible and dried in an oven at 105˚C over night. The residue was then weighed after cooling to determine the NDF content.

3.6.7 Acid detergent fibre (ADF)

Acid detergent fibre was determined by placing 2.4 g of sample in a refluxing beaker and refluxed with acid detergent solution for 60 minutes. The refluxed samples were filtered and thoroughly washed with hot water followed by acetone to remove any remaining plant pigments. The residue was dried in a pre-weighed crucible in an oven at 105˚C overnight. The residue was weighed after cooling to determine the ADF content.

3.7 Animal parameters measured

Parameters measured during the trial included initial live weight, weekly weight gain which was used to derive the average daily gain, intake of supplement and intake of the grass basal diet. Feed intake was determined by subtracting feed refusals (which were weighed back every morning) from feed offered. Blood haematological and biochemical parameters were also measured.

3.8 Blood

Blood samples were taken with hypodermic needles from the jugular vein of all the animals at the end of the feeding trial into vacutainer tubes containing Ethylene diamine-tetra-acetate (EDTA) to keep the samples from clotting.

The plasma samples were stored in a freezer prior to analysis. The samples were allowed to thaw, after which they were shaken thoroughly. Capillary tubes were filled with the samples, sealed and then centrifuged at 3000 revolutions per minute (rpm) for 5 minutes using a micro-haematocrit centrifuge. The capillary tubes were removed after 4 to 5 minutes, for the determination of the packed cell volume (PCV) using the haematocrit counter. The haemoglobin (Hb) was determined spectrophotometrically, the red blood cell (RBC) and white blood cell (WBC) subsequently calculated as described by Doxey (1977), Greenwood (1977) and Potter (1986). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated as described by Jain (1986).

Total Protein was determined using the Biurets method as described by Singh (2003) while the albumen was also determined using the Bromocresol Green method (BCG) as described by Grant (1982). The globulin contents were calculated as the difference between the contents of total protein and albumen. Total cholesterol was determined using the Liebermann Burchard (LB) method as described by Ellefson (1982).

3.9 Cost of Pasture Production study

Records (kind of operation, type and quantity of input used, duration, unit and total costs) were kept on all activities and the costs involved in establishing the pasture (land preparation, preparation of planting materials, weeding and harvesting) to determine the cost of production of pasture per given area of land. Land preparation was carried out by ploughing and harrowing the field after which the land was left for two weeks for the weeds ploughed into the soil to decompose. After planting the cuttings, weeding was carried out twice with hoes before the pasture got fully established for the commencement of harvesting for feeding after 120 days.

3.10 Statistical analysis

The data from the feeding trial were analysed as Completely Randomised Design (CRD) in a 2x3 factorial design using analysis of variance and PROC general linear model (GLM) of SAS (2002) Statistical package.

CHAPTER FOUR

RESULTS

4.1 Overview

But for the few cases of loss of appetite, diarrhoea and orf, all rams remained healthy throughout the feeding trial. Multivitamin injections, administration of Sulphurthelazole (a sulphur-based drug), injections with Tylosine (an antibiotic) and the direct treatment of the sores around the mouth as a result of the orf were employed to quickly contain the situations as and when they occurred. Four rams died as a result of respiratory infections during the adaptation period and were replaced. As a protective measure, the remaining animals were put on Tylosine injections for three consecutive days. The wire netting upper part of the pen was also covered with black polythene sheets to protect the animals from the adverse cold during the nights and mornings during the period of the feeding trial. The supplemented rams consumed almost always all the supplement (*Broussonetia papyrifera* leaves) offered.

4.2 Feed Characteristics

4.2.1 Chemical composition of Napier grass (*Pennisetum purpureum*)

Table 4.1 shows the chemical composition of the two varieties of the Napier grass used (Local variety and Improved variety (16798)). Harvesting of the grass started 120 days after planting for the feeding trial. The dry matter contents for the two varieties were almost the same, 483.80g/kg and 482.60g/kg for the Local variety and Improved variety (16798) respectively. The organic matter content was higher for the Local variety (938.80g/kg) than the Improved variety (16798) which was 932.85g/kg DM. Also the Local variety was found to be higher in crude protein (96.50g/kg DM), NDF (729.85g/kg DM), ADF (531.97g/kg DM) and cellulose (419.90g/kg DM) than variety 16798 which recorded crude protein (92.98g/kg DM), NDF (724.90g/kg DM), ADF (472.66g/kg DM) and cellulose (383.30g/kg DM). However, hemicellulose was higher in variety 16798 (252.13g/kg DM) than in the Local variety which was 195.70g/kg DM.

Table 4.1 Chemical composition Napier grass *(Pennisetum purpureum)*

	Variety	
Chemical composition	**Local**	**Improved (16798)**
DM (g/kg)	483.80	482.60
OM (g/kg DM)	938.80	932.85
CP (g/kg DM)	96.50	92.98
NDF (g/kg DM)	729.85	724.90
ADF (g/kg DM)	531.97	472.66
Hemicellulose (g/kg DM)	197.88	252.24
Cellulose (g/kg DM)	419.90	383.30

DM – dry matter, OM – organic matter, CP – crude protein, NDF – neutral detergent fibre, ADF – acid detergent fibre.

4.2.2 Chemical composition of Paper mulberry (*Broussonetia papyrifera*)

The chemical composition of Paper mulberry used as supplement is given in Table 4.2. Dry matter recorded for the dried sample analysed was 905.0g/kgDM, crude protein was 205.0g/kgDM, ether extract was 100.0g/kgDM, ash was 132.0g/kgDM, ADF was 340.0g/kgDM, NDF was 430.0g/kgDM and hemicellulose was 90.0g/kgDM.

Table 4.2 Chemical composition of Paper mulberry (*Broussonetia papyrifera*)

Chemical composition	**Values**
Dry matter	905.0
Crude Protein (g/kgDM)	205.0
Ash (g/kgDM)	132.0
Ether Extract (g/kgDM)	100.0
Acid Detergent Fibre (g/kgDM)	340.0
Neutral Detergent Fibre (g/kgDM)	430.0
Hemicellulose (g/kgDM)	90.0

4.3 Live weight changes and feed intake of rams

Table 4.3 presents the results obtained from the feeding trial. Initial live weights of the rams were similar (P>0.05). However there were significant differences (P<0.05) in the final weights which could be attributed to treatment effects. Final live weight was improved significantly (P<0.05) by increasing supplement of Paper mulberry leaves with rams receiving 200g/d achieving the highest live weight. The final live weights were 18.00kg, 18.63kg and19.63kg from initial live weights of 13.75kg, 13.35kg and 14.20kg for supplement levels 0, 100 and 200g/d respectively. There was however, no significant effect (P>0.05) on final weight due to the variety of grass consumed (18.92kg vs 18.59kg).

Average daily gain (ADG) of rams even though increased with increase in the level of supplementation, was not significantly different (P>0.05) for all the treatments. These were 0.05kg, 0.06kg and 0.07kg for supplement levels 0, 100 and 200g/d respectively.

Variety of grass consumed did not also significantly affect (P>0.05) the average daily gain of the rams (0.06kg vs 0.06kg).

Table 4.3 Effect of level of supplementation on intake and average daily gain

	Variety							
	Local			Improved (16798)				
Sup. Level	**0**	**100**	**200**	**0**	**100**	**200**	**Se**	**Sig.**
Live weight								
Initial (kg)	13.50	13.50	15.25	14.00	13.25	13.13	0.567	NS
Final (kg)	17.88^{b}	18.63^{ab}	20.25^{a}	18.13^{b}	18.63^{ab}	19.00^{a}	0.583	*
ADG (kg)	0.05	0.06	0.06	0.05	0.06	0.07	0.005	NS
Intake (gDM/d)								
ADOff grass	771.82	760.47	816.38	788.28	780.86	756.64	29.13	NS
ADI grass	585.56	604.25	616.43	590.25	622.48	614.68	31.98	NS
SUPINT	0.00^{c}	99.11^{b}	184.29^{a}	0.00^{c}	97.47^{b}	191.48^{a}	2.259	***
TOTINT	585.56^{c}	703.36^{b}	800.72^{a}	590.25^{c}	719.95^{b}	806.16^{a}	32.67	**
Intake ($gM^{0.75}/d$)								
ADOff grass	43.57^{a}	41.78^{b}	40.90^{c}	43.53^{a}	41.97^{b}	40.55^{c}	0.250	***
ADI grass	33.06	33.02	30.80	32.59	33.25	32.95	0.741	NS
SUPINT	0.00^{c}	5.50^{b}	9.33^{a}	0.00^{c}	5.30^{b}	10.29^{a}	0.224	***
TOTINT	33.06^{c}	38.53^{b}	40.13^{a}	32.59^{c}	38.55^{b}	43.24^{a}	0.674	***

Within rows, means without letters are not significantly different (P>0.05) while those with different letters (a, b, c) are significantly different (P<0.05).

* P<0.05; ** P<0.01; *** P<0.001

Where ADOff – average daily offer, ADI – average daily intake, SU89PINT – supplement intake, TOTINT - total intake and ADG – average daily gain.

Both the amount of Napier grass offered to and intake of the grass by rams were similar ($P>0.05$) for all the treatments. However, total intake of the grass and supplement was significantly different ($P<0.01$). Total intake improved as the level of supplement increased from 0g/d to 200g/d. There was no substitution effect. There was no significant effect ($P>0.05$) on total intake due to variety of grass consumed (696.5g/d vs 705.5g/d). Variety by level of supplement interaction was absent ($P>0.05$). Intake of supplement was also highly significant ($P<0.001$) and increased linearly as the level increased from 0g/d to 200g/d for both varieties of grass that were used.

When the amount offered or consumed was expressed on metabolic size, amount of grass offered was highly significant ($P<0.001$). Amount of grass offered decreased significantly ($P<0.05$) as the level of supplement increased from 0g/d to 200g/d. There was no significant effect ($P>0.05$) due to the variety of Napier grass fed. Average daily intake of the grass was however similar ($P>0.05$). Total intake of grass and supplement expressed on metabolic size was significantly different ($P<0.001$). The total intake improved as level of supplement increased linearly from 0g/d to 200g/d. There was no significant effect on total intake expressed on metabolic size due to the variety of grass consumed (37.2g$M^{0.75}$/d vs 38.1 g$M^{0.75}$/d). Thus there was no interaction between variety and level of supplement.

4.4 Blood Parameters

4.4.1 Haematological assessment

Results of the haematological assessments carried out are presented in Table 4.4. Haemoglobin (Hb) content of the blood showed significant differences (P<0.05) which were attributable to the treatment effects. For the Improved variety (16798), there was a significant (P<0.05) increase in Hb content as the level of supplement increased to 200g/d for treatment Imp200 from an initial drop for Imp100 at 100g/d. The opposite was the case for the Local variety where there was a decrease in Hb content for treatment Loc200 with 200g/d of supplementation from Loc100 with 100g/d of supplementation. Thus there was an interaction between variety of grass consumed and level of supplementation.

Table 4.4 Haematological analysis on the ovine blood samples

	Variety							
	Local			Improved (16798)				
Sup. Level	**0**	**100**	**200**	**0**	**100**	**200**	**Se**	**Sig.**
Parameters								
Hb (g/*l*)	10.750^{ab}	10.950^{ab}	10.325^{b}	10.450^{ab}	10.250^{b}	11.525^{a}	0.3807	*
HCT (%)	32.600^{c}	62.925^{ab}	55.075^{b}	31.575^{c}	51.225^{b}	78.175^{a}	6.1738	***
RBC (x 10^{12}/ *l*)	7.475^{ab}	7.650^{a}	6.225^{ab}	7.425^{ab}	5.850^{b}	7.300^{ab}	0.5921	*
WBC (x 10^{9}/ *l*)	9.075	8.425	8.650	7.600	6.000	6.475	1.1128	NS
MCV (f *l*)	38.33^{b}	85.68^{a}	88.18^{a}	37.30^{b}	94.15^{a}	99.03^{a}	10.095	***
MCH (pg)	13.675^{b}	14.650^{b}	16.725^{ab}	13.825^{b}	18.075^{a}	15.900^{ab}	1.0643	*
MCHC (g/d*l*)	34.275^{a}	19.450^{b}	19.150^{b}	34.400^{a}	21.425^{b}	16.350^{b}	2.5020	***

Within rows, means with the same letter (a, b, c) are not significantly different (P>0.05). * P<0.05; ** P<0.01; *** P<0.001

Where Hb – Haemoglobin, HCT – Haematocrit (or PCV – Packed cell volume), RBC – Red blood cell, WBC – White blood cell, MCV – Mean cell volume, MCH – Mean cell haemoglobin, MCHC – Mean cell haemoglobin concentration

Packed cell volume (PCV) contents of the blood for the treatments were highly significant ($P<0.001$) as a result of the treatment effects. Supplementation generally led to a significant ($P<0.05$) increase in PCV content. There was an interaction between variety of grass consumed and level of supplement. In the Local variety, PCV content dropped significantly ($P<0.05$) when level of supplement was increased to 200g/d from 100g/d whereas in the Improved variety there was a significant ($P<0.05$) linear increase as level of supplement was increased from 0g/d to 200g/d.

There were significant differences ($P<0.05$) in the red blood cell (RBC) content of the blood which could be attributed to treatment effects. Interactions between variety and level of supplement were evident ($P<0.05$). With the local variety, RBC content dropped when the level of supplement was increased to 200g/d from 100g/d. On the contrary, in the Improved variety RBC content increased significantly ($P<0.05$) when level of supplement was increased to 200g/d after an initial drop with supplementation level of 100g/d.

White blood cell (WBC) contents were similar ($P>0.05$) for all the treatments. It is noteworthy however, that supplementation resulted in marginal decrease in WBC contents for both varieties of grass consumed.

There were significant differences ($P<0.001$) in the mean cell volume (MCV) content which could be credited to treatment effects. MCV content increased significantly ($P<0.05$) as the level of supplement increased linearly from 0g/d to 200g/d. There was no significant effect ($P>0.05$) that could be ascribed to the variety of grass consumed (70.7f*l* vs 76.8f*l*).

Differences in the content of mean cell haemoglobin (MCH) were significant ($P>0.05$) as a result of treatment effects. With the Local variety, MCH increased significantly ($P<0.05$) only when level of supplement was increased to 200g/d whereas with the Improved variety, MCH dropped when level of supplement was increased to 200g/d after an initial significant ($P<0.05$) increase at 100g/d. There was however no significant effect ($P>0.05$) on MCH due to the variety of grass consumed (15.0pg vs 15.9pg).

Differences in the mean cell haemoglobin concentration (MCHC) of the blood were highly significant ($P<0.001$) which could be attributed to treatment effects. Supplementation generally led to significant ($P<0.05$) reduction in MCHC for both varieties of grass. Accordingly, there was no significant effect ($P>0.05$) on MCHC due to the variety of grass consumed (24.3g/d*l* vs 24.1g/d*l*).

4.4.2 Biochemical assessment

The results obtained from the ovine blood biochemistry analysis carried out are presented in Table 4.5. There were no significant differences ($P>0.05$) in total cholesterol among the various treatments. Levels of supplementation and varietal differences did not influence ($P>0.05$) the values obtained for the content of total cholesterol.

There were significant differences ($P<0.05$) however in total protein content which could be credited to treatment effects. Total protein increased significantly ($P<0.05$) as the level of supplement increased from 0g/d to 200g/d. There was no significant effect (P>0.05) on total protein attributed to the variety of grass consumed (52.1g/*l* vs 53.0g/*l*). Interaction as a result of variety and level of supplement was consequently absent (P>0.05).

Albumen contents of the blood were similar (P>0.05) for all the treatments. Level of supplement as well as variety of grass consumed did not have any significant effect (P>0.05) on albumen content.

There were nonetheless significant differences (P<0.01) in the globulin content of blood. This could clearly be attributed to treatment effects. Supplementation significantly (P<0.01) led to an increase in the globulin content of the blood but there was no significant effect (P>0.05) on globulin content attributed to the variety of grass consumed (27.6g/*l* vs 29.8g/*l*).

Table 4.5 Biochemical analysis on the ovine blood samples

	Variety							
	Local			Improved (16798)				
Sup. Level	0	100	200	0	100	200	Se	Sig
Parameters								
Total Cholesterol (mmol/*l*)	0.7825	1.0500	0.9500	0.8000	1.000	0.8500	0.1135	NS
Total Protein (g/*l*)	41.450^{b}	57.725^{a}	57.025^{a}	39.825^{b}	61.350^{a}	57.750^{a}	5.1017	*
Albumen (g/*l*)	23.850	23.550	25.950	22.225	23.850	23.400	2.3772	NS
Globulin (g/*l*)	17.600^{b}	34.150^{a}	31.075^{a}	17.575^{b}	37.525^{a}	34.300^{a}	3.5911	**

Within rows, means with the same letter (a, b, c) are not significantly different (P>0.05). * P<0.05; ** P<0.01

4.5 Cost of pasture production

The records kept on the cost of pasture production study are presented in Table 4.6. Land preparation operations carried out on the 1.7- acre land used included ploughing and harrowing each of which cost twenty Ghana cedis (Gh¢20.0) and a total of forty Ghana cedis (Gh¢40.0) which amounted to 7% of the total cost. This service was provided by the Mechanisation Department of the Faculty. Ropes procured for lining and pegging prior to planting cost five Ghana cedis (Gh¢5.0) which was just 1% of the total cost. The planting materials used (mature stems of Napier grass) were already available at the Department and preserved in a herbarium.

Labour for harvesting the matured stems from the herbarium, their preparation (cutting the stems/canes into pieces with at least 3 nodes each) and subsequent planting for the two varieties at a spacing of 60cm x 60cm cost a total of one hundred and twenty Ghana cedis (Gh¢120.0). This cost amounted to 21% of the total cost. The pasture was weeded twice (two weeks and eight weeks after planting) before the canopy closed in. The total cost of the two weeding sessions, which involved five workers on each occasion, was two hundred and fifty Ghana cedis (Gh¢250.0). This constituted 44% of the total cost of establishing and harvesting the pasture.

Upon the commencement of the feeding trial, the grass was harvested from the pasture every morning and chopped for feeding consecutively for twelve weeks. Even though the herbage yield of the improved variety was higher than that of the local variety as reported by Ansah *et al*. (2010), the cost of harvesting and chopping the grass for feeding was the same since similar quantities were harvested from each plot every morning throughout the period of the feeding trial. The total cost of harvesting and chopping the grass over the twelve-week period amounted to one hundred and fifty Ghana cedis (Gh¢150.0) which was equivalent to 27% of the total cost.

The grand total of all the costs listed amounted to five hundred and sixty five Ghana cedis (Gh¢565.0) excluding the cost of the land on which the pasture was established as well as the cost of fencing the land.

Table 4.6 Record of activities on cost of pasture production study

SIZE OF FIELD: 94m x 73m (1.7155 acres)

OPERATION	DATE	INPUT	QUAN-TITY	DURATION (HRS/MINS)	COST/ UNIT	TOTAL COST	REMARKS
1.Ploughing of field	02/05/09	Tractor and plough	-	-	-	Gh¢20.0	
2.Harrowing of field	10/05/09	Tractor and harrow	-	-	-	Gh¢20.0	
3.Cost of ropes for lining and pegging	25/05/09	Rope	1	-	Gh¢5.0	Gh¢5.0	
4.Preparation of planting materials and planting of Local Variety of Napier grass	1-6/06/09	Labour	2	5 hours	Gh¢30.0	Gh¢60.0	Planting materials were already available at the department
5.Preparation of planting materials and planting of Improved Variety of Napier	7-12/06/09	Labour	2	5 hours	Gh¢30.0	Gh¢60.0	Planting materials were already available at the department
6.First weeding (hoeing) of established pasture	27/06/09 – 03/07/09	Labour	5	5 hours	Gh¢25.0	Gh¢125.0	
7.Second weeding(hoeing) of established pasture	09-15/08/09	Labour	5	5 hours	Gh¢25.0	Gh¢125.0	
8.Daily harvesting of Napier grass for 12 weeks	27/10/09 – 19/01/10	Labour	1	1 hour daily	Gh¢12.5 weekly	Gh¢150.0	
GRAND TOTAL						Gh¢ 565.0	

CHAPTER FIVE

DISCUSSION

5.1 Nature of feeds offered

5.1.1 Napier grass (*Pennisetum purpureum*)

The chemical composition of the two varieties of Napier grass used (the local and 16798 varieties) according to the results obtained, is comparable to those reported by Ansah *et al*. (2010). Compared to other varieties of Napier grass reported by Ansah *et al*. (2010), both varieties have a higher moisture (low dry matter) and cellulose content. The high moisture content is bound to increase the rate of deterioration of the grasses when improperly stored.

More importantly, both varieties have crude protein (CP) levels higher than the 70g/kg needed for voluntary intake in ruminants according to Nori *et al*. (2009). Also, the local variety had a higher crude protein value of 96.50g/kgDM than variety 16798 which had 92.98g/kgDM. This observation is also in accordance with findings of Ansah *et al*. (2010) who also reported a CP level of as high as 109.0g/kgDM of DM after 60 days of planting which depreciated to as low as 80.0g/kgDM of DM 120 days after planting. A similar trend that the nutritive value of pasture species varies greatly with the stage of maturity has been reported by both Speedy and Pugliese (1992) and Ranjhan (1999). This explains why the CP value reported in the current study was not as high as 109.0g/kgDM reported earlier by Ansah *et al*., (2010) since the chemical composition was assessed 120 days after planting when the feeding trial commenced.

The contents of DM, ADF and NDF were high compared to Ansah *et al*. (2010) and Bayble (2007) where Napier grass was harvested earlier than 120 days (60 and 90 days for instance). Peiretti (2009) has also reported an increase in DM, ADF and NDF contents with an increase in maturity date in safflower (*Carthamus tinctorius*)

5.1.2 Paper mulberry (*Broussonetia papyrifera*)

The crude protein (CP) content of Paper mulberry obtained (205.0g/kgDM) makes it a good and suitable supplement for ruminants as the need for supplementation of straws, fibrous feeds and low quality diets have been established and emphasized by the works of Bondi (1987), Norton *et al*. (1992), Ibrahim *et al*. (1994) and Liu *et al*. (1998) to mention a few. The organic matter contents (875.6g/kgDM and 880.00g/kgDM for mature and young leaves respectively) and ash contents (124.4g/kgDM and 120g/kgDM for mature and young leaves respectively) reported by Oduro (2009) are also a plus for the plant in this regard.

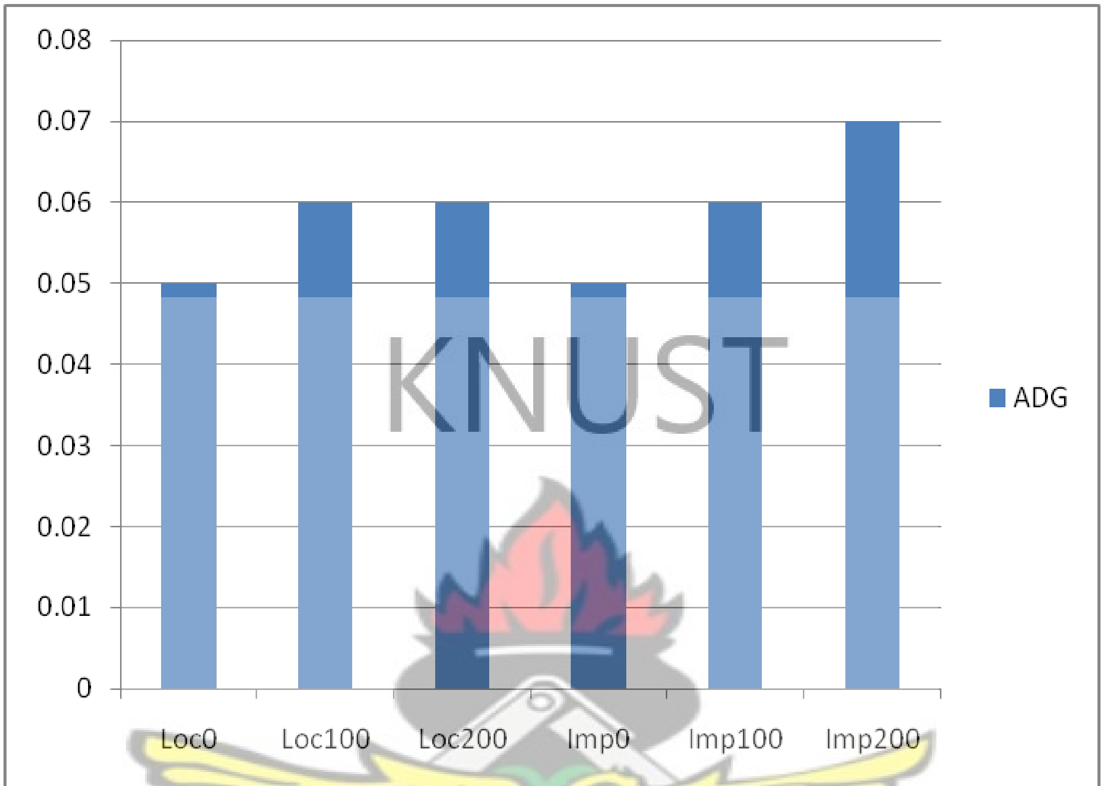
Furthermore, the chemical composition of Paper mulberry obtained in the current study compares favourably with those of other tree leaves like neem (*Azardirachta indica*), siris (*Albizzia lebbek*) and ardu (*Ailanthus excels*) reported by Raghuvansi *et al*. (2007) and the leaves and stems of Stylosanthes hamata reported by Attoh-Kotoku (2003). The dry matter content, however, is lower than those of the leaf supplements reference has been made to. The chemical composition is also comparable to the findings of Misra *et al*. (2000) and Nagpal and Arora (2002) who reported increased CP and reduced fibre contents in tree leave diets. Ventura *et al*. (2004) have also reported low levels of fibre fractions in tree leaves.

5.2 Effects of supplementation and variety on performance

The initial weights of the animals used showed that there was no significant difference across the various treatments. The means ranged from 13.13kg to 15.25kg. However, significant differences which were observed in final live weight showed that treatment effects were evident. Supplementation with Paper mulberry leaves had a positive impact generally on final live weight which improved linearly as the level of supplement of Paper mulberry increased. Thus the nitrogen supplementation provided by the Paper mulberry leaves (CP - 205g/kgDM) enhanced cellulolysis in the rumen which probably improved rumen microbial retention and supply as suggested by Bondi (1987). The increase in final weight could also be attributed to the high nitrogen content of the supplement which helped to improve the rumen's ecosystem thereby increasing the animal's ability to digest fibrous portions of the forage as reported by Preston and Leng (1987). Increase in weight gain in goats fed Napier grass basal diet supplemented with forage tree legumes has been reported by Van Eys et al. (1986) which goes to buttress the trend observed. The variety of Napier grass consumed did not affect final live weight gain perhaps because the CP contents of the two varieties were close: 96.50g/kgDM and 92.98g/kgDM for the Local and Improved varieties respectively.

Average daily gain (ADG) was not significantly different ($P>0.05$) for all treatments even though it was improved with increase in the level of supplementation (see Figure 5.1). Again, the increases observed in total intake across the treatments attributable to treatment effects did not impact positively on ADG. This observation could be attributable perhaps to the levels of supplementation which may have been low. The results generally showed some marginal increases in ADG with supplementation albeit not significant statistically. This is a pointer to the fact that had the levels of supplementation been increased beyond the 200g/d up to a certain threshold, perhaps the increases in ADG would have been apparent and significant. This is especially so as the levels of supplementation were positively correlated with total intake. Consequently, the levels used did not influence (P>0.05) ADG. Varietal differences did not influence ADG even though it appeared that treatment Imp200 responded comparatively better than Loc200 even though the margin of improvement was not significant (P>0.05). This is quite interesting because the Local variety has a slightly better CP content than the Improved (16798) variety. This observation perhaps could be attributed to a more severe impact of disease as a result of the short spells of ill-health during the feeding trial. In effect, treatment did not have any influence on ADG.

Figure 5.1 Effect of level of supplement on average daily gain (ADG) in kg.



Loc0: Local without supplementation, Loc100: Local with 100g of supplementation, Loc200: Local with 200g of supplementation, Imp0: Improved without supplementation, Imp100: Improved with 100g of supplementation, Imp200: Improved with 200g of supplementation.

The absence of any significant effect as a result of treatment differences in ADG could also be partly ascribed to the short spells of ill-health (respiratory infections mainly and orf) that affected a few of the animals across the various treatments and led to either a decrease or a stabilization in the ADG of the animals concerned for those respective weeks during the feeding trial. These short spells of ill-health however, did not lead to any mortality.

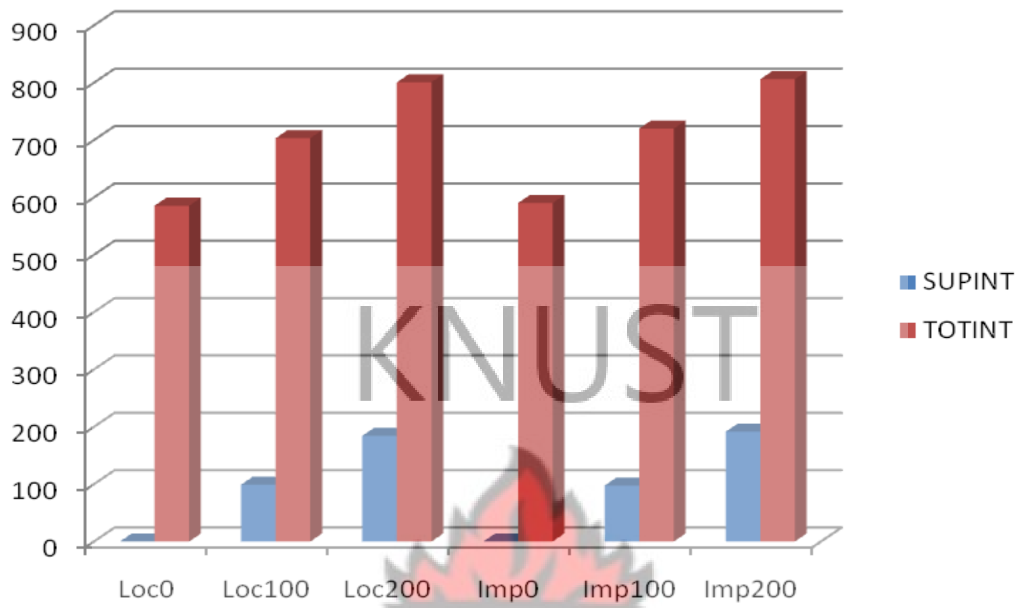
The non-existence of significant effects notwithstanding, the ADG values obtained were comparable to some earlier reports. Treatment Loc0 recorded an ADG of 0.05kg (50g) as against an ADG of 0.06kg (60g) for Loc100 and Loc200 while Imp0 on the other hand also recorded an ADG of 0.05kg (50g) as against 0.06kg (60g) and 0.07kg (70g) for Imp100 and Imp200 respectively. Theses ADG values are comparable to those of Njwe and Godwe (1989) who reported a live weight gain of 77g/d for Napier grass supplemented with soya bean flour and 41g/d for feeding solely Napier grass in sheep.

The results also show that there was no significant differences (P>0.05) in average daily offer since the amount of feed offered was directly proportional to the live weight of the animal. The same could be said for average daily intake of dry matter. Intake of supplement offered was highly significant (P<0.05) when expressed on the bases of both gDM/d and on metabolic body size. This is indicative of a high degree of acceptability of the supplement. Variety of grass consumed did not influence supplement intake because supplement intake increased linearly as the level of supplementation increased for both varieties. There was no substitution effect which meant more room for even further increases in the levels of supplement.

Total intake of grass and supplement was significantly affected (P<0.01) by treatment effects. Supplementation greatly enhanced total intake. Total intake improved linearly as the level of supplement was increased from 0g/d to 200g/d in both varieties of grass consumed (see Figure 5.2). This observation is a clear indication of the fact that supplementation had a positive impact on total intake. In consequence, variety of grass consumed did not affect (P>0.05) total intake. The level of supplementation however did influence (P<0.05) total intake because the higher the level of supplementation, the higher the total intake.

This trend of increase in feed intake is in conformity with Gatenby's (2002) contention that supplements are required to correct deficiencies thereby increasing basal feed intake and hence animal production. Thus the increase in the level of supplement meant an increase in CP and for that matter nitrogen needed to improve the rumen's eco-system and increase the animal's ability to digest fibrous portions of forage. Bammualin *et al*. (1984a, 1984b) have also reported an increase in feed intake and an overall improvement in diet digestibility with supplementation. Liu *et al*. (1988) have also reported a similar observation regarding mulberry leaves that the benefits of supplementation included an increased intake of basal diet.

Figure 5.2 Effect of supplementation on total intake (gDM/d)



Loc0: Local without supplementation, Loc100: Local with 100g of supplementation, Loc200: Local with 200g of supplementation, Imp0: Improved without supplementation, Imp100: Improved with 100g of supplementation, Imp200: Improved with 200g of supplementation.

5.3 Effects of treatments on blood parameters

Changes in concentration of blood components of ruminants have been used both as a criterion of nutrient status (Russel and Wright, 1983; Russel, 1984) and as an index of metabolic disturbance or toxicity (Puoli *et al.*, 1992). Jawasreh *et al*. (2010) have also reported that haematological and blood chemical tests have been widely used for the diagnosis of various animal diseases. Biochemical and haematological parameters assessed to find out the effects of the feed used on the well-being of the animals follow.

5.3.1 Haematological assessment

With the exception of the WBC count, all other haematological parameters measured were statistically significant (P<0.05).

Treatment effects were evident for the contents of Hb. The concentration of Hb declined with an increase in the level of supplement for treatment Loc200. Conversely, there was an improvement in Hb concentration when level of supplement was increased for treatment Imp200. Inconsequence whereas total increase in CP intake for Loc200 (100.5gDM/d) led to a decline in Hb concentration in the Local variety, it led to an increase rather in the Improved variety for treatment Imp200 with total CP intake of 98.2gDM/d. Thus, both the variety of grass consumed and the level of supplement influenced the concentration of Hb. The contrasting effects of treatment notwithstanding, the Hb concentrations of 10.325g/d*l* to 10.750g/d*l* and from 10.250g/d*l* to 11.525g/d*l* for the Local and Improved varieties respectively obtained were all within the normal physiological range of 8–16g/d*l* reported by Greenwood (1977).

The PCV values obtained were highly significant across the treatments. Only values recorded for treatment Loc0 and Imp0 (without any supplementation) were within the normal physiological range of 27-45% given by Jain (1993). It was clear that supplementation and increase in total CP intake resulted in higher PCV values outside the normal physiological range. Treatment effects on the content of PCV were present and varied. In treatment Loc100, PCV was significantly higher (P<0.001) than Loc200 even though total CP intake was higher for Loc200 (100.5gDM/d) than Loc100 (78.8gDM/d). In the Improved variety however, PCV levels increased linearly significantly (P<0.001) as the level of supplement and total CP intake increased. In consequence level of supplement and variety of grass consumed led to an increase in PCV beyond the normal range of reference values reported earlier for sheep and stated above.

While most of the RBC values obtained were comparable to the normal physiological range of 7.87-11.29 x10^{12}/L obtained by Fadiyimu *et al*. (2010), those of two treatments (Loc200 and Imp100) were slightly lower. Thus treatment differences as a result of level of supplement and variety of grass consumed were present. Compared to the reference values range of 9.0-15.0 x10^{12}/L reported by Greenwood (1977) however, RBC values obtained appeared much lower. This meant that level of supplementation (even though led to increases in total CP intake) and the variety of grass consumed did not increase RBC content. According to Ikhimioya and Imausen (2007), RBC count aids in the characterization of anaemia. Thus the low RBC values obtained for the treatments Loc200 and Imp100 could be an indication of susceptibility to anaemia-related disease condition by the animals within those two treatments. This is corroborated by the fact that those same treatments also had high MCV contents (88.18f*l* and 94.15f*l* respectively for Loc200 and Imp100) which were way outside the normal ranges of 28-40 f*l* (Jain, 1993) and 35.3-43.7f*l* (Borjesson *et al*., 2000). High MCV values, according to MERCK (1979) increases the probability of the release of immature red blood cells in the circulatory system. This observation was probably as a result of the few cases of loss of appetite, diarrhea and orf that were encountered in the cause of the feeding trial.

The values for WBC count obtained were all within the normal range of 6.93-12.66 x10^{9}/L (Fadiyimu *et al*., 2010) ideal for clinically healthy sheep signifying that the animals were generally quite healthy during the feeding trial since high WBC count could be in response to poor health status. High WBC counts in young ruminants may probably be due to environmental disposition in view of the fact that tropical environments are known to be havens of parasites (Coles, 1980). Among the various treatments, WBC contents were similar (P>0.05) showing that treatment effects as a result of level of supplementation and variety of grass consumed did not influence the WBC contents of the blood.

For MCV, significant differences were manifest (P<0.001) and only the values obtained for treatments Loc0 and Imp0 without any supplementation were within the normal physiological range of 28-40 *fl* (Jain, 1993) and 35.3-43.7*fl* (Borjesson *et al.*, 2000) reported for sheep. Supplementation led to a linearly significant (P<0.001) increase in the MCV content of the blood for both varieties of grass consumed. The increase in total CP intake as a result of supplementation augmented MCV content beyond the normal range of reference values for sheep.

In the case of MCH, significant differences (P<0.05) across the treatments as a result of treatment effects were evident. Except for treatments Loc0 and Imp0, all other values obtained for the treatments that received supplementation were slightly higher than the normal physiological range of 11.3-14.1pg reported by Borjesson *et al.* (2000). Supplementation therefore generally resulted in an increase in MCH content. With the local variety MCH content increased linearly as the level of supplementation increased from 0g/d to 200g/d but in the case of the improved variety, MCH content dropped when the level of supplementation was increased from 100g/d to 200g/d.

Finally, the MCHC count also showed significant differences (P<0.05) across the treatments. Only the values obtained for treatments Loc0 and Imp0 were within the range 30.3-34.3g/dl reported by Borjesson *et al*., (2000). MCHC dropped linearly as supplementation increased for both varieties of grass consumed. Supplementation and for that matter increase in total CP intake resulted in a general reduction in the content of MCHC.

It is interesting to note that increases in the level of supplement from 0g/d to 200g/d led to increases in most of the haematological parameters beyond the normal reference ranges of values, perhaps due to the enhanced N intake. The parameters in question were PCV, MCV, MCH and MCHC. In all these parameters, only the treatments without any supplementation had values that were comparable to the stated reference values.

5.3.2 Biochemical assessment

From the results of the biochemical parameters measured, total cholesterol of the blood showed no significant differences (P>0.05) across the treatments. The ranges of 0.783-1.050 mmol/*l* and from 0.800-1.00 mmol/*l* for the local and improved varieties respectively were outside and lower than the normal physiological range of 1.33-1.95 mmol/*l* (52-76 mg/d*l*) reported by Cox-Ganser *et al*. (1994) for healthy sheep. This comparatively low total cholesterol level is indicative of the fact that treatment differences as a result of variety of grass consumed and levels of supplement did not influence the content of total cholesterol. However, values for treatments Loc100 and Imp100 were comparable to the normal range of values stated above. Thus for total cholesterol content of the blood, increase in the level of supplementation from 100g/d to 200g/d brought about a decline for both varieties of grass consumed.

Total protein concentration values were statistically different (P<0.05) across the treatments showing evidence of treatment effects. Supplementation generally raised the total protein level of the blood in both varieties of grass consumed. These raised total protein values were however still lower than the normal range of 60 – 93g/*l* (6.0 – 9.3g/d*l*) reported by Borjesson *et al*. (2000) with the exception of that of treatment Imp100 that was within the normal range. Thus increase in total CP intake due to supplementation generally resulted in corresponding increases in total protein content of the blood, with the highest increase observed in treatment Imp100.

Albumen contents of the blood were not affected (P>0.05) by treatment effects. All the values obtained were outside the normal range of 30-38 g/*l* for healthy sheep according to Milne and Scott (2006). The values for albumen contents were all lower than the normal range of values that have been reported earlier. Not even the increases in total CP intake as a result of supplementation could elevate the albumen contents to the normal levels stated above. The increases observed attributable to treatment effects had no statistical significance.

Globulin content however were significantly affected (P<0.01) by the treatment effects. The globulin contents were significantly higher in the treatments that received supplementation. All the treatments that received supplementation recorded values that were within the normal physiological range of 30-48 g/*l* (Milne and Scott, 2006) for clinically healthy sheep. In consequence the increase in total CP intake as a result of supplementation generally improved the globulin contents of the blood. Differences in globulin contents observed as a result of variety of grass consumed were not significant.

In conclusion, variations in blood parameters as observed in the foregone discussion have been reported in animals due to several factors. These include: altitude, management, feeding level, age, sex, breed, health status, method of blood collection, hematological techniques used, diurnal and seasonal variation, ambient temperature, and physiological status of the animal (Sherman and Mary, 1994; Tripathi *et al*., 2008). Egbe-Nwiyi *et al*. (2000) have also reported that fluctuations in some haematological parameters of animals could be due to undetected minor infections, weather extremities and management. Subsequently the normal physiological reference values of different blood parameters for animals are bound to differ as a result of the factors afore-mentioned. This probably explains why some of the values obtained differed when compared to the normal physiological ranges or reference values reported in earlier works for healthy sheep.

5.4 Cost of Pasture Production

In respect of the total herbage yield of the two varieties of Napier grass planted, the improved variety (16798) with 44994.4 kgDM/ha is higher than the local variety with 41050.2 kgDM/ha 120 days after planting as reported by Ansah *et al.* (2010) whose work provided the basis for which the two varieties used were selected.

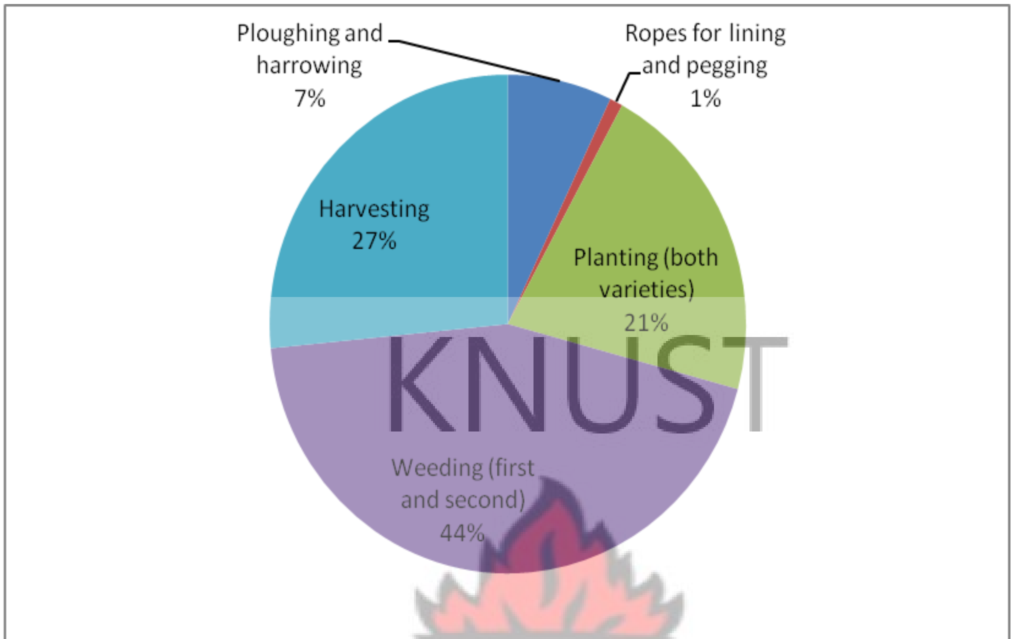
The total size of land planted was 1.7 acres which was divided into two, one half for each variety. Thus each variety was planted on a plot of size 0.85 acres. Going by the total herbage yield established above, the local variety produced an estimated herbage yield of 13957 kgDM/ha while the improved variety produced an estimated herbage yield of 15298 kgDM/ha.

Put together, the total herbage yield of the two varieties on the 1.7 acre land was 29255 kgDM/ha. The total cost of establishing the pasture and harvesting daily to feed 24 sheep for three months consecutively stood at five hundred and sixty five Ghana cedis (Gh¢565.00) excluding the cost of land on which the pasture was established. See Table 5.1 for a breakdown of the total cost and Figure 5.3 for a pictorial representation of the various items as percentages of the total cost.

Table 5.1 Total cost (excluding cost of land) of Pasture Production

Operation	**Cost (Gh¢)**
Ploughing and harrowing	40.0
Ropes for lining and pegging	5.0
Planting (both varieties)	120.0
Weeding (first and second)	250.0
Harvesting	150.0
Total	565.0

Figure 5.3 Pie chart of the total cost (excluding cost of land) of pasture production.

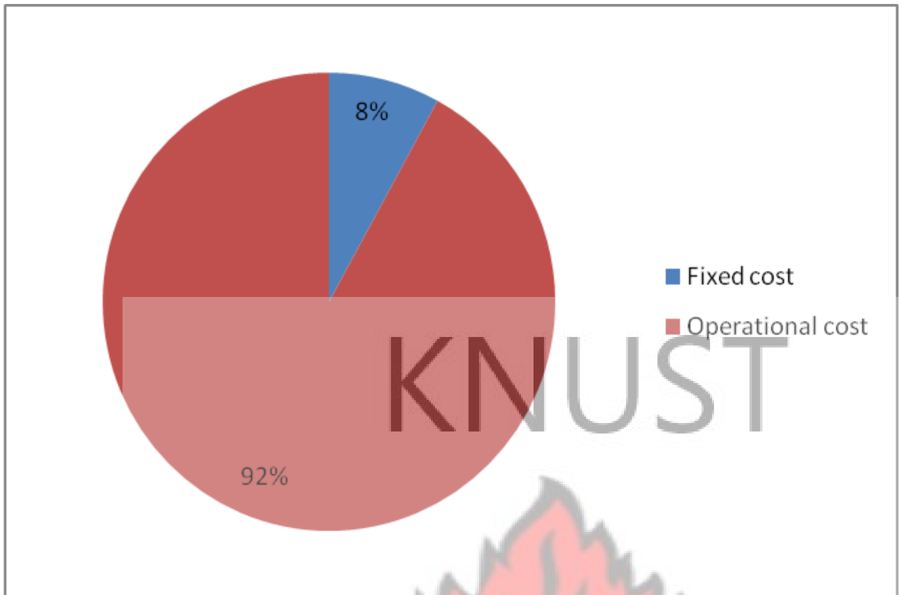


The total cost of Pasture production expressed as fixed and operational costs and the accompanying pictorial representation are shown in Table 5.2 and Figure 5.4 are found below.

Table 5.2 Fixed and Operational Costs of Pasture Production

Fixed Cost	
Operation	**Cost (Gh¢)**
Ploughing and harrowing	40.0
Rope for lining and pegging	5.0
Total	45.0
Operational Cost	
Operation	**Cost (Gh¢)**
Planting (both varieties)	120.0
Weeding (first and second)	250.0
Harvesting	150.0
Total	520.0
Grand total (fixed and operational)	565.0

Figure 5.4 Pie chart of total cost (excluding cost of land) as fixed and operational costs.



From the results of the feeding trial, a total intake of 585.56gDM/d (0.5856kgDM/d) without supplementation provided an average daily gain (ADG) of 0.05kg for sheep weighing averagely 13.5kg and being fed 50g/kg live weight. Therefore if 0.5856kgDM/d could provide an ADG of 0.05kg, then by simple proportion a herbage yield of 13957kgDM/ha (for the local variety) will provide a total ADG or live weight gain of 1191.68kg. By a similar calculation, the yield of 15298kgDM/ha for the improved variety will also provide a total live weight gain of 1306.18kg. Therefore the total herbage yield of 29255kgDM/ha can provide a total live weight gain of 2497.86kg when fed to sheep weighing averagely 13.5kg at 50g/kg live weight daily without supplementation. In consequence, the total cost of producing the said quantity of grass that could provide the stated kilogrammes of live weight is five hundred and sixty-five Ghana Cedis (Gh¢565.0) excluding the cost of land. The cost per live weight gain in kilogrammes from the calculations above is Gh¢0.23 (which is even not up to half of a cedi) and the current price of a kilogramme of mutton at the Kumasi Abattoir is four

Ghana cedis (Gh¢4.0). Thus it makes a lot of economic sense to establish the pasture for feeding sheep when the cost per live weight gain is related to the cost of a kilogramme of mutton on the market. It is however noteworthy that since fixed cost cannot be charged to the enterprise in just one season or year, the cost per live weight gain could even be lower since pastures could remain productive for several years.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study suggests that based on chemical composition and acceptability, the two varieties of Napier grass used (the local variety and variety 16798) are suitable for feeding sheep and for that matter ruminants in the country. More importantly, the crude protein levels of the Napier grass varieties used are higher than even the 70g/kg needed for voluntary intake in ruminants. The study further suggests that to maximize utilization of grass basal diets and achieve a high level of productivity, Napier grass (even though a good resource) needs to be supplemented adequately with Paper mulberry leaves.

The study also showed that Paper mulberry compares favourably with other species used as leaf supplements in ruminant nutrition in respect of the chemical composition and its acceptability by sheep as observed in the study. A strong case of the suitability of Paper mulberry as a leaf supplement for small ruminants has thus been established.

Supplementation of Napier grass basal diet with Paper mulberry increased total feed intake. No substitution effect was observed therefore higher levels of Paper mulberry leaves (that is above 200g/d) could be fed as supplement. Final live weight gain of rams improved linearly as the level of supplementation increased with 200g/d achieving the highest final live weight gain even though this did not translate into a significant improvement in ADG. However, the ADG values obtained compared favourably to those reported earlier by Njwe and Godwe (1989) for feeding Napier grass to sheep with and without supplementation.

There were fluctuations in the haematological and biochemical parameters or indices measured. While some were within the normal ranges of values reported in earlier works, others were outside the normal ranges. However, no major adverse effect as a result of treatment was observed as the rams were generally healthy during the feeding trial.

As a final point, the total cost of establishing the Napier grass pasture and harvesting daily for twelve (12) weeks to feed twenty four (24) rams weighing averagely 13.5kg for three months consecutively stood at five hundred and sixty five Ghana cedis (Gh¢565.00) excluding the cost of land on which the pasture was established. The cost of pasture per live weight gain of rams (Gh¢0.23) in kilogrammes compared to the current price of a kilogramme of mutton at the Kumasi Abbattoir (Gh¢4.0) shows that it makes economic sense to venture into pasture establishment for feeding sheep.

6.2 Recommendations

The following recommendations are made:

First, further work with higher levels of supplementation with Paper mulberry leaves should be carried out to determine the full impact of supplementing Napier grass with Paper mulberry on growth performance of rams as well as the most suitable level of supplementation.

Again, the effects of supplementation with Paper mulberry leaves on ovine blood haematological and biochemical parameters of Djallonké sheep could be explored further and compared with those that have been observed in this study because some of the parameters measured differed significantly outside the normal physiological ranges reported in the literature even though there are several reasons why this may occur.

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APPENDIX 1: ANALYSIS OF VARIANCE (ANOVA) TABLES

Appendix 1.1 ANOVA tables for feeding trial

Dependent Variable: ADOffDM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	9525.8360	1905.1672	0.28	0.9177
Error	18	122232.2074	6790.6782		
Corrected Total	23	131758.0434			

R-Square	Coeff Var	Root MSE	ADOffDM Mean
0.072298	10.57737	82.40557	779.0742

Dependent Variable: ADIDM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	4494.5850	898.9170	0.11	0.9887
Error	18	147250.1178	8180.5621		
Corrected Total	23	151744.7028			

R-Square	Coeff Var	Root MSE	ADIDM Mean
0.029619	14.93482	90.44646	605.6079

Dependent Variable: SUPINT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	141406.9726	28281.3945	693.00	<.0001
Error	18	734.5841	40.8102		
Corrected Total	23	142141.5566			

R-Square	Coeff Var	Root MSE	SUPINT Mean
0.994832	6.697021	6.388288	95.39000

ANOVA tables for feeding trial (continued)

Dependent Variable: TOTINTDM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	187830.5256	37566.1051	4.40	0.0086
Error	18	153658.4765	8536.5820		
Corrected Total	23	341489.0021			

R-Square	Coeff Var	Root MSE	TOTINTDM Mean
0.550034	13.18031	92.39363	700.9975

Dependent Variable: ADOffDMgBM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	34.93236667	4.36654583	8.75	0.0002
Error	18	7.48156667	0.49877111		
Corrected Total	23	42.4139333			

R-Square	Coeff Var	Root MSE	ADOffDMgBM Mean
0.823606	1.679585	0.706237	42.04833

Dependent Variable: ADIDMgBM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	16.58447083	3.31689417	0.75	0.5936
Error	18	79.10002500	4.39444583		
Corrected Total	23	95.68449583			

R-Square	Coeff Var	Root MSE	ADIDMgBM Mean
0.173325	6.427801	2.096293	32.61292

ANOVA tables for feeding trial (continued)

Dependent Variable: SUPINTgBM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	388.0127208	77.6025442	193.95	<.0001
Error	18	7.2019750	0.4001097		
Corrected Total	23	395.2146958			

R-Square	Coeff Var	Root MSE	SUPINTgBM Mean
0.981777	12.47720	0.632542	5.069583

Dependent Variable: TOTINTgBM

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	342.6330833	68.5266167	18.88	<.0001
Error	18	65.3420500	3.6301139		
Corrected Total	23	407.9751333			

R-Square	Coeff Var	Root MSE	TOTINTgBM Mean
0.839838	5.056267	1.905286	37.68167

Dependent Variable: INITBW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	12.30208333	2.46041667	0.96	0.4683
Error	18	46.18750000	2.56597222		
Corrected Total	23	58.48958333			

R-Square Coeff Var Root MSE INITBW Mean

0.210329 11.63230 1.601865 13.77083

ANOVA tables for feeding trial (continued)

Dependent Variable: FINBW

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	14.000000	2.8000000	1.03	0.4305
Error	18	49.000000	2.7222222		
Corrected Total	23	63.000000			

R-Square	Coeff Var	Root MSE	FINBW Mean
0.222222	8.799551	1.649916	18.75000

Dependent Variable: ADG

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.00086771	0.00017354	0.83	0.5426
Error	18	0.00374625	0.00020813		
Corrected Total	23	0.00461396			

R-Square	Coeff Var	Root MSE	ADG Mean
0.188062	25.40256	0.014427	0.056792

Appendix 1.2 ANOVA tables for blood haematological parameters

Dependent Variable: HCT

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6432.212083	1286.442417	8.44	0.0003
Error	18	2744.357500	152.464306		
Corrected Total	23	9176.569583			

R-Square	Coeff Var	Root MSE	HCT Mean
0.700939	23.77786	12.34764	51.92917

Dependent Variable: MCV

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	15955.20500	3191.04100	7.83	0.0005
Error	18	7337.92000	407.66222		
Corrected Total	23	23293.12500			

R-Square	Coeff Var	Root MSE	MCV Mean
0.684975	27.36787	20.19065	73.77500

Dependent Variable: MCHC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1291.720000	258.344000	10.32	<.0001
Error	18	450.725000	25.040278		
Corrected Total	23	1742.445000			

R-Square	Coeff Var	Root MSE	MCHC Mean
0.741326	20.69918	5.004026	24.17500

Dependent Variable: Hb

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	4.60333333	0.92066667	1.59	0.2138
Error	18	10.43500000	0.57972222		
Corrected Total	23	15.03833333			

R-Square	Coeff Var	Root MSE	Hb Mean
0.306107	7.110303	0.761395	10.70833

ANOVA tables for blood haematological parameters (continued)

Dependent Variable: RBC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	11.36375000	2.27275000	1.62	0.2052
Error	18	25.24250000	1.40236111		
Corrected Total	23	36.60625000			

R-Square	Coeff Var	Root MSE	RBC Mean
0.310432	16.94760	1.184213	6.987500

Dependent Variable: MCH

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	60.5850000	12.1170000	2.67	0.0562
Error	18	81.5600000	4.5311111		
Corrected Total	23	142.1450000			

R-Square	Coeff Var	Root MSE	MCH Mean
0.426220	13.75535	2.128641	15.47500

Dependent Variable: WBC

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	30.8770833	6.1754167	1.25	0.3288
Error	18	89.1525000	4.9529167		
Corrected Total	23	120.0295833			

R-Square	Coeff Var	Root MSE	WBC Mean
0.257246	28.88716	2.225515	7.704167

Appendix 1.3 ANOVA tables for blood biochemical parameters

Dependent Variable: TotChol

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	0.24452083	0.04890417	0.95	0.4736
Error	18	0.92707500	0.05150417		
Corrected Total	23	1.17159583			

R-Square	Coeff Var	Root MSE	TotChol Mean
0.208707	25.06529	0.226945	0.905417

Dependent Variable: TotProt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1745.667083	349.133417	3.35	0.0258
Error	18	1873.992500	104.110694		
Corrected Total	23	3619.659583			

R-Square	Coeff Var	Root MSE	TotProt Mean
0.482274	19.42746	10.20346	52.52083

Dependent Variable: Globulin

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1566.237083	313.247417	6.07	0.0018
Error	18	928.532500	51.585139		
Corrected Total	23	2494.769583			

R-Square	Coeff Var	Root MSE	Globulin Mean
0.627808	25.02173	7.182280	28.70417

Dependent Variable: Albumen

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	29.3220833	5.8644167	0.26	0.9294
Error	18	406.8875000	22.6048611		
Corrected Total	23	436.2095833			

R-Square	Coeff Var	Root MSE	Albumen Mean
0.067220	19.97321	4.754457	23.80417

APPENDIX 2: Raw data for intake trial

Obs	Var	Rep	SuppOff	ADOffDM	ADIDM	SUPINT	TOTINTDM
1	LOCAL	1	100	690.77	499.79	100.00	599.79
2	LOCAL	1	200	900.32	620.58	165.54	786.12
3	IMPRV	1	100	694.11	510.63	95.36	605.98
4	IMPRV	1	200	781.4	641.91	184.29	826.20
5	LOCAL	1	0	786.9	591.27	0.00	591.27
6	IMPRV	1	0	808.84	595.51	0.00	595.51
7	IMPRV	2	0	833.92	621.82	0.00	621.82
8	LOCAL	2	0	752.91	569.15	0.00	569.15
9	IMPRV	2	200	806.35	639.61	197.26	836.87
10	IMPRV	2	100	710.41	547.8	95.12	642.92
11	LOCAL	2	200	710.61	519.18	188.57	707.75
12	LOCAL	2	100	715.36	544.92	100.00	644.92
13	LOCAL	3	100	721.23	592.29	96.67	688.96
14	LOCAL	3	200	749.13	557.87	184.11	741.98
15	IMPRV	3	100	767.39	615.38	99.40	714.78
16	IMPRV	3	200	676.77	553.15	187.92	741.07
17	LOCAL	3	0	794.61	605.2	0.00	605.20
18	IMPRV	3	0	786.21	607.56	0.00	607.56
19	IMPRV	4	0	724.14	536.12	0.00	536.12
20	LOCAL	4	0	752.86	576.61	0.00	576.61
21	IMPRV	4	200	762.04	624.06	196.43	820.49
22	IMPRV	4	100	951.53	816.1	100.00	916.10
23	LOCAL	4	200	905.45	768.08	198.93	967.01
24	LOCAL	4	100	914.52	780.00	99.76	879.76

Obs: Observation

Var: Variety

Rep: Replication

SuppOff: Supplement offered

ADOffDM: Average daily offer dry matter

ADIDM: Average daily intake dry matter

SUPINT: Supplement intake

TOTINTDM: Total intake dry matter

Raw data for intake trial (continued)

Obs	ADOfDMgKgL	ADIDMgKgLW	SUPINTgKgLW	TOTINTgKgLW	ADOffDMgBM
1	47.14	34.11	6.82	40.93	41.19
2	46.72	32.21	8.59	40.80	42.10
3	47.37	34.85	6.51	41.35	41.39
4	45.76	37.59	10.79	48.38	40.71
5	49.66	37.31	0.00	37.31	43.81
6	49.37	36.35	0.00	36.35	43.72
7	49.17	36.66	0.00	36.66	43.71
8	49.56	37.46	0.00	37.46	43.50
9	46.49	36.87	11.37	48.25	41.43
10	47.36	36.52	6.34	42.86	41.50
11	45.17	33.00	11.99	44.99	39.81
12	47.45	36.14	6.63	42.78	41.61
13	47.12	38.69	6.31	45.01	41.39
14	45.30	33.73	11.13	44.86	40.16
15	47.06	37.74	6.10	43.83	41.65
16	45.23	36.97	12.56	49.53	39.63
17	49.31	37.55	0.00	37.55	43.58
18	49.14	37.97	0.00	37.97	43.40
19	49.55	36.68	0.00	36.68	43.28
20	49.43	37.86	0.00	37.86	43.40
21	45.55	37.30	11.74	49.04	40.43
22	47.95	41.12	5.04	46.16	43.32
23	45.98	39.00	10.10	49.11	41.52
24	47.65	40.64	5.20	45.84	42.92

Obs: Observation

ADOffDMgKgL: Average daily offer dry matter, g/kg live weight

ADIDMgKgLW: Average daily intake dry matter, g/kg live weight

SUPINTgKgLW: Supplement intake, g/kg live weight

TOTINTgKgLW: Total intake, g/kg live weight

ADOffDMgBM: Average daily offer dry matter, g/metabolic body size

Raw data for intake trial (continued)

Obs	ADIDMgBM	SUPINTgBM	TOTINTgBM	INITBW	FINBW	ADG
1	29.80	5.96	35.76	12.0	17.0	0.060
2	29.02	7.74	36.76	18.0	20.5	0.018
3	30.45	5.69	36.13	12.0	16.5	0.054
4	33.44	9.60	43.04	13.0	19.5	0.065
5	32.92	0.00	32.92	14.0	17.5	0.036
6	32.19	0.00	32.19	15.0	18.5	0.042
7	32.59	0.00	32.59	15.0	19.0	0.048
8	32.88	0.00	32.88	13.0	17.0	0.048
9	32.86	10.14	43.00	13.5	20.0	0.071
10	32.00	5.56	37.56	12.0	17.50	0.065
11	29.09	10.57	39.65	13.5	18.5	0.054
12	31.69	5.82	37.51	14.0	17.5	0.042
13	33.99	5.55	39.54	12.0	18.0	0.065
14	29.90	9.87	39.77	13.0	20.0	0.083
15	33.40	5.40	38.79	13.0	18.50	0.065
16	32.39	11.00	43.39	13.0	17.0	0.048
17	33.19	0.00	33.19	14.0	19.0	0.06
18	33.54	0.00	33.54	14.0	18.0	0.048
19	32.04	0.00	32.04	12.0	17.0	0.060
20	33.24	0.00	33.24	13.0	18.0	0.054
21	33.11	10.42	43.53	13.0	19.5	0.077
22	37.16	4.55	41.71	16.0	22.0	0.065
23	35.22	9.12	44.34	16.5	22.0	0.065
24	36.60	4.68	41.29	16.0	22.0	0.07

Obs: Observation

ADIDMgBM: Average daily intake dry matter, g/metabolic body size

SUPINTgBM: Supplement intake, g/metabolic body size

TOTINTgBM: Total intake, g/metabolic body size

INITBW: Initial body weight

FINBW: Final body weight

ADG: Average daily gain