Assessment of Some Productive and Reproductive Traits of Sudan Desert Goats under Conventional and Supplemented Feeding Systems

By

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To my lovely sons Hani and Mustafa (Abdia)

To my parents and my wife Hussna with love

To war affected people of Darfur

for their patience and sacrifices I dedicate

this humble work.

Bushara
ACKNOWLEDGEMENT

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ABSTRACT

This study was undertaken to evaluate the productive and reproductive performance of Sudanese Desert goats under the traditional management systems with supplemented feed containing different energy levels with iso-nitrogenous protein. Also to investigate the effects of rainy and dry seasons on the productive and reproductive performance of desert goats. Hence, the experiment was undertaken to evaluate the effects of supplemented feed with three different levels of energy and iso-nitrogenous protein (A,B,C) compared to unsupplemented feed group (D) on kids performance (birth weight, weaning weight, post-weaning weight and mortality), productive performance (milk yield, lactation period, milk composition and indices of doe productivity) and reproductive performance (kidding interval, gestation length, litter size, post-partum anestrus and puberty). Experiment was also undertaken to determine the effect of season mainly rainy and dry periods on kids performance, productive performance and reproductive performance.

Kid's performance analysis demonstrated that the birth weight, weaning weight, post-weaning weight and kid's mortality percentage was positively affected by feeding supplemented groups; high energy (A), medium energy (B) and low energy (C) compared with unsupplemented group (D). Exception with kid's mortality, kid's performance differed significantly (P<0.05). Supplemented feed group containing higher energy (A) secured the highest values compared with unsupplemented group (D). Also, the effect of season (rainy and dry) analysis on the kid's performance was demonstrated. Rainy season compared with dry season differed significantly (P<0.05). Kid's performance of those kidded on rainy season had secured the highest values compared with kid's borned on dry season.
Reproductive performance of the experimental goats analysis demonstrated that the gestation yield, kidding interval, litter size, post partum anestrus and puberty was affected by feed supplemented groups; high energy (A), medium energy (B) and low energy (C) compared with unsupplemented group (D). Exception with litter size, reproductive performance of experimental goats differed significantly (P<0.05). Supplemented feed group containing higher energy (A) secured the superior values compared with unsupplemented group (D). The effect of season on reproductive performance was also analyzed. Reproductive performance of experimental goats differed significantly (P<0.05). Reproductive performance of experimental goats on rainy season secured the superior values compared with dry season.

Productive performance of the experimental goat's analysis demonstrated that the milk yield, lactation period, indices of doe productivity and milk composition was affected by supplemented feed groups compared with unsupplemented group. Productive performance of experimental goats significantly differed (P<0.05). Supplemented feed groups (A, B and C) had the higher values compared with unsupplemented group (D). Also, the effect of season on productive performance of experimental goats differed significantly (P<0.05). Productive performance of experimental goats on rainy season secured higher values compared with dry season.

Therefore, it is concluded that feeding supplemented groups; high energy (A), medium energy (B) and low energy (C) compared with unsupplemented group increased birth weight, weaning weight, post-weaning weight, milk yield, indices of doe productivity, lactation period and milk composition. Gestation period, kidding interval, post-partum anestrus and puberty were decreased. However, supplementing feed with
different energy levels had no affect on kid's mortality and litter size. This study concluded that, the rainy season compared with dry season increased birth weight, weaning weight, post-weaning, litter size, milk yield, indices of productivity, lactation period and milk composition. On the other hand, kid's mortality, gestation period, kidding interval, post-partum anestrus and puberty were positively decreased.
الطروحات

الملخص

إعداد

دراسة واجريت

هذه الموارد وخصوصية وانتاج النسلية لتحديد الماء القطيع من الناحية المائية والناجحة وإجراءات

الإضافة العالية ونظام التقليدي الرعي ونظام في الصحراوي عز الطاقة من تشيفة مستويات عالي

التحكم مجموعة ومقارنة

البروتيني مستوي ومتوازن

دون الطبيعة الرعي العلوي غذاء التي يقذف من الناحية المائية والناجحة وآثارها

بعد ومزة، وزن الامام، وزن الامال، وزن الامال

ناتجة وذات

لتقييم الموضم من فترية

الشجاعة

المطر، الجاف (السابقة الخصائص وناتجة جميع)

لتقييم التجربة العالية جموعة ومقارنة

البروتيني مستوي والمتساوي

(0.05> p) بعد الكاز أبي، الجاف الذي ترب كهرباء (البروتيني توجيه) لجودة أنت. (0.05> p) بعد

بذلك بيتة. وبنية بيتة (البروتيني توجيه) لجودة أنت

XIV
The document contains text in Arabic. It discusses a study related to rainfall, its duration, and other meteorological conditions. However, the context and the specific findings of the study are not clearly visible due to the language barrier. The text appears to be part of a scientific or academic report, possibly discussing experimental results or data analysis.
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Chapter One

Introduction

The chronic mischaracterization of natural resources conflicts coupled with lack of development in infra-structures and continua’s environmental degradation have positively led to devastating impacts on livestock situation in the study area of North Darfur State, Sudan.

Goats are neglected animals in the Sudan despite the fact that they play a very important role in the rural economy. They live mostly on grazing poor natural pastures in arid and semi-arid areas with no supplementary feeding. They live as scavengers in the streets of towns and cities requiring minimum care and attention despite the fact that they provide many poor urban and rural families with milk and meat. Although their origins in Asia, they are found under all environmental; conditions. thus, their ability to withstand dehydration and their browsing habit enable them to survive where cattle and sheep cannot (Steele, 1996).

There are about 744 million head of goat world wide of which about 30% of world goat population is found in Africa and up to 89% of the 21% of goat population is located in 14 countries of Central and Eastern African regions (Wilson, 1991). F.A.O., (2003) estimated that the arid zone of the world contains about 39% of the goat population, in spite of low grazing potential; the semi-arid zone has the greatest concentration of goats.

Sudan possesses a vast mass of agricultural land and diversified climatic zones ranging from desert in the extreme North to semi-equatorial in the South. The diverse climate creates a variety of animal resources, and recognizes Sudan as one of the countries with promising agricultural
potentials with largest population of livestock in Arab world and is second to Ethiopia in Africa. According to recent estimates of livestock population reached 140.003 million heads that divided into 41.426 million heads of cattle, 51.067 million heads of sheep, 43.104 million heads of goats and 4.406 million heads of camels. Meanwhile, the livestock population in North Darfur State is estimated to be 7.779.184 heads that are distributed into 679.386 heads of cattle, 2.866.416 heads of goats, 3.687.037 heads of sheep and 546.344 heads of camel (M. A. R., 2008).

Goats are important species of livestock in most traditional agricultural production systems. Rural families own small ruminants for provision of milk, meat and other needs. The recognition of the importance of goats is developed as results of the capacity that goats can service under marginal conditions unfavorable for cattle and sheep. Its preferred diet is largely ignored by other animals, and goats can therefore contribute substantially to the solution of food problems in many arid and semi arid areas, where hunger and malnutrition are prevalent.

About 90% of livestock are raised under traditional pastoral system, mainly in the Western States of Kordofan, Darfur and Southern states, rangeland that occupy an area of 110 million hectares and produces about 18.6 million tones of crop residues (AOAD, 1994). Range land provides about 86% of feed for livestock, crop residues and agriculture 10% while irrigated forage and concentrates contributes 4%. The rangeland suffer from un-even distribution of stocking capacity, bush fires, deforestation, un-even distribution of water sources and encouragement of both traditional and mechanized agricultural (Fadlalah and Ahmed, 2005).

Information on performance of the main Sudanese dairy goat breeds is very limited. Also, research on goat’s husbandry, feeding and management
Is comparatively limited compared to other livestock class. One may attribute to the believe that goats are environmentally hostile elements. Meager research is present regarding their particular husbandry needs (Johnson, 2005). The Sudanese desert goat received very little concern in research investigating their productive and reproductive traits, despite their large distribution in the Sudanese rural community where they play important economic roles.

This research is intended to achieve the following objectives:

1. To evaluate the performance of desert goats under the traditional management systems with an immediate objective of securing a valid database on various productive and reproductive traits of this species.
2. To assess the impact of feeding different energy levels with iso-nitrogenous protein on performance of desert goats.
3. To monitor the effect of feed supplementation on pre and post pubertal performance of kids of both sexes.
Chapter Two

Literature Review

2.1. Origin and background of goat:

2.1.1 Classification:

Goats and sheep both belong to the sub-family Caprini of the family Bovidae in the suborder Ruminantia of the order Artiodactyla (Zenuer, 1967). They are typical cloven-hoofed ruminants of relatively small size. The suborder Ruminantia includes many of the well-known large grazing or browsing mammals among them divided into subfamily Bovine and Caprinae. The goat is thought to have been the first animal to be domesticated for economic purposes. Evidence suggests that domestication took place about 7000 BC. in South-West Asia, on the borders of present-day Iran and Iraq, where agriculture was already advanced. From there goats, some have spread into all the tropical zones and most temperate areas (Devendra, 1983). After domestication, physical differentiation into breeds and types began. Early physical changes affected the ears, horns, colour, and hair types. These changes arose from natural mutation and from selection by goat keepers within the environment in which goats were reared, usually in relative isolation. Early goat keepers must also have selected for the production characteristics which were appropriate to their needs. New blood probably entered goat populations when people migrated for economic reasons or in time of conflicts. There is a huge range of size, colour, and hair type among modern breeds of goats.
2.1.2. Goat distribution:

Goats have shown themselves to be extremely adaptable animals and found as far north as Scandinavia and as far south as South America. They can be found at very high altitudes. Some types of goats live in desert area and upper hills, while other goats are able to thrive in the humid forests. The highest proportions of the total world goat 30.7% are found in Africa, while Central America has the lowest population of goats. Within region of the Near East and South America, both sheep and goats are widely distributed (Devendra, 1980). However, goats are probably more widely distributed than sheep from the semi arid and arid areas to the super humid environments. Goats flourish, however, and prefer areas of low rainfalls and sheep are more important than goats in the highland eco-zones and in the semi arid areas of North Africa, the Near East and Northwest Africa.

2.1.3. Sudanese goat types:

The main types of goat in the Sudan are Nubian, Sudan desert, Nilotic dwarf and Taggari. In addition, some of their mixed crossed with Sannen, Toggenburg and Anglo-Nubian were also found since the importation of exotic breeds in 1976.

2.1.3.1. Desert goat

Desert goats are commonly found in the arid regions of northern Sudan and of various countries where goats resemble each other in being medium or large size, with long legs and in most cases a short fine coat. The desert goats are located in the Northern Sudan and is possibly allied to the Shukria goat of western Eritrea, although the latter is probably a much better milk producer, more closely related to the Nubian. The Desert goat estimated to represent about 17% of the Sudanese goat
population. It is probable that the so-called Zaghawa goat that are found in Darfur and western Kordofan with a black colour variant of the Sudan Desert type. The main area of desert goat is dry areas of the Sudan, generally to the north of 12°N but north of 10°. The breed is well-adapted to heat and spares grazing of desert conditions that can thrive well in the desert environmental conditions. They are better meat producers even to desert sheep with tender and juicy meat (Gaili et.al., 1972). At its southern limit in Sudan, intermediate types with small forest goats are seen. Numbers are estimated at 1.0 million in early 1950s but certainly much more numerous than this in 1970s and 1980s. Population figures based on tax returns were 571 000 in Southern Darfur area alone in 1972.

Wilson (1976) describes sedentary herds in Western Sudan. Also, Wilson and Clarke (1975) state that in that area, its large size 65-85 cm with weight 40-60 kg for male and 32.7 ± 5.22 kg for female. Puberty was at 5.87 months in males and 5.54 months in females. Mean age at first kidding was 10.44 ± 0.19 months and kidding interval was 265.25 ± 3.99 days (Mohammed and El-imam, 2007). Head fine, forehead flat, profile straight or slightly dished. Horns in 95 per cent of both sexes large and flattened in cross-section in males, homonymously twisted, up to 35 cm long projecting outwards or backwards; while females finer and curving upwards and backwards, up to 30 cm in length. Ears in medium to very long (12 - 20 cm), lopped. Toggles in 15 percent of both sexes. Beards in both sexes, very bushy in males. Males may have a mane to the shoulders or extending the whole length of the back. Mane in occasionally present in females. Neck rather short. Chest shallow and often pinched. Withers prominent (male 69-83 cm; female 65.5 ± 3.73 cm). Back short and straight. Croup very weak and sharply sloping with tail set low. Legs are long
and poorly boned. Colour is variable from white to black, greys common but many mixed colours black back stripe in dark colours and grey in light colours (Plate, 1). Coat is usually short and fine except for mane, some animals particularly Zaghawa have longer hair which may be general over the whole body or confined to hindquarters and legs.

2.1.3.2. Nubian goats:

Nubian goats are referred as “local breed” and it is widespread in North Eastern Africa and Mediterranean coastal belt. It is the only African breed specialized for milk production. In the Sudan, the Nubian goat, among other indigenous goats is the only acknowledged dairy goat (Hassan and El-Derani, 1990). It's represents about 50% of the goats’ population. The Nubian goats are predominately found in the Northern region and Khartoum. It is widely distributed north of 12º N mainly in the riverain environments (FAO., 1991). Phenotypically it is allied to Egyptian Zariabi, Eriterian Shokri and Syrian Damascus (Devendra and McLeroy, 1982). It is considered an improved dairy goat under local conditions and well adapted to harsh environments. It originated in the Sudan, and is widely distributed in Africa (French, 1970).

Its physical characteristics were described by El-Naim (1979) as a large size goat of 70 -75 cm height males weighing 50 – 70 Kg and females 40 – 60 Kg. the head is small medium, the forehead prominent with markedly convex profile in males and females and depressed just behind nostrils. Horns when present are rather light and medium length. Ears are long (25 cm), broad and pendulous, especially lop with black colour (Plate, 2). Beard usually absent. Legs are long but well proportioned. Colour is generally black, other colours from dark chocolate
Plate (1): Sudan Desert Goats- Phenotypic Characteristics
brown, light fawn also occur. Longer hairs on front legs and especially on hindquarters and hind legs give appearance of breeches. Liveweight range is reported as 27 to 60 kg (Devendra and Burns, 1970). Milk yields arrange in the order of 1 to 2 Kg daily and 120 to 140nkg daily annually in two lactations (Devendra and Burns, 1970). Surplus kids would be valuable for meat production (Mason and Maule, 1960). It could be a very valuable breed for up-grading other non-seasonal breeders in Africa for milk production (Devendra and Burns, 1983).

2.1.3.3. Nilotic goat:

Nilotic goats are riverian known as dwarf, Equatorial or Southern Sudan goat. They are found in the humid tropics of the Sudan throughout Southern Sudan. They are meat type producer and are characterized by variable features of compact body and smaller in size. Nilotic goats often weigh as little as 11 Kg with a height at withers of 40 to 50 cm. Males have short horns, females with either very short horns or none. The forehead is convex and facial profile is straight. The ears are of medium size. Light in colour, black or white or both colors is found predominantly south of 12 latitude and represents 30% of the goat population of goats population in Sudan (Mason and Maule, 1960). They have some similarities with small East African goat. (Devendra and Burns, 1970). There were three varieties of Nilotic goat that can be distinguished: (a) Toposa (Mongola) goat which are mainly found in Eastern Equatorial State and characterized by comparatively large size; (b) Yei (Dinka) goats which are located in Western Equatorial ; and (c) Latuka Bari goat in Jongelli State (AODA, 1990 and Muffarrah, 1995).
Plate (2): Sudanese Nubian goats
2.1.3.4. Taggari goats

Taggari goats also known as mountain goats because their presence is associated with mountain and hills. They are distributed in Nuba Mountain (Southern Kordofan State), Ingessana Mountain (Blue Nile state) and Red Sea mountains (Red Sea State) at Toker and Halaib area (AODA, 1990). Both sexes have straight horned. The male is beard and maned. The coat is short with black lines extended a long the face from the base of the horns to the nostrils. The most common colour is dark-brown or grey-brown (El-naim, 1979 and Muffarah, 1995). Due to their small size and short legs they are very active and well adapted to the topographical and climatic conditions prevailing in the area as well as to vegetation which dominates the predominately mountains rangelands (Muffarah, 1995). It is characterized by very short ears carried horizontally, short neck and legs with live body weight range ranges 20 – 30 Kg. Age of puberty was 7.43 months in males and 8.04 month in females. Age at first service was 6.87 months in male and 7.87 month in female. Age at first kidding was 13.1 month with kidding interval of 245.4 days (El-imam et. al., 2007).

2.1.3.5. Exotic goats’ breeds

There are a number of exotic breeds of goat’s t6 that have been imparted into the country (Abulazayim, 1996). The temperate zones goat breeds are Saaneen, Toggenburg, Anglo-Nubian and Alpine which are frequently owned by individuals and/or in hands of few goat keepers in the country. They are mainly European breeds introduced into the tropics to improve the local breed productivity particularly milk yield. However, some of them such as Anglo-Nubian are recognized as dual purpose (milk and meat) breeds which are not as good milkers as the breeds of the Swiss origin. Damascus breed originated Middle East is also introduced to
improve milk yield production by some owned goat keepers in the Sudan. Its ancestry has been acclimatized well in the tropical climates and successfully been used in up-grading indigenous stock for meat and milk in various countries such as the West Indies, Mauritius, Malaya and Philippines. In the Sudan, the up-graded cross with local goats is known as the Swiss-Nubian cross. The Anglo-Nubian is a British crossbreed from our indigenous Nubian goats. Sannen proved to be an adequate breed. Crosses with selected indigenous Nubian goats produced milk yield as high as 4.5 kg/day.

2.1.4. Role of goat socio-economic contribution:

Goats are socio–economically important in developing countries, ensuring food and fiber supply and providing income to small households (Lebbie, 2004; Sahlu et al., 2004; Sahlu & Goetsch, 2005). Often the only animal protein source, goat meat and milk help ensure infant development and sustain human health. Owing to increased demand for goat products, more livestock producers are raising goats in developing countries, including Ethiopia (Sahlu & Goetsch, 2005). Human population growth, increased urban income in several African countries, and new opportunities for export, has encouraged the marketing of goats from rural households and pastoral communities. Goat production thus helps meet local meat demands, keeps hard currency from being spent on importing meat, and increases hard currency reserves through exports of goat meat and skins. Goat production provides employment for poor rural families, especially for women and children (Lebbie, 2004). Goats can also serve as a store of value and a security system. They can be sold to attain immediate cash assets for poor goat holders, helping them to improve livestock and crop farming and financing social events (Morand-Fehr et
Especially during droughts when crops fail, goats, due to their adaptation capabilities, can survive on woody browse and infrequent watering; coupled with their high reproductive rate and short generation interval. Goats enable their owners to recover quickly and economically (Lebbie, 2004; Peacock, 2005). The value of goats for the use of the vast areas of natural grasslands, regions where crop production is yet impracticable, should not be overlooked (Lebbie, 2004). Goats are also important in various cultural activities, especially in pastoral and agro-pastoral production systems.

2.2. Management and production system of goat:

Livestock production systems in African can possibly distinguish two major systems depending on essentially differ in their use of the main factors of production; traditional and modernized system. With traditional system using mainly land and labor while modernized system have large capital requirements and generally a lesser requirement for one or other of the remaining factors. Principle criteria serve to define traditional systems is the degree of dependence of household or the production unit on livestock or livestock products either for household income or for food supply. In addition, the type of agriculture practiced in association with livestock production. The distance and duration of movement (transhumance and migration) might also be used to define system and it is recognized that this is an important aspect of management within a system.

The feed cost in each of production systems is different and in itself represents an important determinant of the ultimate economic benefit. The proportion of total costs attributable to feed for goats grazing uncultivated grass for meat in Malaysia was 2.2%; for goats stall fed with cultivated grass for meat, feed represented 23% of the total cost, and for
goats stall fed on cultivated grass and concentrates for milk, the figure was 48.2% (Devendra, 1975).

Water is an important but often overlooked nutrient for livestock. Water makes up over 98 percent of all molecules in the body and is necessary for regulation of body temperature, growth reproduction, lactation, digestion, lubricant of joints, eyesight and as a cleaning agent. Limiting water intake can depress animal performance more quickly and drastically than any other nutrient deficiency. Domesticated animals can live about 60 days without food, but only seven days without water. Hearing and sight are impaired without water (Charles and Greg, 1999).

Devendra (1990) stated that production system of goat and sheep in the tropics and subtropics are divided to five systems:

2.2.1. Tethering system:

Tethering system is the most common systems that a very low level of mostly unpaid family labor represents the main work input. Tethering system or village system of feeding is divided to two categories; tethering and alternative. Tethering where one to five heads are involved in situation that there is intensive crops cultivation. The second alternative is feed in situ the various crop residues available. Tethering system embrace the traditional village system typical in Africa, parts of Central America and Southeast Asia. Here, the animals browse and scavenge on what feeds are immediately available near the farm and the households. A tendency to treat sheep and goats with special care and also to feed them with kitchen remnants in Africa encourages the animals to remain closer to the villages than elsewhere.
2.2.2. Extensive system:

Extensive grazing is common where there is access to common grazing involving mainly women and children. The flock size is large (one to fifteen head) and goats are often mixed with sheep belonging to several owners are run and herded together. Stocking density is usually in the range of one to four head per hectare. In the extensive system, sheep and goats graze over large areas, usually on marginal lands with low rainfall which are unsuited for alternative forms of agriculture. Devendra (1976) reported that, extensive system includes nomadic transhumance and sedentrized patterns of production. It is characterized by fact that more animals tend to be carried than in the intensive system. Extensive systems include nomadic, transhumant and sedentarized patterns of production and are characterized by the fact that more animals tend to be carried than in the intensive system. Also, few or no concentrates, salt or mineral licks are provided. Those migratory systems suffer from the seasonal fluctuation in forage and water availability, host social and political problems including those concerning grazing rights.

2.2.3. Semi-intensive system:

Semi-intensive systems are a compromise between the extensive and intensive systems, limited grazing or stall feeding is practiced depending on the availability of time, labour and also feeds. It is essentially a part-time operation, like the village system. The duration of grazing is variable but is about 4 – 6 hours daily, usually in the late morning or evening. The goats are then housed and given cut forage, mainly tree leaves or crop residue, very seldom they concentrates offered.
2.2.4. **Very intensive systems:**

Very intensive systems are of two categories, intensive use of cultivated forges or stall-feeding. Although goats prefer to browse in comparison to grazing, they can sufficiently use cultivated pastures for meat or milk production. Stocking density of the order of 37 – 126 head of goats/ hectare have been reported depending on the type of grass used, level if fertilizer application and the presence or absence of legumes.

The most intensive form of production called zero-grazing is one in which the animals are fed in confinement with limited access to land. It is by definition a system with a high labor and cash input. In this system, cultivated grasses and/or by-products are fed such as straw with molasses-urea supplementation. With goats, this system of feeding also has the advantage of allowing control over the animals. Dairy goats are usually stall-fed which is varied than intensive production based on a stall feeding approach is feedlot fattening. This method appears to have had little application with goats, but it has been used successfully with sheep in Egypt (Salash et. al., 1970). He suggests that much more use can be made of such systems, especially in environments where agro-industrial by-products are plentiful.

2.2.5. **Integration with cropping system:**

Integration system is especially common in the humid and sub-humid regions of the tropics where intensive crop production practice. The integration of sheep and goats with crop agriculture has been practiced to some degree in countries, but the nature and extent of integration depend on the type of crops being grown and the relative importance of sheep and goats. The system is closely associated with the different patterns of crop production, notably tree crops such as coconut, rubber and oil palm.
Devendra (1975) recognized that 70% of the goat population in Fiji is found in the sugar cane growing areas. Similarly, in Sir Lanka, Malaysia, Indonesia and the Philippines, sheep and goats under-graze coconut, oil palm or rubber plantations. The advantages of the integration system are; increased fertility of the land via the return of dung and urine, control of waste herbage growth, reduced fertilizer wastage and use of weedicides, easier management of the crop and possibilities of increases in crop yields and greater economic returns including sale of animals and their products (Devendra, 1990).

2.2.1. Sudanese livestock management systems:

The livestock production systems in Sudan is generally fall under five major systems:

(a) Pastoralist system: (i) nomadic and (ii) transhumant.

(b) Sedentary and semi-sedentary.

(c) Intensified livestock/crop production system.

(d) Commercial production system.

(e) Intra-urban backyard production system

2.2.1.1. Sudanese traditional livestock system

2.2.1.1.1. Pastoralist nomadic

Livestock, mainly camels and sheep, with some goats, are raised entirely on natural rangelands. Households move with their animals and have no permanent base on which to grow crops. They spend the rainy season in the northern, semi-desert zone and during the dry season, move further south into the savannah. Income is derived from the sale of animals, meat and milk in the form of white cheese.

Pastoralists depend on rangelands and move animals where feed and water are available, in specific geographical zones (camel and cattle
owners in Kordofan and Darfur). These groups own 80 - 90% of the total number of cattle, 100% of camels, 80% of sheep and 60% of the goats of the country. The herd sizes in the system vary, averaging 200, 70, 90 and 200 for cattle, sheep, camels and goats, respectively. The system is the main source of meat for the local demand and for export. (Plate, 3).

2.2.1.1.2. Transhumance system

In the transhumant agro-pastoral system, households depend mainly on livestock, mostly cattle, with some sheep and goats, although there is some cropping. In western Sudan, households migrate north during the rainy season and return to the savannah during the dry season. In the central and eastern states, migration is towards the Nile during the rainy season and back during the dry season.

This is practiced in the southern part of the country where herdsmen move away during the flood time and to it when it recedes. The herds are kept in enclosures (luaks). The seasonal movement is short for distances as compared to the nomadic system. Herd sizes are small and are mainly cattle, which represent the pivot for the economic and social life of the people.

2.2.1.1.3. The sedentary and semi-sedentary system

The sedentary system exists where there is rain-fed, arable farming in settled villages. Some livestock, mainly small ruminants, are kept, but the animals are less important than the crops. Sorghum, sesame and cotton are grown on clay soils, and millet and groundnuts on sandy soils.

This includes livestock owners who practice rain-fed agriculture and also send their animals with the nomads to feed on agricultural by-products in the area. The system also includes farmers in the irrigated schemes who raise small ruminants for supplementary financial support.
Owners keep milking animals and send dry ones with the pastoralist nomads. The system supplies milk to towns and urban areas, and is characterized by low technology.

The sedentary and semi-sedentary system is located in the irrigated areas of central Sudan where cotton, sorghum, groundnuts and wheat are grown. They also raise livestock, especially small ruminants. Livestock, although less important than crops, are a supplementary source of income, which is used to hire labour for agricultural work before the harvest. Productivity is low and animals depend heavily on crop residues, industrial by-products and the grazing of limited areas of fallow and the sides of canals. Intensive cow’s milk production is becoming more common within the large irrigation schemes, and these areas are seen as promising for future expansion of livestock production.

2.2.1.1.4. The Intra-urban backyard system

In this system, mainly goats and poultry are kept for domestic supply. This system is widespread in rural and around urban areas for "productive families". Animals and birds live on household waste and as scavengers.

2.2.1.2. Improved modernized systems

2.2.1.2.1. Integrated intensive livestock/crop production system

In this system, intensive dairy production is practiced using irrigated fodder and concentrates with exotic breeds or indigenous local breeds. This system is seen as the promising system for the future supply of milk and meat for the increasing demand of the communities in the country.

Plate (3) a: Natural grazing during rainy season

Plate (3) b: Natural grazing during cool dry season
A migratory agro-pastoral system as a part from integrated intensive livestock/crop production system is found in southern Sudan, where livestock are raised in traditional rain-fed agricultural systems in settled villages. Livestock are moved away from the torches to highlands in the period of flooding and back when the floods recede.

2.2.1.2.2. Commercial production system:

Commercial production system includes (a): Milk cooperatives, specialized. Large dairy enterprises and individuals that own high producing milking cows. The system is particularly seen around big towns; (b): Feedlots for fattening cattle and sheep trekked for long distances from the western regions of the country to urban areas and markets. Fattening is also practiced in big privately owned rain-fed mechanized agricultural schemes on crop residues; and (c): Poultry commercial production business around big towns.

2.2.1.2.3. Transitional system

Improvement of the traditional systems is a progressive activity recently practiced where animals are raised on natural range (especially sheep), and water and feed supplements are transformed to those areas. Another recent activity is raising animals on mechanized rain-fed agricultural schemes.

Ranching is a recent trend in Sudan. Animals are raised for meat on natural rangelands in western Sudan in Kordofan and Darfur, and in Butana in Kassala State. Poor range management within the ranch is, however, a major constraint. Feedlots have existed for over 30 years. Animals, mainly beef cattle, are brought on the hoof from western Sudan and fattened in Khartoum State on sorghum grain, oilseed cakes and roughage, with gains of up to 1 kg/day in cattle and 0.35 kg in sheep. Near
and within urban areas, goats and poultry fed on household waste are kept for domestic supply.

2.3. **Goat nutrition**

Goats have the unique ability to utilize forage resources that cannot be utilized effectively by other ungulates (Meuret, 1994) such as sheep or cattle (thorny plants and species containing high proportions of phenolic compounds). They exhibit a versatile feeding behaviour, advantage which comes mainly from their physical body structure (bipedal stance, mobility of upper lip and vigorous grazing), as well as their variable rumen microflora allows them to cope in harsh environments. In the tropics they exploit even the meager shrubby resources, selecting the more nutritive parts and converting them is a useful product. In the arctic they perform better than other domestic ungulates having considerable versatility in feeding behaviour, but well in all animals, goats have no advantage also coping with cold weather. In temperate climates, where forages are relatively more nutritiously uniform and no special selection skills are needed to select high quality diet, goats may not be different in performance from other domestic ungulates. Goats have a more hospitable microflora environment for noxious phenolic compounds degradation, than other domestic animals. Furthermore it is believed that goats tolerate better phenolic compounds than other ungulates, due to their enlarged salivary gland ensuring extensive proline excretion, neutralizing the negative effect.

Goats’ diet almost always contains high proportions of lignified components whenever woody species exist within the pasture. Lopez-Trujillo and Garcia-Elizondo (1995) have reported at even in shrub land reseeded with grasses goats selected very low proportions of grasses. Similarly Papachristou and Nastis (1994) have demonstrated that even
during spring when herbaceous species are very palatable, goats ingest high proportions of shrubs. However, when herbaceous species are more palatable, certain goat breeds (Fedele et al. 1993) may consume more herbage (63% vs. 28%). Goats naive to *Leucaena leucocephala* (leucaena) are incapable of utilizing it while those that have developed the proper microbial populations thrive effectively on it. A similar phenomenon has been observed for goats naive to *Quercus coccifera* (kermes oak), which, within a week are fully adapted. Sheep require longer period.

**2.3.1. Goat feeding behavior**

Animals decisions where to feed, distance between foraging sites, for how long to graze, how long to search between bites; all greatly affects the rate and level of food intake as well as the nutritional content of their diet.

The factors governing habitat selection seems to be primarily vegetation type and composition parameters. In complex rangeland ecosystems animals congregate in areas of higher forage quality and quantity. Quality seems to be the main driving force (Bailey et al. 1995) being non-linearly related to site selection (overmatching) while quantity within some limits is linearly related. In homogenous areas, though, animals alternate between foraging sites insisting on those with higher yield. Arnold (1987) and Bazely (1990) have reported that sheep preferred higher biomass grass patches quantitatively optimizing intake. Due to different grazing habits goats prefer areas dominated by shrubs (Gordon and Illius 1989) while other ungulates concentrate more on mesotrophic graminoid sites where they can obtain the highest quality diet. The decision making process is influenced, to a lesser extent by other factors such as 'topographic features, slope, aspect, environmental conditions as
well as internal animal-related factors. When qualitative or quantitative differences are small easily accessible sites are always preferred to sites requiring higher expenditure for walking energy. Goats compared to other ungulates are less affected by topographical barriers. They search for food more vigorously even in rough terrain consuming forage up to 1, 5 m height by practicing bipedal grazing. Consecutive visits to a site reinforce memory for spatial distribution while herding modifies their free habitat choice. Despite the existing experimental information, the hierarchy of the factors that govern habitat selection is not yet fully understood. If we are to make the most efficient use of the renewable natural resources available in marginal areas it is essential to improve the understanding of the foraging strategy of goat, which is the animal making the best use of these ecosystems.

Compared to other domestic ungulates goats are more flexible in their feeding habits, expressing rapid seasonal shifts. The goat is characterized as a generalized feeder since it adapts its choice according to what is available, having a very large selection choice (Van Soest 1982). Grazing goats are obliged to shift foods since natural pastures are continuously changing composition and therefore quality. It has been demonstrated experimentally (Papachristou and Nastis 1993) that goats exhibited very rapid seasonal shifts between shrubs, grasses and forbs, depending on their availability and their seasonal nutritive value. Selection rations (Nastis et al. 1993) of most species vary greatly from season to season. Under conditions of extreme nutritional stress Malechek and Narjisse (1987) have reported sheep forage lazily and do not cover wide areas, while goats search more vigorously, even for litter and for less palatable shrubs.
2.3.2. Nutrients requirements

The daily feed intake of goat ranges from 3-4% of body weight as expressed in pounds (dry matter/head/day). The daily feed intake is influenced by body weight, % of dry matter in the feeds eaten (12-35% in forages, 86-92% in hays and concentrates), palatability, and physiological stage of the goats (growth, pregnancy, and lactation).

2.3.2.1. Energy requirements

Fresh pastures and young plants may have highly digestible fiber and provide high energy compared to older plants. Higher energy levels come from lower fiber feeds. Energy is represented as Total Digestible energy (%TDN) in feed analysis reports. It is important to supply half of the goat ration in the form of hay or pasture to avoid high energy related problems. Maintain at least 12% crude fiber in the diet. Energy requirements for different physiological stages; maintenance, pregnancy, lactation and growth vary. The maintenance requirement for energy remains the same for most goats except dairy kids; they require 21% energy higher than the average. It is important to feed high-energy rations at the time of breeding, late gestation and lactation. Lactating does have the highest energy demand.

2.3.2.2. Protein requirements

Feeds like forages, hays, pellets (alfalfa), barley, peas (screenings, whole, split), corn, oats, distilled grains and meals (soybean, canola, cottonseed meals) are common sources of protein for goat rationing. The protein requirements are higher during growth (kids), milk synthesis (lactation), and mohair growth. Producers may need to supplement protein sometimes during the year, especially in late fall or winter. It is very important for a commercial goat operation to do cost-effective rationing as
proteins can be an expensive feed ingredient. Good quality hay does not need much protein supplement for goats. If the hay has about 12-13% protein content then provide ½ lb of protein source in the form of corn, barley, peas or oats (with 20% protein in total). In case the hay is of average quality, add one pound of protein as supplement.

2.3.3. **Nutritional supplementation:**

   During the gestation period and the overall location period under any feeding program, goat can give optimum annual dairy performance because goats have great ability for adapting themselves to different feeding conditions (Fehr and Sauvant, 1977). Nevertheless, the milk production has been shown to exhibit great variation with the quantitative and qualitative character of the diet offered. Owen et. al. (1967) studied the effect of molasses in normal and high grain rations and concluded that, the highest persistency was produced by the two ration combinations containing no molasses and fed with the normal level of grain that averaged 97% persistency. Jubartalla (1998) studied Sudanese Nubian goats and claimed that, sorghum fed group maintained a record of 33% increase in fat corrected milk. While, Tewfik (1997) for Sudanese Nubian goats showed that, the milk produced by goats fed on 1.5 Kg/ day sorghum stalk plus molasses ration containing (50% molasses, 36% wheat bran, 10% cotton seed cake, 3% urea and 1% salt) at rate of 1Kg/ day was found to be significantly higher (P< 0.01) than that produced by goats fed on sorghum stalk only at rate of 2 Kg/ animal/ day.

   Tag Eldin (2000) studied the effect of different energy levels (A = Maintenance, B = Maintenance × 1.125 and C = Maintenance ×1.250) on milk yield of Sudanese Nubian goats and reported that, the effect of energy intake was significant (P< 0.05). Shetaewi et. al. (2001) studied milk
production of Damascus goats in North Sinai, Egypt, the goats were fed 0.6 Kg/ day concentrate and ad libitum amount of any of the following: rice straw (R = control ration), green acacia (A = treat ration) and berseem clover hay (B = treat ration). They found that the total milk yield over 10 weeks was significantly different among the three groups. Group (B) had the highest means while group (R) had the lowest value.

2.3.4. Water requirement:

Water is obviously important for goats, and the amount required depends on that needed for the maintenance of normal water balance and to provide satisfactory levels of production. Goats consumed water at the rate of 8% of their body weight per day under the scarcity conditions (Wani, 2002). Also, he added that goats have the ability to maintain itself at 4 % body weight per day. Maloiy and Taylor (1971); and Macfarlane and Howard (1972) compared the importance of water to goats and other animals. They reported that goats are among the most efficient users of water, after the camel in the low rate of water turnover per unit of body weight. This may be due to ability of goats to be fewer subjects to high temperatures stress than other species.

Wani (2002) demonstrated that, there were many factors affecting water consumption of goats such as: lactation level, environmental temperature, water content of forage consumed, amount of exercise, and salt and mineral content of the diet. Brown and Lynch (1972) and Lynch et. al. (1972) reported that, when feeding on dry forages lacking of water, the efficiency of reproduction will be suffer. Wani (2002) reported that suboptimum water intake will result initially in reduced feed intake, then reduced performance and gradual starvation. Also, he added that a cute
problems occur when goats are unable to maintain water balance or control body temperature.

2.4. **Productive performance:**

2.4.1. **Growth:**

Growth is defined as change per unit time and/or change relative to time. Lawes and Gilbert (1859) established scientifically that a high growth rate leads to an enhanced rate of fat deposition; and conversely Le Maho et. al. (1988) has shown that starvation or slow growth leads to fat utilization and consequent depletion of fat in the body. Wallace (1948) however, questioned whether increases in fat content of an animal could be considered as an essential part of true growth. Wilson (1954) with poultry concluded by conducting further trials on the basis of comparing fat-free carcasses. Growth is measured in terms of liveweight per unit time. This is not sufficient, as the animal grows, its body size or conformation changes and hence body measurements are considered as measurement of growth (Pemeroy et. al., 1952). The growth curve is sigmoid in shape and is much the same in shape in all species except in man where juvenile period is very long.

However, growth has been studied and results interpreted in the terms of theories of algometric and heterogenic growth and centripetal development first postulated by Brody (1927) and Huxley (1932). It is measured in terms of liveweight per unit time due to the different genetic factors in different breeds (Hammond, 1932; Palsson, 1940) and changes due to different patterns of growth (McMeekan, 1940, 1940; Palsson and Verges, 1952, 1954). Hammond (1932) demonstrated in the sheep that as the animal develops, a wave of increasing growth rate passes from the head and extremities of the limbs towards the central region of the body.
2.4.1.1. Birth Weight:

Birth weight represents the weight of the animal which was reached by its tissues and organs at the final stages of development in the uterus. Darokhan and Tomar (1983) reported that, birth weight is one of the traits that have no direct economic values but permit early selection by its high association with growth and production in later ages. The average birth weight of crossbred Sannen and Nubian kids was 3.56 Kg for the range of 4.8 – 2.0 kg (El Zubeir and Abd El Gadir, 2005). Studying production traits of Southern Darfur goats, Wilson (1976) reported that the average birth weights were 2.10 ± 0.61 and 2.16 ± 0.61 Kg for males and females respectively, and 2.09 ± 0.5 and 2.01 ± 0.4 kg for males and females born for the first kidder goats. Ageeb (1992) showed that the birth weight of Baggara goat of South Kordofan were 2.0 ± 0.5 and 1.8 ± 0.40 kg for males and females, respectively. Litter size increase was found to decrease the birth weight of individual goat kids. Elabeid (2002) reported that the average birth weight of Sudanese Nubian kids was 2.489, 1.963 and 1.500 Kg for single, twins and triplets. Similar observation was reported for Sudan Desert sheep. Alama (1987) noted that the birth weight of single and twin Gezira sub-ecotype were 4.2 and 3.2 Kg respectively. Sex of kid also influences weight at birth and males were heavier than females (Khan, 1979; Darkokhan and Tomar, 1983; Lebbie and Manzini, 1989; Karua, 1989 and Nefzaoui et. al., 1995). The birth weight of Jamnapari goats was studied by Khan (1979) and showed that, birth weight of Jamnapari ranged between 2.20 and 4.80 kg for males and between 1.40 and 4.00 Kg for females. Darokhan and Tomar (1983) reported an average birth weight of 2.03 ± 0.83 Kg for Changthang Pashmina goat. On the other hand, Lebbie and Manzini (1989) showed that the average birth...
weight of Swaziland indigenous goat was 1.9 ± 0.14 Kg under traditional management system, with male kids weighing more than females. These findings were differ with both studies of Wilson (1976) and Ageeb (1992), who reported that, the sex of kids had no significant effect on birth weight.

2.4.1.2. Pre-weaning growth rate:

The pre-weaning growth period is characterized by high growth rate compared to the post-weaning growth rate. Wilson (1976) studying the production traits of the Southern Darfur indigenous goats; reported that the average growth rate was 86.9 g/d from birth up to 3 month of age. Ageeb (1992) showed that, the growth rate of Southern Kordofan Baggara goats was 60.0 g/d from birth up to 3 months of age. Pre-weaning daily weight gain of Indian Jamnapari goat was 92.0 g and 85.0 g for males and females respectively from birth up to 90 days of age (Khan, 1979). However, for the different type of birth the same author found that the daily pre-weaning weight gain were 65.0 g/d and 58.0 g/d for male and female single born kids respectively from birth up to 4 – 5 months of age. Joshi (1979) showed that Barabari Indian goat breed had an average growth rate of 61.5, 57.5 and 64.0 g/d for single, twin and triplets born kids up to 3 months of age, respectively. Lebbie and Manzini (1986) stated a growth rate of 68.2 g/d for Swaziland indigenous goats from birth up to 3 months of age, and the growth rate was influenced by the kid birth weight, sex of kids and environment. Moreover, Kiwuwa (1986) reviewing the growth characters of East African goats showed that pre-weaning daily weight gain were 56.0, 53.0, 57.0, 62.0, 106.0 and 102.0 g for East African, Mudende, Sudanese Nubian, Galla, Boer and Galla× Boer goat breeds respectively. Rossanigo et. al. (1995) studying Argentina Criollo goats reported a pre-weaning daily weight gain of 76.8 g and 91.3 g under extensive and semi-
intensive management systems. Mahgoub (1997) reported that, Omani Dhofari Wethers have a pre-weaning growth rate of 96.0 and 88.0 g/d for males and females respectively. Mahgoub and Lodge (1998) showed that the pre-weaning daily weight gain was 120.0 and 105.0 g/d for Oman Batina male and female kids respectively. An average pre-weaning daily weight gain of Spanish Criollo goats was studied by (Dayenoff et. al., 1999) and reported 90.1± 20.6 g/d from birth up to 42 days of age. El-Moula et. al. (1999) reported that, males of Sudan Desert goat kids had a significantly (P<0.05) greater liveweight gain and consumed more dry matter with slightly higher feed conversion efficiency than females.

Devendra and Burns (1970) reported an average liveweight gain of 0.5 Kg weekly for tropical goats. Babiker et. al. (1985) reported a weekly rate of liveweight of 0.5 Kg with Sudan desert goats for entire and 0.38 Kg for castrated goat kids fed intensively from weaning to 7.5 month of age. Mukudan et. al. (1982) compared variation in body weight gain between Malabari goats and their Sannen half bred goats under intensive feeding. He reported Sannen half bred goats to grow faster by 0.091 Kg per week in all periods than the purebred Malabari goats. Mukudan and Bhat (1978) compared Malabari goats and their crosses with Sannen and Alpine. They found their weekly growth rates to be 0.24 kg, 0.29 Kg and 0.36 Kg respectively. Bello (1985) reported growth rate of 0.57 kg per week in crossbred kids. Wilson (1988) carried out study of the factors affecting weight in traditional managed goats and sheep in central Mali. He reported that the growth rates observed during the study were within the range reported for African goats and sheep of similar mature size.
2.4.1.3. Weaning weight:

The weaning age and weight are dependent on the individual growth performance before weaning and factors affecting it, beside the type of production. However, many workers studied factors affecting weaning weight. Nicoll (1985) working with Angora goats in New Zealand stated that, the single reared kids were significantly heavier at weaning. A similar result was reported by Mavrogenis et. al. (1984) for Damascus goats in Cyprus. Laes and Peters (1995) in a comparative study of performance of Egyptian goat breeds (Baladi, Zaraibi and Damascus) stated that birth litter size significantly (P<0.05) affected the weaning weight. Al kass et. al. (1999) working on native Iraqi goats reported a significant (P<0.01) effect of the type of birth on weaning weight. On the other hand, the sex of the kids was reported to affect the weaning weight. Nicoll (1985) studying the weaning weight of Angora goat in New Zealand and reported that, male kids were significantly heavier at weaning than female. Leaes and Peters (1995) stated that the kids weaning weight of Egyptian goats were significantly affected by the sex of the kids. Also, Al kass et. al. (1995) reported a highly significant (P<0.01) difference in weaning weight between males and females; males were heavier than females for native Iraqi goat and their crosses with Sannen and Damascus goats. On other hand, Morand (1997) and Lu and Potchoiba (1988) reported that weaning as a procedure of stopping suckling is to result in a shock to kids growth rate.

2.4.1.4. Post-weaning weight:

The post-weaning growth period is characterized by a decrease in growth rate, and the kids start to depend on their self to meet their nutrients requirements. Therefore, weight gain is much lower compared to the pre-
weaning growth period. Wilson (1976) reported an average daily weight gain of Southern Darfur indigenous goats was 67.0 g/d up to six months of age. Moreover, Ageeb (1992) showed that the growth rate of the Southern Kordofan Baggara goats was 40.8 ± 18.1 g/d and 38.6 ± 22.7 g/d for ages up to 6 months and 9 months, respectively. For Indian Jamnapari goat, Khan (1979) reported a post-weaning growth rate of 42.0 g/d and 32.0 g/d for male and female kids, respectively. In the same study the growth rate from 3 to 12 months of the single born males and females were 31.0 and 24.0 g/d respectively, and for twin born males and females were 41.0 and 32.0 g/d respectively. Mahagoub and Lodge (1998) studying the production performance of Batina goats of Oman, showed that the post-weaning growth rate of this breed was 102.0 g/d.

2.4.2. Kidding Mortality:

Kid mortality is one of the main factors that reduce the profitability of goat enterprises. There are many factors affecting kids mortality such as diseases, inadequate nutrition and other individual characters of the kid. Usually kids have higher mortality rates than adult goat. Khan (1979) for Jamnapari goats of India showed that, the pre-weaning mortality was higher in the kids having low birth weight and the mortalities were 8.49%, 14.92% and 10% for pre-weaning, post-weaning and adult respectively. Ageeb (1999) using South Kordofan Baggara goats, reported a mortality of 40.2% for kids than 6 months of age. Vihan (1979) investigated the common causes of mortality in kids and their control, showed that 50 % of the deaths were infected in the first month and about 25% in the first week of the birth, with other peak death from 3rd to 5th month where milk is completely from kid diets. Nair (1979) found a mortality rate of 5.06%, 6.05% for Malabari adult males and females respectively, under normal
conditions then the mortality rates increased to 32.73%, 11.16% for males and females due to outbreak of viral pneumonia.

2.4.3. Milk Yield:

Milk yield is the most important factor in dairy economy. The profitability of dairy enterprise depends on obtaining as high a level of milk production as possible. Goat milk is more widely produced than sheep milk, and globally goat production yields 60% of its value as milk, 35% as meat and 5% as skin (Devendra and McLeroy, 1988; Malau-Aduli et. al., 2001). Sulieman and El-Tahir (1989) investigated the milking capacity of Dubasi and Shugur ewes at El-Huda Sheep Research Station in Gezira Irrigated Agricultural Scheme. They recorded 140.2 liters of milk in 186.3 days for Shugur and 134.1 liters in 189.5 days for Dubasi. They mentioned that the ewes were sustained only sorghum straw for some days during the rainy season. It's likely that such poor quality feeds could have caused a substantial decline in milk yield. Milk biosynthesis depends on the mammary gland receiving a continuous supply of various metabolites and hormones from the blood. The milk yield of the mammalian species undergoes seasonal variation (Harding, 1999). Webster (1989) reported that, countries like Iraq and Libya obtain half of their total milk requirements from goats. Although, there is similarity between cattle, goats, sheep and buffaloes in the genetics of milk production, there is evidence that on liveweight basis the goat is a much more efficient milk producer than the other species (Malau-Aduli et. al., 2001). Also, the goat has higher feed conversion efficiency to meat and milk than cattle, sheep and buffaloes (Okello and Obwolo, 1985).
Milk yield of goats is affected by many factors such as: plane of nutrition, doe body weight, litter size, lactation length, dry period, persistency and season of kidding.

2.4.3.1. Factors affecting on milk yield:

2.4.3.1.1. Nutrition:

Milk production will rapidly rise in early lactation and reach peak between 50 and 70 days, and dry matter intake does not peak until 75 to 100 days. Thus, doe not able to consume enough nutrients to meet her needs for producing greater levels of milk, to compensate for this lack of energy intake, fat reserves are metabolized to provide the energy necessary to accommodate higher milk production (Hadjipanayiotou et. a., 1988; Susmel and Cuzzit, 1988). Leclerc (2000) reported that, energy seemed to be the limited factor for milk yield. The pre-natal and post-natal nutrition of the doe influences milk yield, milk composition and persistency, and is known to have major affects on the growth of kids (Ali et. al., 1991).

Supplementation of diets affects the daily milk yield over the 90 day period of the cool dry season (Malau-Aduli et.al., 2004; Min et. al., 2005). Abdel Wahab (1998) found that, milk yield of Sudanese Nubian goats was 208.72 ± 95.5 and 254.07 ± 9.3 Kg for goats given two level of energy. Alexander et. al. (2002) showed that, milk production is higher in supplemented goats than grazing goats were 1023 ± 162 and 520 ± 174 days over the 12 weeks of lactation, respectively. Jubartalla et. al. (2002) reported that, the average daily milk yield was 1.14 ± 0.4 and 1.7 ± 0.3 Kg for doe fed molasses and sorghum respectively. Mirgani and Nasir (1993) reported that, a 30% increased in milk yield of Sudanese Nubian goats fed on 30% molasses and sesame cake. However, El Gallad et. al. (1988) found that, increasing dietary did not improve total lactation milk yield.
2.4.3.1.2. Body weight of doe:

Lactation of goats has been shown to have affected significantly by size of the animal. Moreover, milk yield in dairy goats is positively correlated with the weight of the lactating doe. Havrevoll et. al. (1995) showed that, the milk yield in Norwegian goats increase with increasing age and weight of doe up to five years. Also, Gamal and Elkhidir (1993) found that milk yield of Sudanese goats is influenced by the weight of the doe up to 40 Kg of liveweight.

2.4.3.1.3. Litter size:

Litter size or multiple births influence subsequent milk yields so, the effect of litter size was significantly with highest value of daily milk yield found in goats with three and more kids (Ciappesoni et. al., 2004). Also, he added that the number of kids born and the number of kids suckled affected the milk yield after weaning. Lyatuu et. al. (1994) reported that, the does with single kids had higher lactation yields and longer lactation lengths.

Generally, mothers of twins gave proportionately 0.27 more milk yield than mothers of singles and mother of triplets who gave 0.47more. Moreover, it was suggested that multiple fetuses led to a higher lactogenic activity, thus causing higher yields post-partum (Williams, 1993).

2.4.3.1.4. Lactation length:

Lactation length had a significant influence on the total milk yield. Papachristoforou and Mavrogenis (2000) revealed that, the lactation length was longer for lactation third, fourth and fifth compared with lactation second, sixth and first. Moreover, Concalves and Wechsler (2000) reported that milk yield was $635.3 \pm 39.75$ Kg for mean lactation length of 246 days. Tambajong et. al. (2000) showed that, the average daily milk yield
increased from 1.19 ± 0.14 Kg at the end of the first week to 2.32 ± 0.14 Kg at the fifth week.

2.4.3.1.5. Dry period:

Dry period is period which extended from the end of lactation to the following parturition. This period should be at least 6 – 8 weeks to allow the doe to build up enough reserves for coming lactation and to provide nutrients for the fetus (Kudouda, 1985). Salama et. al. (2005) reported that pregnancy reduced milk yield from week to after conceiving onwards, extended lactation did not significantly decrease milk yield, but increase milk components.

2.4.5.1.6. Persistency:

Persistency or ability of the lactation goat to maintain a high milk secretion throughout the period affects on milk yield. Gonales and Marting (1988) reported that, the peak of daily milk yield was obtained between 5th and 11th week of lactation. Napoleone and Gillet (1990) revealed that, maximum daily milk yield in a flock of goats was observed in the first to second month of lactation. Also, Gamal and Elkhidir (1993) studied Sudanese Nubian goats reported that the peak of daily milk yield was in the second month of lactation.

2.4.5.1.7. Season of kidding:

Ciappesoni et. al. (2004) reported that, season of kidding have affect on milk yield and lactation length, probably due to climatic variation between the months and years. El-naim (1979) reported that, in Sudanese Nubian goats, there was no effect of season on milk yield. Banda et. al. (1992) reported that, the mean total milk for 12 weeks of lactation in the dry and wet season was 84.6 ± 3.1 and 66.8 ±2.6 Kg respectively, for Malawi goats. Lyatuu et. al. (1994), and Concalves and Wechsler (2000)
they reported that, does kidding in wet season had higher lactation milk yields and longer lactation length compared with does kidded in cool dry season. This variation is due to availability of flush, green pastures during the wet season compared to low quality forages in the cool dry season. The reduction in milk production during exposure to heat, or during the summer, cannot be attributed solely to a fall in feed intake or forage quality. The effect of heat on physiological mechanisms related to lactation is also of importance, mainly, the low level of thyroxin during the summer (Haffez, 1968).

2.4.4. Lactation Length:

Lactation length is defined as the period from parturition till drying off. This is the period during which ewes are capable of producing milk or lactating.

2.4.4.1. Factors affecting lactation length:

The lactation length has been an extremely large variability exceeding that in cattle and sheep. Variability may be contributed greatly to the variation in milk yield.

2.4.4.1.1. Breeds:

Many workers investigate the lactation length of Sudanese Nubian goats and their significant influence on the total milk yield (Elnaim, 1979; Kudouda, 1985 and Khalaffalla and Sulieman, 1990). Elnaim (1979) reported that lactation length of Sudanese Nubian goats was 147 days with 73.5 Kg milk yield. Kudouda (1985) reported that in Sudanese Nubain goats the lactation length was 24 weeks (168 days) and the goat dried up 2 – 3 months after conception. Also, Khalaffalla and Sulieman (1990) reported that lactation length of Sudanese Nubian, Sannen, Toggenburg and Anglo-Nubian goats were 121.47, 253, 206 and 60 days with milk
yield 71.8, 249.3, 244.3 and 162.4 Kg respectively. Garcia et. al. (1976) working on Nubian, Alpine, Toggenburg and Sannen goats imported to Venezuela reported that, there was a phenotypic correlation of 0.54 between milk yield and lactation length. The maximum daily production in goats was reached between the 8th and 12th week of lactation (Mackenize, 1967).

2.4.4.1.2. Year and season of kidding:

Year and season of kidding had a significant effect on lactation length. Garcia et.al. (1976) reported that the lactation length was significantly affected by month and year of kidding for Anglo-Nubian, Alpine, Toggenburg and Sannen goats imported into Venezuela. Khan and Sahni (1983) pointed to Jamnapari goats verified that lactation length was significantly affected by year and season of kidding and their interaction.

2.4.4.1.3. Parity order:

Parity order affect on lactation length. Singh and Acharya (1980) reported that the lactation length of Beetal goats ranged from 172 ± 2.71 days in the third lactation to 188.24 ± 2.52 in the second lactation. Montaldo et. al. (1981) reported that parity had a significant effect on lactation length of Mexico goats. Bhatnagar et. al. (1976) stated claimed that in Alpine × Beetal, Alpine and Beetal, the first lactation length averaged 238.206 and 161 day respectively.

2.4.4.1.4. Level of nutrition:

Tewfik (1997) working on Sudanese Nubian goat reported that the lactation length of goats fed on 1.5 Kg/day sorghum stalk plus concentrate ration compose of (50% molasses, 36% wheat bran, 10% cotton seed cake, 3% urea and 1% salt) at a rate of 1 Kg/ day was found to be not significantly higher than the lactation length fed on sorghum stalk only.
2.4.5. Persistancy:

Persistancy demonstrates the ability of the female’s animal to maintain a leveled milk yield during the lactation period.

Persistency estimates were measured to predict the approximate milk yield of the goat to be below in the next lactation. Elnaim (1979) reported for Sudanese Nubian goats that total milk yield was highly correlated with the first month yield \((r = 0.74)\). While, Echoche and Buvanedran (1983) referred to Red Sokoto goats showed that the correlation of 12 week milk yield with 2 week and 4 week yield were 0.88 and 0.94 respectively for female rearing singles, and 0.82 and 0.91 for females rearing twins \((P<0.01)\) for all correlations.

2.4.6. Indices of doe productivity:

Productivity indices were used to examine the overall annual output of doe-kid unit. The productivity indices combining characters of doe productive performance, kid viability, kid weaning weight and doe weight to build three productivity indices. Index 1, the total weight of weaned kid per doe per year, it equals the number of kids/doe/parturition \(\times\) kids weaning weight \(\times\) 365 \(\div\) kidding interval period. Index 2, the total weight of weaned kid per Kg of doe per year, it equals index 1 \(\div\) doe average kidding weight. Index 3, the total weight of weaned kid per Kg of metabolic weight of doe per year, it equals index 1 \(\div\) doe average weight 0.75.

According to Wilson (1986) reported that productivity indices of goat and sheep were constructed in the same manner as for cattle, except that weight of the litter at presumed weaning at 150 days was used as the measure of production. Wilson (1986) studied the productivity indices of Mali goats and reported that the total weight of weaned kid per doe per
year (index, 1) was found to be 14.6 Kg/ doe, the total weight of weaned kid per Kg of doe per year (index, 2) was found to be 0.494 Kg., and the total weight of weaned kid per Kg of metabolic weight of doe per year (index, 3) was found to be 1.23 Kg.

Productivity indices were affected by many factors such as: production system, season, year, parity type of birth and nutrition Wilson (1986). Season affect on productivity indices such that goats given birth in the hot dry or rainy seasons were more productive than those kidding in the post-rains season, while births in the cold dry resulted in lowest productivity. First-parity does were clearly inferior to the indices of index, (1) only and when the resources-based indices, (2) and (3) were calculated, the productivity of primiparous does did not differ significantly from that of second-parity females and most of those from the sixth parity upwards. There were no differences in goat productivity arising from sex of young, this being most probably due to the relative lack of precocious sexual dimorphism in goats at weaning. Although, twin-bearing does had indices superior to those giving birth to singles, the productivity of dams giving birth to triplets was inferior to those having twins and equal only to those giving birth to singles. This was due to largely to the high death rate in triplets.

2.5.7. Milk composition:

Milk composition and quality are most important attributes that determine the nutritive value and consumer acceptability. Goat milk contains more fat and ash than cow milk. However, as infant food it is nearly as high in vitamin B6 and twice in vitamin B12 as human milk. They also reported that vitamin A in goat milk exists exclusively in its true form and not as carotenoid pigments. Goat's milk exhibits wide variation
which is encountered within and among breeds, feeding standards, technique of yield estimation, number of kids suckling and parity (Banda et. al., 1992).

2.5.7.1. Milk fat:

Fat content of goats is comparable to that of cow's milk, which is range from 2.7 to 5.9 % (Parakash and Jennes, 1968). Milk fat content varied due to different factors.

2.5.7.1.1 Factors affecting on milk fat:

2.5.7.1.1.1. Breeds:

Breeds contribute to influence in fact content of the goat milk. El-naim (1979) reported that, Sudanese Nubian goats milk fat content was 3.6% fat. While, Baruah et. al. (2000) revealed that, the percentage of fat of Assam local goats range from 6.58 ± 0.09 to 5.87 ± 0.08 and overall mean levels of fat was 6.8% for local Malawi goats.

2.5.7.1.1.2. Age:

Milk fat content increase due to increasing age of does, 23.4% of total variation. Statistically, significant differences in the fat contents depending on lactation number levels were observed. Ciappesoni et. al. (2004) reported that, first lactation goats had a significantly lower fat content than goats in second and fourth further lactations. Moreover, Papachristoforou and Mavrogenis (2000) reported that, milk fat percentage in third to sixth lactation was higher than that in second and first lactation.

2.5.7.1.1.3. Nutrition

Nutritional status of the lactating doe and the composition of the diet affect significantly the fat content of goat's milk. Morand-Fehr et. al. (2000) observed that, milk fat percentage in goats even fed on Mediterranean rangeland can be lower than protein percentage because of
low availability of vegetation especially in summer and reduced ingestion of fiber. Min et. al. (2005) reported that, the average percentage of milk fat was lower in goats giving zero concentrate (2.9%) compared with other groups giving concentrate (3.1%). Schmidely et. al. (1999) confirmed that, increasing the level of energy intake in dairy goats improved their milk yield and decreased the milk fat percentage. While, Hussein et. al. (1996) reported that, with less yielding goats an increase in energy increased sometime milk yields and fat percentage. Spruzz and Selegoska (2006) worked on goats given supplemented diets and found that, supplemented diets increased milk yield by 12.64% and fat content to 3.2%.

2.5.7.1.1.4. Stage of lactation:

Stage of lactation had a marked influence on milk fat content. Knowles and Watkins (1983) reported that, the milk fat percent reaches the maximum values about second months from kidding and decrease to minimum values in fourth month and rises again. Arkinosoynu et. al. (1975) worked on West African Dwarf goats and reported that, there was a significant fall in milk fat content with advancement of lactation.

2.5.7.2. Milk protein:

Protein content of goat's milk show a small variation range between 2.3 to 3.7%, this variation may be due to the interaction of the factors which affect of milk production and chemical composition. Spruzz and Selegoska (2006) reported that, goat supplemented with wheat bran and grazing pasture and hay increased protein, fat and sugar contents of goat's milk on 13.3%, 22.8% and 1.1% respectively. Tambajong et. al. (2000) demonstrated that, milk protein content dropped slightly until the end of the fourth week of lactation. Min et. al. (2005) reported that, average milk concentration of protein, fat and lactose decreased as lactation progressed,
except for fat in the second year and tended to increase toward the end of lactation. Highest protein contents were observed in goats with single litter size and lowest fat contents in does with three and more kids (Ciappesoni et. al., 2004).

2.5.7.3. Milk total solids:

Total Solids (TS), Solid-Not-Fat (SNF) and ash contents of goat's milk show a little variation within and in between breeds of goats. El Gallad et. al. (1998) reported that, all milk constitutes were negatively correlated to the amount of milk secreted by the dairy goats, and increase with increased energy content of the diet. Baruah et. al. (2000) reported that, the milk total solids ranged between 15.77 ± 0.18 to 14.92 ± 0.23 and the overall mean for total solids, solids-not-fat, lactose and ash were 17.4%, 10.6%, 4.7% and 0.88% respectively.

2.5. Reproductive Performance:

The reproductive performance and hence the production capabilities of the animal are governed by a diversity of factors. The following parameters constitute important criteria for improved reproductive traits.

2.5.1. Gestation Period:

It is the period extending from the date of conception and fertilization of one or more ova after successful mating to that of delivery. Its duration ranged between 145 and 155 days for both sheep and goats (Mukasa-Mugerwa et al., 1988). For tropical goats it is reported to be less by 3 – 5 days which may be attributed to either genetic or environmental factors. Devendra and McIeroy (1987) studied the gestation periods in
several breeds of goats in the tropics and reported that gestation periods ranged between 144 to 153 days with average 146 days.

2.5.1.1. Factors affecting gestation period:

There several factors affecting the gestation periods of goats include genetical and or/ or environmental factors, such as breed, size of goat, sex of kids, litter size, order of birth, ambient temperature and time of year.

2.5.1.1.1. Breed:

Many workers (Elnaim 1979, Jubartalla, 1998 and Elabeid, 2002) studied the gestation periods of Sudanese Nubian goats. Elnaim, (1979) reported that the gestation period was 146.5 ± 1 days, while Jubartalla (1998) reported that gestation periods ranged between 143 – 149 days. Also, Elabeid (2002) was agree with other workers and reported that, gestation periods averaged 148.57 ± 3.6 days. Badawy et. al. (1971) studied the gestation periods in Egyptian Baladi goats and reported that the gestation period was 148.81 days.

2.5.1.1.2. Sex of kids:

Ageeb (1992) studied the effect of sex of kids on gestation periods of Bagghara goats and observed that, the sex of kids had significantly effect on gestation. Obviously, when does bearing female kids had longer gestation period (147 ± 2.9 days) than does bearing male kids (146 ± 1.3 days). On the other hand, El-naim (1979) and Kudouda (1985) studied Sudanese Nubian goats and Mishra et. al. (1979) studied Indian Sirohi goats and reported that sex of kid had no significant effect on gestation period.
2.5.1.1.3. **Litter size (type of birth):**

Forbes and Robinson (1967) stated that duration of gestation within a particular breed is extremely stable and there was no obvious influence observed in gestation length with the increase in litter size. These results were confirmed by Prasad et. al. (1972) and Koudoua (1985), who reported that gestation period was not affected by type of birth for Barbari and Sudanese Nubian goats respectively. While Khan et.al. (1982) used 107 gestation records of Jamunapari breed in India. They reported that the mean value of the gestation length was 147.9 ± 0.327 days and observed one day difference in gestation period length between single and twin. These results were confirmed by Ageeb (1992), who reported that the goats that carried twins had longer gestations compared to those carried for Baggara goats.

**2.5.1.1.4. Season of kidding:**

Mishra et. al. (1979) and Esquivel and Camara (1991) for Sirrohi and Criollo × Anglo-Nubian goats reported that season of kidding had no significant effect on gestation period.

**2.5.2. Kidding Interval:**

It is the period between two consecutive kidding. The interval comprises the service period and the gestation period. This is a useful comparison of fertility and productivity between breeds. A regular kidding is known to be economical in terms of production and breeding efficiency. Wilson (1979) reported that, the kidding interval of Southern Darfur goats averaged 238 ± 41 days.
2.5.2.1. Factors affecting kidding interval:

The length of the kidding interval is mostly affected by the service period and varies with breed, level of nutrition, age of the dam and season.

2.5.2.1.1. Breed:

Khalaffala and Sulieman (1990) noted that the average kidding interval period of Sannen breed in Sudan was 346 ± 68 days and this was longer than 326 ± 76 for Toggenburg breed in Sudan. Ageeb (1992) reported that, the kidding interval of Baggara breed was 234.1 ± 28.9 days.

2.5.2.1.2. Level of nutrition:

The kidding interval has been studied by many workers and they reported to be affected by the level of nutrition. Singh and Sengar (1970) reported that, the kidding interval of Jamnapari does was shorter when fed on high and medium energy feeds compared to does on lower energy diet. Sachdeva et. al. (1973) studied the effect of plane of nutrition on reproductive performance of Barbari and Jamnapari goats. They found that the kidding intervals were 245, 231, 242, 243 and 244 of Barbari goats Vs. 298, 283, 307, 333 and 385 of Jamnapari for high energy-high protein, high energy-medium protein, medium energy-medium protein, medium energy-low protein and low energy-low energy respectively. Kudouda (1985) working on Sudanese Nubian goats and reported that, the kidding interval of roughage fed group was 343.5 ± 57.3 days, while it was 251.2 ± 19.3 days for concentrate supplemented goats. Also, Jubartalla (1998) studied the effect of feeding Molasses based ration and sorghum based ration to Sudanese Nubian goats and reported that, the kidding interval was 271 ± 27 for sorghum fed group and longer compared to the molasses fed group 251 ± 41 days.
2.5.2.1.3. Season of kidding:

Season of kidding influences on kidding interval was studied by many workers (Haumesser, 1975; Gracia et. al., 1976; Gangwar and Yadav, 1987 and Cabello et. al., 1991) for different goat breeds. Haumesser (1975) worked on Red Sokoto goats reported that, following parturition during September – April, May – June or July – August, the kidding intervals average 343.2, 302.3 and 266.1 days respectively. Garcia et. al. (1976) working on Nubian, Alpine, Toggenburg and Sannen goats reported that, the length of kidding interval average 388.5 days and the month of the previous kidding had a significant effect on kidding interval. Ganwar and Yadav (1987) studied the influence of various factors on service period and kidding interval in Indian goats and reported that, year and season of kidding had a significant effect on drinking interval 235.71 days in the monsoon season Vs. 271.39 and 278.22 days in summer and winter respectively. Cabello et. al. (1991) claimed that in Anglo-Nubian goats, season of kidding significantly affected kidding interval 214.9 days for female kidding in the rainy season Vs. 246.3 in the dry season.

2.5.3. Post-partum Anestrous Period:

The period from parturition of ovarian activity is called the post-partum an estrous period.

The post-partum (PP) period is comprised of a series of integrated anatomic and physiologic re-adjustments of both the uterus and endocrine system, and is a crucial factor for the resumption of reproductive capacity and regular cycling of a breeding goat. Morphological changes or their delay in the PP uterus and ovaries of farm animals exert a limitation on reproductive performance following parturition (Greyling, 2000).
Completion of uterine involution and resumption of sexual activity following parturition in ruminants normally depend on several factors, such as nutrition, nursing of offspring and season of parturition (Van et al., 1972; and Delgadillo et al., 1998;). Different research reports have shown different intervals to complete uterine involution in goats. While Baru et al. (1983) demonstrated complete macroscopic uterine involution by day 19 P.P., Greyling and Van Niekerk (1991) reported day 28 P.P. as the day of complete uterine involution. Moreover, histochemical study of caprine endometrium indicated complete regression of endometrium and re-epithelialization by day 16 PP (Sanchez et al., 2002).

The post-partum period in ewes characterized by a gradual recovery of ovarian activity and high prolactin hormone level that gradually decreased after the first week of parturition (Lamming et al., 1974) and also low tonic LH level which increased slowly (Restall and Starr, 1977). Akinbami et al. (1992) found the uterine involution to be in ewes between day 30 and day 50 after lambing. They concluded that the low fertility and conception rate observed in ewes mated before day 50 after lambing was probably a consequence of incomplete uterine involution. Boly et al. (1993) found that the average period before the resumption of ovarian cyclicity after parturition for the West African dwarf ewes was 56 ± 0.95 days and it was delayed by lamb suckling, however, good feeding was found to modify this response. Effect of nutrition on the length of post-partum an estrous period was observed by Kamwanja et al. (1985) on the Droper of Kenya and local Malwi sheep and their crossed. They found that the post-partum an estrous period of natural grazing ewes was 105 days and it was reduced by high feeding level to the mean of 52.4
days. Kushwaha et al. (1997) reported a shorter period range between 16 – 30 days and an average 26 days, for the Indian Chokla ewes.

2.5.4. Litter Size:

Litter size is defined as the number of kids born per nanny at one kidding (Steele, 1996). It is one of the most important factors influencing the birth weight in goats. Breed, age and body condition of the animal as well as the environmental factors may contribute towards the incidence of multiple births in goats as reported by many workers (Karua, 1989; Devendra, 1990; Alexander et. al., 1999; Shalaby et. al., 2000; Sodiq et. al., 2003; and Webb and Mamabolo, 2004). Devendra (1990) demonstrated that, the litter size is affected by body weight, birth type, size, season and level of nutrition. Webb and Mamabolo (2004) found that, the litter size of South African indigenous goats was 1.7 kids per doe. Also, Alexander et al. (1999) showed that, the litter size at birth, during suckling and weaning were 2.25, 2.05 and 1.95 kids respectively. Karua (1989) who studied the litter size of Malawi indigenous goats revealed that, the litter size was 1.35 ± 0.5 and 1.33 ± 0.5 in village and ranch systems conditions. Shalaby et. al (2000) reported that, the litter size at birth was 1.47.

2.5.5. Puberty:

Puberty is defined as the stage or time at which generative organs become functioning and female or male is sexually mature and able to reproduce (Robberts, 1971, Arthur and Ahunu, 1989). Walkden (2001) stated that the attainment of puberty in does occur when there is spontaneous ovulation and occurrence of oestrus signs and for bucks when there are able to induce pregnancy. Chakraporty et. al (1989) defined puberty in males as the stage at which and ejaculation containing motile
spermatozoa was first collected by electro-ejaculation. While Hafez and Hafez (2000) stated that puberty in a male or female is governed by their ability to release gametes and exhibit sexual behaviours. Moreover, Bearden and Fuquay (1997) reported that puberty is the stage at which expressed oestrus with ovulation occur, and gonadotrophins (FSH and LH) are produce at enough levels to initiate follicular growth and oocyte maturation and ovulation.

Generally, in goats the age of puberty ranges between 5 – 7 months in does and 4 – 6 in bucks (Arthur et al., 1998; Hafez and Hafez, 2000). Moreover, Bearden and Fuquay (1997) added that males at body weight range between 10 – 30 Kg reach puberty between 3 – 5 months of age. Walkden (2001) reported that age at puberty ranged between 5 – 7 months when body weight approximately reaches 50 % of the mature weight, but bucks born after the season of breeding and did not reach puberty in the first breeding season will be delayed up to 18 moths of age. Chakraporty et al. (1989) reported that sexual maturity was reached at age and body weight of 34.4 ± 0.9 weeks and 27.7 ± 3.3 Kg in Anglo-Nubian goats. Wolde-Michael et al. (1989) found that the age and weight of puberty was 172 days and 15 Kg in Feral Cashmere respectively, while male were sexually active at weight of 22 Kg. Camboav et al. (1992). reported that age of puberty was 209.8 days in Sinaloa goats. Wang et al. (1991) found that age and body weight was 154.7 days and 10.2 Kg in Sannen goats in China. Lawar et al. (1991) reported that age and weight at puberty were 677.5 ± 22 days and 20.3 ± 0.3 Kg in Angora goats. Myenuddin and Wahab (1989) reported that age of puberty was 180.74 ± 1.68 days in Black Bengal goats. However, Mintal (1991) reported that age and weight
were 560 and 326 days and 25.5 and 15.8 Kg in Kutachi and Morwari goats respectively.

2.5.5.1. Factors affecting puberty:

Arthur et. al. (1998) stated that the time of onset of puberty is determined by individuals’ genotypes, and this inherent time is influencing by a number of external factors such as:

2.5.5.1.1. Breeds:

The smaller breeds of animals tend to reach puberty earlier (Arthur and Ahunu, 1998). However, variations in age of puberty exist within the same species (Bearden and Fuquay, 1997; Arthur and Ahunu, 1998 and Hafez and Hafez, 2000).

2.5.5.1.2. Level of nutrition:

Weight of puberty is affected by genetic factors (Bearden and Fuquay, 1997). The onset of puberty is more closely related to weight and nutritional levels modulate age at puberty (Bearden and Fuquay, 1997 and Hafez and Hafez, 2000). Thus, Arthur et. al. (1998) and Walkden (2001) stated that animals are well fed with good growth rate reach puberty before those which are poorly fed with slow growth rate.

2.5.5.1.2. Season of the year:

Arthur et. al. (1998) reported that age of puberty in seasonal breeders will be influenced by of the year. Moreover, if the seasonal breeds fail to reach puberty weight in the first breeding season after birth, puberty will be delayed until the next breeding season (Arthur and Ahunu, 1998 and Walkden, 2001).
2.5.5.1.3. Presence of the male:

Many workers studied the effect of presence of the male on puberty of females (Bearden and Fuquay, 1997; Arthur and Ahunu, 1998; Hafez and Hafez, 2000 and Walkden, 2001). They reported that exposure of females to the male of the same species will advance the timing of onset of puberty and this is called male affects while, Hafez and Hafez (2000) added that puberty occurs earlier in animals bred in groups than those bred alone. Arthur et. al. (1998) reported that the male effect is probably mediated by pheromones and some other sensory cues influencing the hypothalamic-GnRH secretion.
Chapter Three

Materials and Methods

The experiment was conducted during the period extending from July 2006 to June 2008, to assess the effect of conventional and supplemented feeding system on productive and reproductive traits of Sudanese Desert goats.

3.1. Area of study:

3.1.1 Location:

The experiment was carried out in North Darfur State at (Shangli Tobya) located south of Al-fashir town about 65 Km) the region is a flat land sloping from West to the East where the rain collects in a few water reservoir. The soil is clay vertisole with sandy (Goze).

3.1.2. Climate:

The North Darfur State lies within the low rainfall woodland savanna with an annual rainfall ranging 250 – 500m.m. Rainfall has a maximum of 300 mm but it's very erratic in distribution occurring in June to September and along cool dry season of about eight to nine months. The climate can generally be considered to be semi-arid with rain. Average annual temperatures of the diurnal variate from 27 – 43 °C (UNDP, 2006).

3.1.3. Vegetation:

Vegetation in North Darfur is largely of a low-rainfall woodland savanna type with thorny, predominantly Acacia species, dwarf shrubs and ephemeral grasses. Semi-arid zone vegetation is an important features of pasture and grazing for nomadic herds of camels, sheep and goats (Ministry of Environment and Tourism, 1990).
In the study area, the native vegetation is a complex of grasses, herbs, woody species (mainly shrubs). Dominant annual grasses are *Cenchrus biflours*, *Aristida spp.*, *Eragrotis tremula* and *Echinochloa*. The dominant forbs are *Tribulus terrestris* and *Ipomoea spp*. The dominant trees and shrubs are *Boslia senegalensis*, *Acacia nubica*, *Acacia Senegal*, *Acacia tortilis* *Leptadenia pyrotechnica* and *Capparis deciduas*. (Table, 1).

Water scarcity represents a meager problem compared to pasture mainly in dry season, where livestock herders depend on hand dugged well, engine pumps and few water reservoirs for both animals and human drinking water. Meanwhile, in the rainy season the rainfall is consider of a key source of water needs for naturally grazing animals in the area.

### 3.2. Experimental animals

Sixty adult lactating desert goats and two bucks, indigenous to arid and semi-arid northern and savannah regions of western Sudan, were employed in this experiment together with their kids. The goats and bucks were purchased and collected from small-scale farmers who live mainly in Shangli Tobaya and local market around the study area. The goats had medium body size (20 Kg) with different colors ranging from black to gray and white. Horns are present in both sexes, large and flatter in the male (30±35 cm in length), the long lop ears are 12±20 cm. The does were ear tagged. General examination was carried out for each doe of the flock and treated against ecto-parasites (ticks) sprayed with Gamatox. Dewarming was done against endo-parasite using Pamizole ambolus of 2 mg for every 10 kg liveweight plus Ivermactin. Treatments were done at the beginning and middle of the experiment. The data were collected for the two generation and whole lactation period of the goats whereas the kids were followed up to weaning age.
Table (1): Some information of some range plants in the study area:

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Life form</th>
<th>Period of use</th>
<th>Animal kinds</th>
<th>Local name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cenchrus biflorus</td>
<td>Annual</td>
<td>Wet season</td>
<td>Cattle, sheep, goats</td>
<td>ﺣﺴﻜﻨﻴﺖ ﺧﺸﻦ</td>
</tr>
<tr>
<td>Echinochloa colonum</td>
<td>Annual</td>
<td>Wet and dry season</td>
<td>Cattle, sheep, goats</td>
<td>الدفرة</td>
</tr>
<tr>
<td>Tribulus terrestris</td>
<td>Annual</td>
<td>Wet season</td>
<td>Sheep, goats, donkeys</td>
<td>الدريسة</td>
</tr>
<tr>
<td>Ipomoea spp.</td>
<td>Annual</td>
<td>Wet season</td>
<td>Sheep, goat, camels</td>
<td>الحنتوت</td>
</tr>
<tr>
<td>Acacia tortilis</td>
<td>Perennial</td>
<td>Wet and dry season</td>
<td>Camels, sheep, goat,</td>
<td>السイラل</td>
</tr>
<tr>
<td>Acacia Senegal</td>
<td>Perennial</td>
<td>Wet and dry season</td>
<td>Camels, sheep, goat,</td>
<td>الهشاب</td>
</tr>
</tbody>
</table>

Source: Dr. Abdel Rahman M. Taheer
3.3. Housing

The goats were divided into four equal groups of fifteen each (A, B, C and D) that were as far as possible matching in liveweight. The mean liveweight of each group was 20 Kg. The four groups were kept in a separate enclosures constructed from local materials with a sandy floor mixed with clay soils. Each pen was equipped with feeders and water troughs with clean water. Inside each enclosure the animals were kept together at sufficient distance space and offered feed and water in gathered troughs for supplemented groups only. Kids were kept in a separate enclosure during the night and left with their does during the day with special means to ensure no suckling.

3.4. Feed and Feeding:

Based on live body weight, animals were blocked randomly into two feeding regimes, conventional and supplementary. Supplemented animals group was also blocked into three feeding groups (A, B and C) differ (low, medium and high) dietary energy levels (9.5, 10.5 and 11.5 MJ ME/kg DM) respectively. The supplemental diets were fed daily at early morning where the animals were kept in isolated enclosures and the refusal was collected and weighed to determine the daily feed intake. The ration of supplemented groups are composed of concentrate mixtures offered once daily consisting of millet, millet bran, groundnut hulls and ground nut cake (Table, 2). The proximate analysis of supplemented diets samples were proceeded to determine metabolic energy (ME) and chemical composition content of experimental diets. The chemical composition of pasture plants
Table (2): Formulation of supplemented rations:

<table>
<thead>
<tr>
<th>Feed ingredients</th>
<th>Ration A</th>
<th>Ration B</th>
<th>Ration C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millet</td>
<td>40%</td>
<td>24%</td>
<td>30%</td>
</tr>
<tr>
<td>Sorghum</td>
<td>25%</td>
<td>26%</td>
<td>5%</td>
</tr>
<tr>
<td>Groundnut cakes</td>
<td>11%</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>Groundnut hulls</td>
<td>23%</td>
<td>35%</td>
<td>44%</td>
</tr>
<tr>
<td>Common salt</td>
<td>1%</td>
<td>1%</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Chemical analysis:**

<table>
<thead>
<tr>
<th></th>
<th>Ration A</th>
<th>Ration B</th>
<th>Ration C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic energy (MJ/Kg)</td>
<td>12.54</td>
<td>11.51</td>
<td>10.50</td>
</tr>
<tr>
<td>Protein % *</td>
<td>15.48</td>
<td>15.45</td>
<td>15.46</td>
</tr>
<tr>
<td>Fat %</td>
<td>3.99</td>
<td>3.89</td>
<td>4.00</td>
</tr>
<tr>
<td>Ash %</td>
<td>3.95</td>
<td>4.40</td>
<td>4.60</td>
</tr>
</tbody>
</table>

Ration (A) = low energy level.
Ration (B) = medium energy level.
Ration (C) = high energy level.

* Iso-nitrogenous
was considered also (Appendix, 1 and plate, 3, 4, 5 and 6). Each goat fed together and offered concentrates at the rate of 0.75 Kg/head of supplemental diet.

In conventional grazing system experimental animals’ flock were moved to the natural range pastures starting early in the morning at sunrise and they return at sun set during the experiment period. Animals offered drinking water once per day after returning from the range on cool dry season. Meanwhile, during autumn season while range plants are succulent, usually there was no water offer to animals on daily basis.

Bucks are used for mating for the first time at an age of one year and were kept for about 2 years.

3.5. Productive performance:

3.5.1. Kids and does growth:

The kids were weighed immediately following delivery at their birth weight and recorded and then weighed at definite intervals up to weaning at the third month of age (pre-weaning, weaning and post-weaning). Kid's mortality for each group also was recorded. On the other hand, goat’s milk yield, lactation length, persistency indices of productivity and milk composition were recorded.

3.5.2. Milk yield:

The kids were kept with their mothers during the first week after birth; during this week milk is considered as closterom. The second week the kids were kept away from their dams from 8:00 p.m. till 8:00 a.m. However, the does were hand milked once a in the morning. The yield was considered half-day production and it was multiplied by two to estimate the daily yield using a graduated milk cup.
Plate (3): *Ipomoea* spp.
Plate (4): *Echinochloa colonum*
Plate (5): *Cenchrus biflorus*
Plate (
3.5.3. Milk composition:

Five liters of milk samples were collected from each group and frozen for analysis to determine chemical composition. Immediately after samples of milk were collected, frozen for sometime till it was receiveds milk laboratory of Animal Production Research Centre (Kuku) in Khartoum North for analysis.

3.5.3.1. Determination of milk Fat content:

Fat content was determined using Gerber method (marshal 1993). Ten ml of sulfuric acid (specific gravity 1.82 at 15.5C) was measured into a Gerber butyrometer. From a well mixed sample at 24C, a sample of milk was with drawn using 10.94 ml pipette. Milk was allowed to drain into the butyrometer slowly at first to prevent a violent reaction with the acid then the pipette was permitted to drain normally. One ml of amyl alcohol (sp.g. 0.814 at 15.5c) was added and the lock stopper was inserted securely. With the stopper end up, the butyreometer was grasped at the graduated column and shaken until the crude was completely digested. Holding the butyrometer at the stopper and neck was inverted five times to mix the acid remaining in the bulb with the contents. The butyrometers were then placed in a rack and centrifuged at 1100rpm for four minutes.

The butyrometer was placed in the water- bath 65c, leaving only the bulb exposed, for five minutes. the straight line at the bottom of the fat column was pushed gently upwards so that it coincided with nearest whole percent graduation mark .the scale at the bottom of the meniscus at the top of the fat column was read promptly to the nearest 0.05% graduation the lower reading was subtracted from the upper reading and the differences was recorded as fat content.
3.5.3.2. Determination of milk protein content

Total Nitrogen was determined using Kjeldahal method (Marshal, 1993). Ten ml of milk sample was weighed into Kjeldahal digestion flask. 25 ml of sulfuric acid (Sp.g. 1.84, nitrogen-free) was added to the flask. Two tablets of Kjeldahal catalyst (each tablet contain 1 gram of Na2So4 and equivalent of 1 gram Hg). The flask was placed on a heater for three hours or until the solution became clear. The flask was then cooled to room temperature and the solution diluted to 100 ml by graduate pipette using distilled water. Five ml of the sample was transferred to distillator and then 10 ml of 40% sodium hydroxide (Na OH) were added. The distillate was received in a conical flask containing 25 ml of boric acid and bromocresol green plus methylene blue as indicator, until the volume reached 75 ml, the sample was then titrated with N/10 HCL. The acid consumed was then measured.

The protein content was calculated as follows:

\[
\text{Crude protein (\%)} = \frac{T \times N \times 0.014 \times 20 \times 6.38 \times 100}{\text{Weight of Sample}}
\]

Where:

\[
T = \text{titrate volume}
\]

\[
N = \text{normality of the HCL}
\]

3.5.3.3. Determination of milk ash content:

Ash was determined by gravimetric method (Marshal, 1993). The principle of the method is to burn all organic matter at a temperature of 540-550 C. Ten grams of milk were weighted accurately into a dry clean pre-weighted crucible. The sample was burned in a muffle furnace.
regulated at 550°C for 1.5 hr. Then cooled. The crucibles were removed and placed in a descanter to cool and weighed. Then the ash content was calculated accordingly to the following formula:

\[
\text{Ash (\%)} = \frac{\text{Weight of residue}}{\text{Weight of the sample}} \times 100
\]

3.5.3.4. Total solid content:

The total solid content was determined by gravimetric method as follows: the required number of trays of aluminum drying dishes were placed into a desiccators from the oven (100°C) using fresh phosphorus pentoxide as desiccant. When cooled the numbered dishes were removed singly from the desiccators and weighed. One gram of milk sample was added into the dish and reweighed accurately. The dishes were tilted to give an even covering of milk on the base and transferred to the hot plate surface (137°C). When the milk has dried and just started to brown the dish was removed from the hot plate, placed on its appropriate position on the tray and placed in the oven (100°C) for 1½ to 2 hours. The tray was then removed to a desiccator with fresh phosphorus pentoxide, cooled and the dishes reweighed.

Calculation:

\[
\text{Wt. of (dish + sample)} - \text{Wt. of dish} = \text{Wt. of milk sample.}
\]

\[
\text{Wt. of (dish + dried sample)} - \text{Wt. of dish} = \text{Wt. of solid material}
\]

Total solids % = \[
\frac{\text{Wt. of solid material} \times 100}{\text{Wt. of milk sample}}
\]
3.5.4. The productivity indices of doe:

The productivity indices of doe combining characters of doe productive performance, kid viability, kid weaning weight and doe weight to build three productivity indices calculated by equation.

3.5.4.1. Index 1:

Index 1 is the total weight of weaned kid per doe per year and calculated as follows:

\[
\text{Index 1} = \frac{\text{The number of kids/doe/parturition} \times \text{kids weaning weight} \times 365}{\text{Kidding interval period}}
\]

3.5.4.2. Index 2:

Index 2 is the total weight of weaned kid per Kg of doe per year and calculated as follows:

\[
\text{Index 2} = \frac{\text{Index 1}}{\text{Doe average kidding weight.}}
\]

3.5.4.3. Index 3:

Index 3 is the total weight of weaned kid per Kg of metabolic weight of doe per year and calculated as follows:

\[
\text{Index 3} = \frac{\text{Index 1}}{\text{Doe average weight 0.75.}}
\]

3.6. Reproductive Performance:

During experiment of period the bucks were allowed to stay with females, where close observations changes in behavior and appearance of estrus cycle signs were recorded. So the post-partum anestru for female was
recorded, and gestation period, kidding interval, litter size and puberty were also recorded.

3.7. Data Collection:

Data of 60 parent female goats in their first and second season were arranged according to feeding system, beening used in the present study. For each female in the first and second season, the data of daily feed intake, kidding interval, gestation length, litter size, post-partum anestrus, milk yield, lactation period, milk composition, persistency, indices of doe productivity and puberty were recorded. On the other hand, birth weight, pre-weaning weight, weaning weight post-weaning weight kidding mortality for kids were all collected.

3.8. Statistical Analysis:

The experiment was designed as a completely randomized design (CRD) arranged 4 × 2 × 2 factorial to compare four feeding groups (A, B, C and D) for low, medium and high energy supplemented and conventional grazing groups respectively, two types of season (Cool dry and Rainy) for two off-springs. The conventional grazing system was used as a compare group. Data were analyzed statistically according to Steal and Torrie (1980) by the analysis of variance (ANOVA). For each response, the average values for the main effects of different feeding group, types of season and generation number treatments were subjected to pair wise comparison procedures by Duncan Multiple Range test (Duncan, 1955) to determine which pairs were different.
Means, standard deviations, standard errors and co-efficient of variations of the reproductive and productive traits were computed by using the SPSS program (version, 12).
CHAPTER FOUR

RESULTS

4.1. Kid's performance:

4.1.1. Birth weight:

The data pertaining to the effect of feeding supplement A (high energy), B (medium energy) and C (low energy) compared with D (natural grazing without supplementation) on birth weight is presented in table (3). The results show that birth weight of kids differ significantly (P< 0.05) for supplemented groups and unsupplemented group. The mean values of birth weight of kids were 2.20Kg ± 0.40, 1.95 ± 0.36, 1.63 ± 0.14 and 1.55 ± 0.23 for supplemented groups (A, B, C and D). The results indicated that group of does supplemented with A (higher energy) secured the highest birth weight (2.20) compared the unsupplemented that secured the lowest birth weight (1.55).

The data highlighting the effect of season on birth weight of kids presented in table (4). The results shows that birth weight of kids during rainy season was significantly (P< 0.05) higher than that kids born in cool dry season. The mean values of birth weight of kids were 1.982 ± 0.44 and 1.695 ± 0.29 for rainy season and cool dry season respectively. The results indicated that does born during the rainy season gave a higher birth weight of kids as compared to birth weight of kids born in cool dry season.

4.1.2. Weaning weight:

Weaning weight of kids was measured at 3 month of age. The effect of feed supplementation on the body weight of kids at weaning was
Table (3): Effect of supplementation feed on experimental kid's performance.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Supplemented</th>
<th>unsupplemented</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Birth weight (Kg)</td>
<td>2.20 ± 0.40a</td>
<td>1.95 ± 0.36b</td>
<td>1.63 ± 0.14c</td>
</tr>
<tr>
<td>Weaning weight (Kg)</td>
<td>12.95 ± 1.55a</td>
<td>11.03 ± 0.99b</td>
<td>10.08 ± 1.62c</td>
</tr>
<tr>
<td>Post-weaning weight (Kg)</td>
<td>20.3 ± 3.9a</td>
<td>18.10 ± 1.90b</td>
<td>17.65 ± 1.50c</td>
</tr>
<tr>
<td>Kid's mortality (%)</td>
<td>20.0%</td>
<td>30.0%</td>
<td>20.0%</td>
</tr>
</tbody>
</table>

A, B, C, D,

Supplemented feed groups:

A = high energy iso-nitrogenous.
B = medium energy iso-nitrogenous
C = low energy iso-nitrogenous.
D = unsupplemented feed

a, b, c, d: Means values in the same row having different superscript, differ significantly (P< 0.05).
Table (4): Effect of season on experimental kid's performance:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Season</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainy</td>
<td>Cool dry</td>
</tr>
<tr>
<td>Birth weight (Kg)</td>
<td>1.982 ± 0.44&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.695 ± 0.29&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weaning weight (Kg)</td>
<td>11.10 ± 2.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.22 ± 1.79&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Post-weaning weight (Kg)</td>
<td>19.10 ± 2.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.60 ± 3.20&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kid's mortality (%)</td>
<td>71.0%&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.0%&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a, b</sup>

Means values in the same row having different superscript, differ significantly (P< 0.05).
Monitored and tabulated in table (3). The results shows the weaning weight of the supplemented groups (A, B and C) was significantly (P<0.05) higher than unsupplemented group. The mean values of weaning weight of kid were 12.95 ± 1.55, 11.03 ± 0.99, 10.08 ± 1.62 and 8.58 ± 1.07 for supplemented groups (A, B, C) and unsupplemented group (D) respectively. The results indicated that kid’s born to group (A), maintained on higher energy secured the heaviest birth weight compared to the other groups.

The data in table (4) shows the effect of season on birth weights. The results verified significant effects on the birth weight (P<0.05). The heaviest weaning weight was attained by kids kidded in rainy season (11.10 ± 2.24), while the lowest weaning weight was attained by kid's kidded in cool dry season (10.22 ± 1.79). The overall results indicated the poorest performance of kid's born in cool dry seasons compared to wet season.

4.1.3. Post-weaning weight:

The post-weaning weight of kid's was measured at 9 month of age. The effect of feed supplementation on the body weight of kid's post-weaning was monitored and tabulated in table (3). The results shows the post-weaning weight of the supplemented groups (A, B and C) was significantly (P<0.05) higher than unsupplemented group. The mean values of post weaning weight of kids were 20.3 ± 3.9, 18.10 ± 1.90, 17.65 ± 1.50 and 14.30 ± 2.10 for supplemented groups (A, B, C and D) respectively. These results indicated that kids grow faster when fed supplemented feed with higher energy diets compared to feed on grazing pastures without supplemented feed.
The effect of season on post-weaning weight of kid's was revealed in table (4). The results revealed significant differences (P<0.05) on the post-weaning weight of kid's. The heaviest post-weaning weight was attained by kids grown in the rainy season (19.10 ± 2.50), while the lowest post-weaning weight was attained by kid's grow in cool dry season(15.60 ± 3.20). The results indicated that when kids grow in wet season the post-weaning growth rate was faster compared to grow in cool dry season.

4.1.4. Kids mortality:

Kid mortality refers to all kids' deaths that occurred during the first three months post kidding to the total pregnancies. The effect of feed supplementation on the Kid mortality percentage was monitored and tabulated in table (3). The results shows the kid's mortality percentage of the supplemented groups (A, B, C and D) was not significantly different (P<0.05). The percentage values of kid's mortality were 20.0%, 30.0%, 20.0% and 30% for supplemented groups (A, B, C and D) respectively. Although, the results indicated that kid's mortality was not affected by feed supplementation but kid's may be dead due to scare of nutrient requirements combined with other factors such as diseases, weight losses and pre-weaning rearing.

The effect of season on kid's mortality percentages was monitored and tabulated in table (4). The results shows that kid's mortality was significantly differ (P<0.05). The results indicated that the percentage of kid's mortality was higher in rainy season (71.0%) compared to kid's mortality percentage in cool dry season (29.0%).
4.2. Reproductive performance:

4.2.1. Gestation period:

The data revealed in table (5) indicated that the average gestation period of the experimental goats was 149.48 ± 3.10 days. The data in table (5) also shows that the gestation period of goats belonging to different supplementation groups was significantly different (P<0.05). The mean values of gestation period of supplemented feed groups were 146.60 ± 3.10, 148.9 ± 2.34, 150.8 ± 1.89 and 151.63 ± 2.11 days for supplemented group (A, B, C and control D) respectively. This result indicated that gestation period of goats of supplemented group A and B had the shortest gestation period (146.60 ± 3.10 and 148.9 ± 2.34 days), while the supplemented groups C and D had the longest gestation period (150.8 ± 1.89 and 151.63 days). The results also indicated that mean values of gestation period of supplemented (C and D) did not differ statistically.

The data revealed in table (6) shows the effect of season on gestation period. They reflected that the gestation period significantly different (P<0.05). The results indicated that the goat kidding in cool dry season had the longest gestation period (150.28 ± 2.51 days), while the goats kidding in rainy season had the shortest gestation period (148.68 ± 3.37 days).

4.2.2. Kidding interval:

The data depicted in table (5) indicated that the overall average kidding interval was 245.25 ± 24.2 days.

The data also revealed that the effect of supplemented feed on kidding interval differ significantly (P<0.05). Those results indicated that
Table (5): Effect of supplementation feed on reproductive performance of experimental goats.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Supplemented</th>
<th>unsupplemented</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Gestation period (days)</td>
<td>146.60 ± 3.10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>148.9 ± 2.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>150.8 ± 1.89&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kidding interval (days)</td>
<td>210.20 ± 11.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>231.50 ± 29.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>230.70 ± 23.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Litter size</td>
<td>1.10 ± 0.31</td>
<td>1.03 ± 0.18</td>
<td>1.00 ± 0.10</td>
</tr>
<tr>
<td>Puberty (days)</td>
<td>173.98 ± 22.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>182.83 ± 16.00&lt;sup&gt;c&lt;/sup&gt;</td>
<td>194.53 ± 17.09&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Post-partum anestrus (days)</td>
<td>48.10 ± 17.41&lt;sup&gt;d&lt;/sup&gt;</td>
<td>78.40 ± 15.55&lt;sup&gt;c&lt;/sup&gt;</td>
<td>101.07 ± 14.14&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

A, B, C, D,

Supplemented feed groups:

A= high energy iso-nitrogenous.
B= medium energy iso-nitrogenous
C= low energy iso-nitrogenous.
D= unsupplemented feed

a, b, c, d,

Means values in the same row having different superscript, differ significantly (\(P< 0.05\)).
Table (6): Effect of season on reproductive performance of experimental goats:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Season</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainy</td>
<td>Cool dry</td>
</tr>
<tr>
<td>Gestation period (days)</td>
<td>148.68 ± 3.37(^b)</td>
<td>150.28 ± 2.51(^a)</td>
</tr>
<tr>
<td>Kidding interval (days)</td>
<td>216 ± 12.80(^b)</td>
<td>228 ± 23.60(^a)</td>
</tr>
<tr>
<td>Litter size</td>
<td>1.07 ± 0.25</td>
<td>1.00 ± 0.00</td>
</tr>
<tr>
<td>Puberty (days)</td>
<td>174 ± 17.06(^b)</td>
<td>205.53 ± 16.78(^a)</td>
</tr>
<tr>
<td>Post-partum anestrus (days)</td>
<td>75.95 ± 30.15(^b)</td>
<td>92.27 ± 22.13(^a)</td>
</tr>
</tbody>
</table>

\(^a, b\) Means values in the same row having different superscript, differ significantly (P< 0.05).
The kidding interval of goats of the supplemented groups were 210.20 ± 11.7, 231.50 ± 29.8, 230.70 ± 23.30 and 238.60 ± 25.1 days for supplemented groups (A, B, C and D) respectively. The results showed that the goats of supplemented group (A) had the shortest kidding interval (210.20 ± 11.7 days), while goats of unsupplemented group (D) had the longest kidding interval (238.60 ± 25.1). The results also indicated that the mean values of kidding interval of supplemented groups (B and C) were not statistically different.

The data depicted in table (6) shows the effect of season on kidding interval. The results show that the kidding interval differ significantly (P<0.05). The results also revealed that the goat kidded in cool dry season had the longest kidding interval (228 ± 23.60 days), while the goats kidded in rainy season had the shortest kidding interval (216 ± 12.8 days).

4.2.3. Litter size:

The results revealed in table (5) shows the effect of supplemented feed on litter size. The data demonstrated a non significance (p 0.05) between all supplemented groups. The mean values of litter size of supplemented group were 1.10 ± 0.31, 1.03 ± 0.18, 1.00 ± 0.10 and 1.00 for supplemented groups (A, B, C and D) respectively. The overall litter size of experimental goats was 1.03 ± 0.18.

The data presented in table (6) shows the effect of season on the litter size. The results shows that the Litter size differed significantly (P<0.05). This result indicated that the litter size of goats which kidded in rainy season (1.07 ± 0.25) higher than litter size of goats which kidded in cool dry season(1.00 ± 0.00).
4.2.4. Puberty:

The data in table (5) monitored the effects of supplemented feed on kid puberty and shows that the average age at puberty of female kids was 189.95 ± 23.00 day (6.33 ± 0.23 months).

The data indicated that the age at puberty was significantly (P<0.05) affected by feed supplementation. Also the results show the age of experimental female kids at puberty were 173.98 ± 22.03 day, 182.83 ± 16.00 day, 194.53 ± 17.09 day and 208.43 ± 21.15 day. Table (5) shows female kids belonged to supplemented feed group (A) were sexually mature at an earlier age (173.98 ± 22.03 day) compared to female kids belonged to group (D) unsupplemented feed (208.43 ± 21.15 day). This results indicated that supplementation feed accelerate sexual maturity age.

The data revealed in table (6) shows the effect of season on the age of female puberty. The results show that the sexual maturity of female in rainy season was significantly (P<0.05) earlier than female kids mature sexually at cool dry season. This result shows that the puberty of females' goats which matured in cool dry season (205.53 ± 16.78 day) delay than puberty of females' goats which matured in rainy season (174 ± 17.06 day).

4.2.5. Post-partum anestrus:

Post-partum anestrus of experimental goats was revealed in table (5). It reflect a high significant (P<0.05) effect of feed supplementation. The results also show that mean values of female post-partum anestrus were 48.10 ± 17.41 day, 78.40 ± 15.55 day, 101.07 ± 14.14 day and 108.87 ± 8.35 day.
The effect of season on post-partum an estrus is revealed in table (6). The result shows that the post-partum anestrus was affected significantly (P<0.05) by season of year. The results indicated that post-partum anestrus of female in cool dry season was longer (92.27 ± 22.13 day) than post-partum anestrus of female in rainy season (75.95 ± 30.15).

4.3. Productive performance:

4.3.1. Milk production:

The data in table (7) shows that the overall average total milk yield of the experimental goats was 52.31 ± 20.07 Kg. The data also highlighted the effects of feed supplementation on milk yield and demonstrated that there were highly significant differences (P < 0.05). They also show that total milk yield of goats were 78.97± 7.54 Kg, 56.57± 14.22 Kg, 40.50± 9.81Kg and 33.20 ± 4.46 Kg for the un-supplemented groups (A, B, C and D) respectively. This results indicated that goats of supplemented group (A) having the highest milk yield (78.97± 7.54 Kg), while goats of unsupplemented group D having the lowest milk yield (33.20 ± 4.46 Kg). Generally, the goats of supplemented groups having the higher total milk yield compared with goats of unsupplemented group.

The data in table (8) revealed the effect of season on total milk yield. Those results show that there was highly significantly (P<0.05) affect on average milk yield of goats. The results indicated that goats kidded in rainy season having the highest milk yield 59.12± 19.86 Kg compared with the milk yield of the goats kidded in cool dry season45.50 ± 17.99Kg.
Table (7): Effect of season on productive performance of experimental goats:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Supplemented</th>
<th>unsupplemented</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Milk yield (Kg)</td>
<td>78.97± 7.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>56.57± 14.22&lt;sup&gt;b&lt;/sup&gt;</td>
<td>40.50± 9.81&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lactation period (days)</td>
<td>121.47 ± 17.71&lt;sup&gt;a&lt;/sup&gt;</td>
<td>113.63 ± 14.44&lt;sup&gt;b&lt;/sup&gt;</td>
<td>99.03 ± 8.66&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Index 1 (Kg)</td>
<td>23.89 ± 3.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.07 ± 2.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>17.23 ± 3.01&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Index 2 (Kg)</td>
<td>0.79 ± 0.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.78 ± 0.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.63 ± 0.14&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Index 3(Kg)</td>
<td>1.85 ± 0.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.74 ± 0.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.44 ± 0.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Milk fat %</td>
<td>3.36 ± 0.35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.95 ± 0.34&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.19 ± 0.38&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Milk protein</td>
<td>3.94 ± 0.68&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.77 ± 0.86&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.75 ± 0.12&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Milk total solid</td>
<td>15.54 ± 2.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>14.23 ± 1.74&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.92 ± 0.85&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

A, B, C, D: Supplemented feed groups: A= high energy iso-nitrogenous, B= medium energy iso-nitrogenous, C= low energy iso-nitrogenous and D= unsupplemented feed

a, b, c, d,

Means values in the same row having different superscript, differ significantly (P< 0.05).
Table (8): Effect of season on productive performance of experimental goats:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Rainy</th>
<th>Cool dry</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total milk yield (Kg))</td>
<td>59.12 ± 19.86(^a)</td>
<td>45.50 ± 17.99(^b)</td>
<td>52.31 ± 20.07</td>
</tr>
<tr>
<td>Lactation period (days)</td>
<td>116.87 ± 16.73(^a)</td>
<td>92.52 ± 16.07(^b)</td>
<td>104.69 ± 20.40</td>
</tr>
<tr>
<td>Index 1 (Kg)</td>
<td>19.82 ± 4.84(^a)</td>
<td>17.27 ± 3.70(^b)</td>
<td>18.60 ± 4.47</td>
</tr>
<tr>
<td>Index 2 (Kg)</td>
<td>0.65 ± 0.21</td>
<td>0.69 ± 0.20</td>
<td>0.67 ± 0.20</td>
</tr>
<tr>
<td>Index 3 (Kg)</td>
<td>1.47 ± 0.41</td>
<td>1.59 ± 0.41(^a)</td>
<td>1.53 ± 0.41(^b)</td>
</tr>
<tr>
<td>Milk fat %</td>
<td>2.74 ± 0.74(^a)</td>
<td>2.34 ± 0.66(^b)</td>
<td>2.54 ± 0.73</td>
</tr>
<tr>
<td>Milk protein %</td>
<td>2.83 ± 1.22(^a)</td>
<td>2.19 ± 0.85(^b)</td>
<td>2.54 ± 0.11</td>
</tr>
<tr>
<td>Milk total solid</td>
<td>14.84 ± 2.05(^a)</td>
<td>12.42 ± 1.27(^b)</td>
<td>13.63 ± 2.08</td>
</tr>
</tbody>
</table>

\(^a\), \(^b\)

Means values in the same row having different superscript, differ significantly (P<0.05).
4.3.2. Lactation period:

The data depicted in table (7) revealed the effect of feed supplementation on lactation period. The results show that the overall mean of lactation period of the experimental goats was $104.69 \pm 20.40$ day. The data also shows the effect feed supplementation on lactation period and demonstrated there were highly significant differences ($P<0.05$). The mean values of lactation period of goats were $121.47 \pm 17.71$ day, $113.63 \pm 14.44$ day, $99.03 \pm 8.66$ day and $84.63 \pm 16.95$ day for supplemented feed groups (A, B, C and D) respectively. Goats of supplemented group (A) have the longest period of lactation ($121.47 \pm 17.71$ day), while goats of unsupplemented group (D) have the shortest period of lactation ($84.63 \pm 16.95$ day). Generally, goats of the supplemented feeds groups have the longest lactation period compared with goats of unsupplemented feed group.

Effect of season on lactation period of kidding of the experimental goats was monitored and tabulated in table (8). The results indicated that rainy season born does had significantly ($P<0.05$) the longest lactation period ($116.87 \pm 16.73$ day) compared with goats kidded in cool dry season that had the shortest lactation period ($92.52 \pm 16.07$ day).

4.3.3. Indices of doe productivity:

The data of indices of doe productivity (index 1, index 2 and index 3) were monitored and tabulated in table (7). The results shows that the indices of doe productivity were highly significantly different ($P<0.05$). The mean values of index 1 (the total weight of weaned kid per doe per year) were $23.89 \pm 3.64$, $19.07 \pm 2.12$, $17.23 \pm 3.01$ and $14.19 \pm 1.92$ Kg/ doe for supplemented feed groups (A, B, C and D) respectively. The mean values
of index 2 (the total weight of weaned kid per Kg of doe per year) were 0.79 ± 0.20, 0.78 ± 0.16, 0.63 ± 0.14 and 0.48 ± 0.1 Kg for supplemented feed groups (A, B, C and D) respectively. The results also indicated that index 2 of supplemented groups A and B were highest (0.79 ± 0.20 and 0.78 ± 0.16 Kg) than that of supplemented groups C (0.63 ± 0.14 Kg) and D (0.48 ± 0.10 Kg) respectively. The mean values of index 3 (the total weight of weaned kid per Kg of metabolic weight of doe per year) were 1.85 ± 0.39, 1.74 ± 0.27, 1.44 ± 0.30 and 1.11 ± 0.19 Kg for supplemented groups (A, B, C and D) respectively. The results also indicated that index 3 of supplemented groups A and B were highest (1.85 ± 0.39 and 1.74 ± 0.27 Kg) than that of supplemented groups C (1.44 ± 0.30 Kg) and D (1.11 ± 0.19 Kg) respectively.

The effect of season on indices of doe productivity was revealed in table (8). Except with, index 2 the indices of doe productivity were significantly differ (P<0.05). The mean values of index 1 (the total weight of weaned kid per doe per year) were 17.27 ± 3.70 and 19.82 ± 4.84 Kg/doe for cool dry and rainy respectively. The mean values of index 2 (the total weight of weaned kid per Kg of doe per year) were 0.65 ± 0.21 and 0.69 ± 0.20 Kg for cool dry and rainy season respectively. The results also indicated that index 2 of cool dry season (0.65 ± 0.21 Kg) was not significantly differences with rainy season (0.69 ± 0.20 Kg). The mean values of index 3 (the total weight of weaned kid per Kg of metabolic weight of doe per year) were 1.47 ± 0.41 and 1.59 ± 0.41 Kg for cool dry and rainy season respectively. The results also indicated that index 3 of rainy season was highest (1.59 ± 0.41 Kg) than that of cool dry season (1.47 ± 0.41 Kg) respectively.
4.3.4. Milk composition:

4.3.4.1. Milk fat:

The effect of supplementation feed groups data of milk fat content depicted in table (7). The results show that the milk fat content was affected significantly (P<0.05) by feed supplementation. The results show the overall average milk fat content was 2.54 ± 0.73 %. Those results also show that the mean values of milk fat content were 3.36 ± 0.35 %, 2.95 ± 0.34 %, 2.19 ± 0.38 % and 1.68 ± 0.14 % for feed supplemented groups (A, B, C and D) respectively. The results indicated that the milk fat content increased when goats were fed on feed supplementations which have higher energy content.

Table (8) shows the effect of season on milk fat content and the milk fat content in rainy season (2.74 ± 0.74) was significantly (P<0.05) higher than milk fat content in cool dry season (2.34 ± 0.66).

4.3.4.2. Milk protein:

The data on milk protein content revealed in table (7) shows the effect of feed supplementation. The results show that the milk protein content was affected significantly (P<0.05) by supplementation of feed. The results show the overall average milk protein content was 2.54 ± 0.11 %. The results also show that the mean values of milk protein content were 3.94 ± 0.68 %, 2.77 ± 0.86 %, 1.75 ± 0.12 % and 1.59 ± 0.22 % for supplemented feed groups (A, B, C and D) respectively. Milk protein content of supplemented groups (C and D) was not statistically different for milk protein of supplemented groups (A and B). The data indicated that the milk protein content was affected by feed supplementation.
Table (8) shows the effect of season on milk protein content. The milk protein content in rainy season (2.83 ± 1.22) was significantly (P<0.05) higher than milk protein content in cool dry season (2.19 ± 0.85).

4.3.4.3. Milk total solid:

The data in table (7) revealed milk total solid and shows the effect of feed supplementation. The results show that the feed supplementation was significantly (P<0.05) affecting on milk total solid content. The results show that the overall average of milk total solid was 13.63 ± 2.08 %. The results also show that the mean values of milk total solid content were 15.54 ± 2.03 %, 14.23 ± 1.74 %, 12.92 ± 0.85 % and 11.83 ± 1.41 % for supplemented and un-supplemented feed groups (A, B, C and D), respectively. The data indicated that the milk total solid content increased when goats were fed by higher energy feeds.

Table (8) shows the effect of season on milk total solid content. The milk total solid content in rainy season (14.84 ± 2.05) was significantly (P<0.05) higher than that of cool dry season (12.42 ± 1.27).
CHAPTER FIVE

DISCUSSION

5.1. Kid's performance:

5.1.1. Birth weight:

The overall average birth weight of experimental kids of this study was 1.84 ± 0.40 Kg. This result was in agreement with data authenticated by both Wilson (1976) who studied production traits of Southern Darfur goats and reported that the average birth weights were 2.10 ± 0.61 and 2.16 ± 0.61 Kg for males and females respectively, and 2.09 ± 0.5 and 2.01 ± 0.4 kg for males and females born for the first kidder goats. And Ageeb (1992) who reported that, the birth weight of Baggara goat of South Kordofan were 2.0 ± 0.5 and 1.8 ± 0.40 kg for males and females respectively, the average birth weights were 2.10 ± 0.61 and 2.16 ± 0.61 Kg for males and females respectively, and 2.09 ± 0.5 and 2.01 ± 0.4 kg for males and females born for the first kidder goats.

The effect of feed supplementation on birth weight of experimental kid's was investigated. The Findings of this study showed that birth weight of kids differ significantly (P< 0.05) for supplemented and unsupplemented groups. The results indicated that group of does supplemented with A (higher energy) secured the highest birth weight (2.20) compared to the unsupplemented group (D) that secured the lowest birth weight (1.55). These differences in kid's birth weight could be attributed to differences in nutritional energy levels. As the energy requirements is variate for different physiological stages of doe such as; maintenance, pregnancy, lactation and growth.

The impact of season on birth weight of kids was also investigated and showed that the birth weight of kids during rainy season was, 1.982 ±
0.44, significantly (P< 0.05) higher than that kids born in cool dry season, 1.695 ± 0.29. The results indicated that does born during the rainy season maintained a higher birth weight of kids as compared to birth weight of kids born in cool dry season. Higher values of birth weight of kid's on rainy season could be referred to availability of green grasses and forages, and young succulent plants that containing edible portion that provide high energy in rainy season resulting in a well body condition score compared to older browsing plants with undigested fiber which are found greatly in cool dry season.

5.1.2. Weaning weight:

The overall average weaning weight of experimental kid's that was weighted at 3 months of age was 10.95 ± 2.07. These results were compatible with claims obtained by Elabid (2002), who reported that the average weaning weight of Nubian kids were 8.641 Kg and 8.150 Kg for male and female respectively.

The effects of feed supplementation on the weaning weight was studied and showed that the weaning weight of the supplemented groups (A, B and C) was significantly (P<0.05) heavier than unsupplemented group. Those differences in weaning weight might be referred to differences in feed energy levels. The mean values of weaning weight of kids were 12.95 ± 1.55, 11.03 ± 0.99, 10.08 ± 1.62 and 8.58 ± 1.07 for supplemented groups (A, B, C) and unsupplemented group (D) respectively. The results indicated that kid's borned and maintained on higher energy (A) secured the heaviest weaning weight compared to the other groups.
The present result verified significant effects of season on the weaning weight (P<0.05). The heaviest weaning weight was attained by kids kidded in rainy season (11.10 ± 2.24), while the lowest weaning weight was attained by kid's kidded in cool dry season (10.22 ± 1.79). This result could be attributed to availability of good young pasture during rainy season as compared with cool dry season. Moreover, the poorest performance of kid's born in cool dry season may be due to the lower milk yield of their dams when compared to rainy season kidders.

5.1.3. Post-weaning weight:

The effect of feed supplementation on the body weight of kid's post-weaning measured at 9 month of age, the supplemented groups (A, B and C) was significantly (P<0.05) higher than unsupplemented group (D). These results indicated that kids grow faster when fed on supplemented feed with higher energy diets compared to fed on grazing pastures without supplementation.

The effect of season on post-weaning weight of kid's verified significant differences (P<0.05). Results show that the heaviest post-weaning weight was attained by kid's grown in rainy season (19.10 ± 2.50) compared with the lowest post-weaning weight attained by kid's grown in cool dry season (15.60 ± 3.20). These differences could be referred to the presence of pastures and browsing plants in rainy season.
5.1.4. Kids mortality:

Kid mortality encountered in this study (25%) refers to all kids' deaths that occurred during the first five months post kidding to the total pregnancies and represent about quarter of the whole kids to be produced by the experimental flock. The mortality rate in this study was due to many factors such as diseases, inadequate nutrition and other individual. These results were complying with many authors (Khan 1979; Ageeb 1999; Vihan 1979 and Nair 1979). Khan (1979) studied the kid's mortality for Jamnapari goats of India and reported that, the pre-weaning mortality was higher in the kids having low birth weight and the mortalities were 8.49%, 14.92% and 10% for pre-weaning, post-weaning and adult respectively. Ageeb (1999) using South Kordofan Baggara goats, reported a mortality of 40.2% for kids less than 6 months of age. Vihan (1979) investigated the common causes of mortality in kids and their control, showed that 50 % of the deaths were infected in the first month and about 25% in the first week of the birth, with other peak death from 3rd to 5th month where milk is completely forms kid diets. Nair (1979) found a mortality rate of 5.06%, 6.05% for Malabari adult males and females respectively, under normal conditions then the mortality rates increased to 32.73%, 11.16% for males and females due to outbreak of viral pneumonia.

The present study indicated that results of the kid's mortality percentages of the supplemented and un-supplemented groups (A, B, C and D) exerted no significant effect (P<0.05).

On the other hand, the effect of season on kid's mortality revealed significant differences (P<0.05). The results indicated that the overall (25 %) percentage of kid's mortality occurred higher in cool
dry season compared to one-third in rainy season. However, these rates of kid's mortalities are due to deficiencies of nutrients requirements combined with other factors such as bacterial disease (diabetes), viral pneumonia and other individual causes.

5.2. Reproductive performance:

Importance of reproductive performance of an animal referred to the efficiency of the animal production, whatever on production function of animal keeping. Dairy goats are kept primarily for milk production, the economic utilization does not begin until after kidding, since with each kid the lactation period is limited. Meanwhile, in case of goats kept primarily for meat the kidding rate and the frequency of kidding determine the attainable economic benefit.

In this study, the reproductive performances of experimental goats investigated, were gestation period, kidding interval, litter size, puberty and post-partum anestrus period.

5.2.1. Gestation period:

Data revealed in table (5) indicated that the average gestation period of the experimental goats was 149.48 ± 3.10 days. These results were in conformity with Mukasa-Mugerwa et al. (1988), and Devendra and McLeroy (1987). Mukasa-Mugerwa et al. (1988) reported that duration of gestation ranged between 145 and 155 days for both sheep and goats. Devendra and McLeroy (1987) studied the gestation periods in several breeds of goats in the tropics and reported that gestation periods ranged between 144 to 153 days with average 146 days. However, those researchers
concluded that the gestation period for most of tropical goat's variate by less 3 – 5 days could be to either genetic or environmental factors.

Data in table (5) also shows that the gestation period of experimental goats belonging to different supplementation groups was significantly different (P<0.05). The differences in gestation period might be referred to differences in energy supplementation levels used in this study. Results also showed that gestation period of experimental goats of supplemented group A and B had shorter gestation period (146.60 ± 3.10 and 148.9 ± 2.34 days), while the supplemented groups C and D had longer gestation period (150.8 ± 1.89 and 151.63 days). Hence, provision of amount of energy level in pregnant doe feed would accelerate in growth rate of fetus that ultimately result in shortening gestation period.

Data presented in table (6) shows the effect of season on gestation period. Goats pregnant in the cool dry season had significantly (P<0.05) longer gestation period (150.28 ± 2.51 days) compared to goats pregnant in the rainy season. These differences might be referred to the seasonal impact on grazing pastures quality which negatively influence the pregnant doe requirement.

5.2.2. Kidding interval:

The overall average of the kidding interval in experimental goat was 245.25 ± 24.2 days. These results were in agreement with Wilson (1979), who reported that the kidding interval of Southern Darfur goats averaged was 238 ± 41 days. Also, these results were similar to Ageeb (1992) who reported that, the kidding interval of Baggara breed was 234.1 ± 28.9 days.
The effect of supplemented feed on kidding interval significantly different (P<0.05). These results were comparable with results that had been advocated by many authors who studied effects the of nutritional level on kidding interval. Singh and Sengar (1970) reported that, the kidding interval of Jamnapari does was shorter when fed on high and medium energy feeds compared to does fed on lower energy diet. Sachdeva et. al. (1973) studied the effect of plane of nutrition on reproductive performance of Barbari and Jamnapari goats. They found that the kidding intervals were 245, 231, 242, 243 and 244 of Barbari goats Vs. 298, 283, 307, 333 and 385 of Jamnapari for high energy-high protein, high energy-medium protein, medium energy-medium protein, medium energy-low protein and low energy-low protein respectively. Kudouda (1985) worked on Sudanese Nubian goats and reported that, the kidding interval of roughage fed group was 343.5 ± 57.3 days, while it was 251.2 ± 19.3 days for concentrate supplemented goats. Also, Jubartalla (1998) studied the effect of feeding Molasses based ration and sorghum based ration to Sudanese Nubian goats and reported that, the kidding interval was 271 ± 27 for sorghum fed group and longer compared to the molasses fed group 251 ± 41 days.

The findings of this study concerning with most of these workers indicated that goats of supplemented group (A) had secured shortest kidding interval (210.20 ± 11.7 days), while goats of unsupplemented group (D) had longest kidding interval (238.60 ± 25.1). However, the mean values of kidding interval of supplemented groups (B and C) were not statistically different.
Data demonstrated in table (6) revealed significant (P<0.05) difference in responses to season influenced on kidding interval. These results were in match with data obtained by many workers (Haumesser, 1975; Gracia et. al., 1976; Gangwar and Yadav, 1987 and Cabello et. al., 1991) for different goat breeds. Haumesser (1975) worked on Red Sokoto goats reported that, following parturition during September – April, May – June or July – August, the kidding intervals average 343.2, 302.3 and 266.1 days respectively. Ganwar and Yadav (1987) studied the influence of various factors on service period and kidding interval in Indian goats and reported that, year and season of kidding had a significant effect on drinking interval 235.71 days in the monsoon season Vs. 271.39 and 278.22 days in summer and winter respectively. Cabello et. al. (1991) claimed that in Anglo-Nubian goats, season of kidding significantly affected kidding interval 214.9 days for female kidding in the rainy season Vs. 246.3 in the dry season where factors such as temperature, humidity and availability are the main influential.

5.2.3. Litter size:

In the present study, the overall average of litter size obtained (1.03 ± 0.18) had shown significant differences (P<0.05) and remained in harmony with other workers (Karua 1989, Shalaby et. al. 2000 and Webb and Mamabolo 2004). Karua (1989) studied the litter size of Malawi indigenous goats and revealed that, the litter size was 1.35 ± 0.5 and 1.33 ± 0.5 in village and ranch systems conditions. Shalaby et. al. (2000) reported, the litter size at birth was 1.47, while, Webb and Mamabolo (2004) reported that, the litter size of South African indigenous goats was 1.7 kids per doe.
On the other hand, the overall average of litter size tackled in this study was contradictable with claims of Alexander et. al. (1999) who showed that, the litter size at birth, during suckling and weaning were 2.25, 2.05 and 1.95 respectively. This contradiction might be attributed to the different breed's sizes, environmental and managerial factors involved in the different experiment conducted. Furthermore, the effect of season on the litter size was calculated and the results showed that the litter size of experimental goats which kidded in rainy season (1.07 ± 0.25) was significantly (P<0.05) higher than goats kidded in cool dry season (1.00 ± 0.00). These findings were corresponding with Devendra (1990), who stated that, the litter size is affected by level of nutrition, body weight and birth type.

5.2.4. Puberty:

The data in table (5) monitored the effects of supplemented feed on puberty and shows that the average age at puberty of female kids was 189.95 ± 23.00 day (6.33 ± 0.23 months). Results were favourably in confairmtty with data indicated by many workers (Myenuddin and Wahab, 1989; Wolde-Michael et.al. 1989; Camboav et. al., 1992 and Walkden, 2001). Myenuddin and Wahab (1989) who reported that the age at puberty of Black Bengal goats was 180.74 ± 1.68 days. Wolde-Michael et.al. (1989) found that the age and weight of puberty was 172 days and 15 Kg in Feral Cashmere respectively. Camboav et. al. (1992). reported that age of puberty was 209.8 days in Sinaloa goats. Moreover, Walkden (2001) reported that age at puberty ranged between 5 – 7 months when body weight approximately reaches 50 % of the mature weight, but bucks born after the season of breeding and did not reach puberty in the first breeding season would be delayed up to 18 moths of age.
Data of this study indicated that the age at puberty was significantly (P<0.05) affected by feed supplementation. Results and observations were in agreement with the results obtained by many researchers (Arthur et. al., 1998 and Walkden, 2001), who reported that animals well fed with good growth rate reach puberty before those which were poorly fed with slow growth rate.

Data revealed in table (6) shows the effect of season on the age of female puberty. Results shows that the sexual maturity of female in rainy season (174 ± 17.06 day) was significantly (P<0.05) earlier than female kids matured sexually at cool dry season (205.53 ± 16.78 day). These results were in line with (Arthur and Ahunu, 1998 and Walkden, 2001) who reported that age of puberty in seasonal breeders will be influenced by the year. However, it came clear in the review if the seasonal breeds fail to reach puberty weight in the first breeding season after birth, puberty will be delayed until the next breeding season.

5.2.5. Post-partum anestrus:

In this study, the overall average of experimental female post-partum anestrus was 84.11 ±27.58 day.

Post-partum an estrus of experimental goats was revealed in table (5) and affected significantly (P<0.05) by the feed supplementation. These results were in conformity with what had been observed by (Kamwanja et al., 1985) on the Droper of Kenya and local Malwi sheep and their crosses. They found that the post-partum an estrous period of natural grazing ewes was 105 days and it was reduced by high feeding level to the mean of 52.4 days.
The effect of season on post-partum an estrus is revealed in table (6). The results shows that the post-partum anestrus was affected significantly \((P<0.05)\) by season of year. The results indicated that post-partum anestrus of female in cool dry season was longer \((92.27 \pm 22.13 \text{ day})\) than post-partum anestrus of female in rainy season \((75.95 \pm 30.15)\). The differences might be attributed to availability of good feeding in rainy season compared to cool dry season coupled with breed’s intervention.

5.3. Productive performance:

5.3.1. Milk production:

Data in table (7) shows that the overall average total milk yield of the experimental goats was \(52.31 \pm 20.07 \text{ Kg}\). This result is lower than the findings obtained by other workers (Abdel Wahab, 1989, Jubartall et. al., 2002) who worked on Sudanese Nubian goats.

Further, the data also highlighted the effects of feed supplementation on milk yield and demonstrated that there were highly significant differences \((P < 0.05)\) among the supplemented groups. Group (A) revealed the highest milk yield \((78.97 \pm 7.54 \text{ Kg})\), while group D secured the lowest milk yield \((33.20 \pm 4.46 \text{ Kg})\). These findings supporting the concept concluded by Ali et. al., (1991) and Leclerc (2000) who reported that energy seemed to be the limiting factor for milk yield. Prenatal and post-natal nutrition of the doe influence milk yield, milk composition and persistency, and is known to have major effects on the growth of kids. Abdel Wahab (1998) found that, milk yield of Sudanese Nubian goats was \(208.72 \pm 95.5\) and \(254.07 \pm 9.3 \text{ Kg}\) for goats given two
levels of energy. Alexander et. al. (2002) showed that, milk production is higher in supplemented goats than grazing goats were 1023 ± 162 and 520 ± 174 days over the 12 weeks of lactation, respectively. Jubartalla et. al. (2002) reported that, the average daily milk yield was 1.14 ± 0.4 and 1.7 ± 0.3 Kg for doe fed molasses and sorghum respectively. Mirgani and Nasir (1993) reported that, a 30% increase in milk yield of Sudanese Nubian goats fed on 30% molasses and sesame cake.

Data in table (8) revealed the effects of season on total milk yield. The results depicted that there were highly significant effect (P<0.05) on average milk yield of goats. Goats kidded in rainy season produced higher milk yield (59.12 ± 19.86) compared with the milk yield of the goats kidded in cool dry season (45.5 ± 17.99). The seasonal effect is in agreement with results obtained of Concalves and Wechsler, (2000) and (Haffez, 1968) whom reported that, does kidding in wet season had higher lactation milk yields and longer lactation length compared with does kidded in cool dry season. This variation is due to availability of fresh, green pastures during the wet season compared to low quality forages in the dry season. The reduction in milk production during exposure to heat, or during the summer, cannot be attributed solely to a fall in feed intake or forage quality. The effect of heat on physiological mechanisms related to lactation is also of importance, mainly, the low level of thyroxin during the summer.

5.3.2. Lactation period:

The overall mean of lactation period of the experimental goats was 104.69 ± 20.40 days. Results showed that the lactation period of experimental goats was lower than other breeds investigated by other workers. The lactation length of Sudanese Nubian goats was investigated
by (Elnaim, 1979; Kudouda, 1985 and Khalaffalla and Sulieman, 1990). Elnaim (1979) reported that lactation length of Sudanese Nubian goats was 147 days with 73.5 Kg milk yield. Kudouda (1985) reported that in Sudanese Nubain goats the lactation length was 24 weeks (168 days) and the goat dried up 2 – 3 months after conception. Also, Khalaffalla and Sulieman (1990) noted that lactation length of Sudanese Nubian, Sannen, Toggenburg and Anglo-Nubian goats were 121.47, 253, 206 and 60 days with milk yield 71.8, 249.3, 244.3 and 162.4 Kg respectively.

The data demonstrated in table (7) revealed the effect of feed supplementation on lactation period. Results showed that there were highly significant differences (P<0.05) between supplemented groups. Group (A) showed the longest period of lactation (121.47 ± 17.71 days), while goats of unsupplemented group (D) showed the shortest period of lactation (84.63 ± 16.95 days). The variations of lactation period encountered among the supplemented groups could be solely attributed to offer supplemented feed containing required ingredients for milk synthesis. was, hence ultimately enhance prolonging the lactation period.

Impact of season on lactation period for the experimental goats was monitored, and the results indicated that rainy born dams had significantly (P<0.05) the longest lactation period (116.87 ± 16.73 days) compared with goats kidded in cool dry season that had the shortest lactation period (92.52 ± 16.07 days). Those results emphasizing the results obtained by many workers (Garacia et.al., 1976; and Khan and Sahni, 1983). Garacia et.al. (1976) who, reported that the lactation length was significantly affected by month and year of kidding for Anglo-Nubian, Alpine, Toggenburg and Sannen goats imported into Venezuela. Khan and Sahni (1983) pointed out
that the Jamnapari goats verified that lactation length was significantly affected by year and season of kidding and their interaction.
5.3.3. Indices of doe productivity:

There is a little information about indices of goat’s productivity. It is used to examine the overall annual output of doe-kid unit which combine characters of doe productive performance, kid viability, kid weaning weight and doe weight to build three productivity indices.

The effect of feed supplementation on indices of doe productivity (index 1, index 2 and index 3) was monitored and tabulated in table (7). These results show that the indices of doe productivity were highly significantly different (P<0.05). The mean values of index 1 (the total weight of weaned kid per doe per year) were 23.89 ± 3.64, 19.07 ± 2.12, 17.23 ± 3.01 and 14.19 ± 1.92 Kg/does for supplemented feed groups (A, B, C and D) respectively. The mean values of index 2 (the total weight of weaned kid per Kg of doe per year) were 0.79 ± 0.20, 0.78 ± 0.16, 0.63 ± 0.14 and 0.48 ± 0.1 Kg for supplemented feed groups (A, B, C and D) respectively. The results also indicated that index 2 of supplemented groups A and B were highest (0.79 ± 0.20 and 0.78 ± 0.16 Kg) than that of supplemented groups C (0.63 ± 0.14 Kg) and D (0.48 ± 0.10 Kg) respectively. The mean values of index 3 (the total weight of weaned kid per Kg of metabolic weight of doe per year) were 1.85 ± 0.39, 1.74 ± 0.27, 1.44 ± 0.30 and 1.11 ± 0.19 Kg for supplemented groups (A, B, C and D) respectively). The results also indicated that index 3 of supplemented groups A and B were highest (1.85 ± 0.39 and 1.74 ± 0.27 Kg) than that of supplemented groups C (1.44 ± 0.30 Kg) and D (1.11 ± 0.19 Kg) respectively. These results were in line with (Wilson, 1986) who, studied the productivity indices of Mali goats and reported that the total weight of weaned kid per doe per year (index, 1) was found to be 14.6 Kg/ doe, the total weight of weaned kid per Kg of doe per year (index, 2) was found to
be 0.494 Kg., and the total weight of weaned kid per Kg of metabolic weight of doe per year (index, 3) was found to be 1.23 Kg.

The effect of season on indices of doe productivity revealed in table (8). Exception with, index 2 the indices of doe productivity were significantly different (P<0.05). The mean values of index 1 (the total weight of weaned kid per doe per year) were 17.27 ± 3.70 and 19.82 ± 4.84 Kg/doe for cool dry and rainy respectively. The mean values of index 2 (the total weight of weaned kid per Kg of doe per year) were 0.65 ± 0.21 and 0.69 ± 0.20 Kg for cool dry and rainy season respectively. The results also indicated that index 2 of cool dry season (0.65 ± 0.21 Kg) was not significantly difference with rainy season (0.69 ± 0.20 Kg). The mean values of index 3 (the total weight of weaned kid per Kg of metabolic weight of doe per year) were 1.47 ± 0.41 and 1.59 ± 0.41 Kg for cool dry and rainy season respectively. The results also indicated that index 3 of rainy season was highest (1.59 ± 0.41 Kg) than that of cool dry season (1.47 ± 0.41 Kg) respectively. Results were in line with (Wilson, 1986) who, stated that Productivity indices were affected by many factors such as: production system, season, year, parity type of birth and nutrition moreover, season effect on productivity indices such that goats given birth in the hot dry or rainy seasons were more productive than those kidding in the post-rains season, while births in the cold dry resulted in lowest productivity.
5.3.4. Milk composition:

5.3.4.1. Milk fat:

In the present study, the overall average milk fat content was 2.54 ± 0.73 %. Results were in line (Parakash and Jennes, 1968) who, reported that the milk fat content ranged from 2.7 to 5.9 %. Also, El-naim (1979) reported that, Sudanese Nubian goat’s milk fat content was 3.6%.

Feed supplementation feed of the experimental lactating does was significantly (P<0.05) affecting on milk fat. Results indicated that the milk fat content increased when goats were fed on feed supplementations which had higher energy content. These results were in conformity with results obtained by (Hussein et. al., 1996; Schmidely et. al., 1999; Morand-Fehr et. al., 2000; Min et. al., 2005; and Spruzz and Selegoska, 2006). Morand-Fehr et. al. (2000) observed that, milk fat percentage in goats even fed on Mediterranean rangeland can be lower than protein percentage because of low availability of vegetation especially in summer and reduced ingestion of fiber. Min et. al. (2005) reported that, the average percentage of milk fat was lower in goats giving zero concentrate (2.9%) compared with other groups giving concentrate (3.1%). Schmidely et. al. (1999) confirmed that, increasing the level of energy intake in dairy goats improved their milk yield and decreased the milk fat percentage. While, Hussein et. al. (1996) reported that, with less yielding goats an increase in energy increased sometime milk yields and fat percentage. Spruzz and Selegoska (2006) worked on goats given supplemented diets and found that, supplemented diets increased milk yield by 12.64% and fat content to 3.2%.

Table (8) shows the effect of season on milk fat content and the milk fat content in rainy season (2.74 ± 0.74) was significantly (P<0.05)
higher than milk fat content in cool dry season (2.34 ± 0.66). These differences might be due to availability of green pastures in rainy season as compared with scarcity of green fodders and pastures in cool dry season.

5.3.4.2. Milk protein:

The overall average milk protein content was 2.54 ± 0.11 %. The data of milk protein content revealed in table (7) showed that the milk protein content was affected significantly (P<0.05) by feed supplemented. The results indicated that the milk protein content was affected by feed supplemented energy. Results were agreement with (Spruzz and Selegoska, 2006) who reported that goats supplemented with wheat bran and grazing pasture and hay increased protein, fat and sugar contents of goat's milk on 13.3%, 22.8% and 1.1% respectively.

Table (8) shows the effect of season on goats milk protein content where the milk protein content in rainy season (2.83 ± 1.22) was significantly (P<0.05) higher than milk protein content in cool dry season (2.19 ± 0.85). The differences might be due to presence of young pastures and other factors affecting milk protein during rainy season as compared with cool dry season.

5.3.4.3. Milk total solids:

In the present study, the overall average milk total solids were 13.63 ± 2.08 %. Result of this study was in harmony with results obtained by Baruah et. al. (2000) who reported that the milk total solids ranged between 15.77 ± 0.18 to 14.92 ± 0.23 and the overall mean for total solids, solids-not-fat, lactose and ash were 17.4%, 10.6%, 4.7% and 0.88% respectively.
The effect of the feed supplementation had influenced significantly (P<0.05) on milk total solid content. The data indicated that the milk total solids content was increased when goats were fed by supplemented with feed containing higher energy. Results were in reliance with findings of Gallad et. al. (1998) who, reported that all milk constitutes were negatively correlated to the amount of milk secreted by the dairy goats, and increase with increased energy content of the diet.

Table (8) shows the effect of season on milk total solids content and the milk total solids content in rainy season (14.84 ± 2.05) was significantly (P<0.05) higher than milk total solid content in cool dry season (12.42 ± 1.27). Those differences could be attributed to availability of wide varieties of grazing pastures in the rainfall season compared to scarce feeding sources in cool dry season.
CONCLUSIONS AND RECOMMANDATIONS

Productive and reproductive performances of Sudan Desert Goats under conventional system with supplemented feedings composed of different energy levels with Iso- nitrogenous protein were studied. In addition to, the influences of rainy and cool dry seasons on both goat and kid productive and reproductive performances were monitored.

Milk yield, Lactation period, milk composition, and indices of doe productivity were measured as productive traits. Meanwhile, Kidding interval, gestation length, Litter size, Post-partum anoestrus and Puberty were calculated as reproductive traits.

The concluded results of the study were:-

1. The positive impacts of feed supplementation on most of the studied parameters suggest that the plan of nutrition on Desert goat’s production systems is a crucial issue.

2. Sudan Desert goats had revealed better productive and reproductive potentialities that ensured its contribution in increasing social economical benefits for local societies as well as its tolerance to harsh conditions.

As there are meager conducted studies regarding Sudan Desert goats potentials, this study was undertaken to contribute in securing data base on various productive and reproductive performances.
With Recommendations of further studies in the following areas:-

1. Improvement of range pastures quality, quantity and improvement of grazing land to.

2. Utilization of watering interval systems that practiced in the study area as the constrain factor of goats productive performance.

3. Rising up the awareness of local communities to adopt feed supplementation as strategic goal to enhance goat’s productive and reproductive performances.
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