**Sudan University of Sciences and Technology**

**College of graduate Studies**

# Effect of Water Scarcity and Feed Supplementation under Natural Grazing on the Performance of the Desert Sheep (Hamari) in Um Rawaba Locality - North Kordofan State

أثر ندرة المياه والإضافات العلفية تحت الرعي الطبيعي على أداء الأغنام الصحراوية (الحمري) في محلية روابة – ولاية شمال كردفان

**A Thesis Submitted in Fulfillment for the Requirements of the Degree of Philosophy Doctor in Animal Production (Animal Nutrition)**

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# DEDICATION

*To the soul of my mother*

*To my dear father*

*To my dear sisters and brother*

*To my dear uncles, aunt and friends*

***ABDELMONEEM***

# Acknowledgements

I am most grateful to **my supervisor Dr. ABDELAZIZ MAKKAWI** for his guidance, encouragement, help and invaluable remarks throughout the research.

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# ABSTRACT

This study was conducted to find out the effect of supplementation and water limitation on the reproductive characteristics of desert sheep (Hamry breed) in the Umm Rawaba area, and assessing some biochemical blood components. 100 ewes were selected from the desert sheep, at age 4-5 months. The Ewes were marked and divided randomly into four groups in the form of A, B, C, and D. The first group (A) was allowed to drink water every day and supplemented with additional concentrates consisting of 40% of sorghum, 30% of beans and 29%Wheat bran and 1% salt. Each head of this group was given concentrates 150 g daily, the second group (B) was allowed to drink water every day without supplements, the third group (C) was allowed to drink water with an interval of (2-3) days with supplements, The fourth group (D) was also allowed to drink water with intervals (2-3) days without supplementation, this group is considered as a control group. Regarding reproductive traits, there were no significant differences between treatments, for each of the age at first service, and age at first calving, on the other hand, there were significant differences (P<o.o5) between treatments in abortion, which was 8%, in group B ,and group D 8%,while no abortion in A,C. For mortality 3%and 8% were observed in group C and D respectively . The results of the study also showed that there were no significant differences in weight at birth and weight at weaning between treatments. While the study showed the presence of Significant differences (P<0.05) between treatments in mortality of the newborns.

As for the blood serum samples, estradiol and Triiodothyronine( T3 )hormones when analyzed, no significant differences between the treatments, was observed

As for the Minerals, ca.and p. they were estimated by using voltmeter, and it was noted that no significant differences were found between the treatments. Regarding the biochemical components of the blood under the study, total protein and glucose were evaluated. The study revealed that there were no significant differences between the treatments.

This study concluded that the reproductive characteristics of desert sheep showed improvement when the stress in the search for water and pasture were reduced.

# الخلاصة

## Arabic Abstract


أجريت هذة الدراسة لمعرفة اثر الإضافات ومحدودية المياه على الصفات التناسلية للأغنام الصحراوية (السلالة الحمرية ) فى منطقة ام روابة ,وتقيم بعض مكونات الدم الكيميائية الحيوية:- تم اختيار حوالى مائة نعجة من الأغنام الصحراوية (سلالة الحمرى ) فى عمر (4—5)أشهر وتم وضع علامة على الاذنين وتقسيمها عشوائا الى اربع مجموعات على شكل ا,ب,ج,د سمح للمجموعة الأولى (ا)بشرب الماء كل يوم واضافات بمركزات اضافية تتكون من 40% زرة و30% امباز فول و29%ردة قمح و1%املاح . كل رأس من هذه المجموعة تعطى مركزات يوميا ,المجموعة الثانية (ب)سمح لها بشرب الماء كل يوم بدون إضافات ,المجموعة الثالثة (ج) سمح لها بشرب الماء بفاصل (2—3)يوم مع الإضافات .كما سمح للمجموعة الرابعة (د) بالماء بفواصل زمنية (2−3)يوم بدون مكملات .تعتبر هذه المجموعة بمثابة مجموعة تحكم,

بالنسبة للصفات التناسلية لم تكن هنالك فروقات معنوية بين المعاملات, لكل من العمر عند اول تلقيح ,والعمر عند الولادة الأولى ,من جانب آخر كانت هنالك فروقات معنوية (P<o.o5) بين المعاملات فى الإجهاض حيث بلغت فى المجموعة ب 8% أما في المجموعة د% 8 ,اما النفوق (%8D,%3C ) نتائج الدراسة أوضحت انة لم تكن هنالك فروقات معنوية فى الوزن عند الميلاد والوزن عند الفطام بين المعاملات .بينما أظهرت الدراسة وجود فروقات معنوية ( P<0.05)بين المعاملات فى النفوق بالنسبة للمواليد .

اما عينات مصل الدم فقد تم تحليل هرمونات الاستراديول والتراي أيودوسايرونين ( T3) وقد لوحظ بان الاستراديول وال T3 لم تكن هنالك فروقات معنوية بين المعاملات .

اما عن الاملاح فقد تم تقديرها باستخدام جهاز الفولتميتر لقياس الكالسيوم والفسفور ,وقد لوحظ بان لم تظهر فورقات معنوية بين المعاملات .

بالنسبة لمكونات الدم الكيموحيوية التى كانت تحت الدراسة وتم تقييمها هى البروتين الكلى والجلكوز ,كشفت الدراسة بأنه لاتوجد فروقات معنوية بين المعاملات .

وقد خلصت هذه الدراسة بان الصفات التناسلية فى الأغنام الصحراوية أظهرت تحسن عند تقليل الإجهاد فى البحث عن الماء والمرعى .

# TIBLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHPTER ONE

## Introduction

Sudan is the second largest livestock owning country in Africa. Its animal wealth was estimated in 2007 to be 50.944, 42.987, 41.404 and 4.250 million heads of sheep, goats, cattle and camels, respectively FAO,( 2009). North Kordofan is the home land of Hammari and Kabashi tribal desert sheep. They included about 8.89 million heads that represent 41.9% of total animals in the State and 17.4% of national sheep, MAWF( 2006). It plays an important nutritional and economical role in the lives of human beings .In spite of the importance of sheep they are still raised under. nomadic conditions using traditional methods of management depending on natural grazing .The specific problem regarding sheep nutrition under range land conditions is feed shortage and nutrient deficiencies. This situation becomes very critical during the dry season which extends from November through to June .This is reflected in seasonality of reproduction, high mortality rate among both young and adult animals and poor reproductive performance Elhag et al .(1998).Reproduction is synchronized in such a way that lambs are dropped during wet summer when fodder and water are available .Rarely farmers provide their animals with different supplements during the critical period of feed shortage .supplements used are mainly oilseed cakes and cereal grains .However ,Kordofan, where most of the sheep shortage wealth is located has a high density of trees and shrubs from which pods and foliage could be used as feeds, fadul (,2007),there is scarcity of data on how to improve the nomadic management systems under range conditions to enhance the reproductive and productive performance of hamari sheep .The direct effect of poor nutrition are reflected in reduced conception ,embryonic losses , reduced lambing rate and high ewe mortality .The present experiment was designed to study the effect of changing the nomadic husbandry practices during summer with feed supplementation restriction and sex on the performance of desert sheep(Hamari sub type).More than 65% of the sheep in Sudan are of the Desert type(0vis Aries )(Suleiman et al.,1990),which is believed to be a descendant of a sheep of Egyptian origin (Ovis, longipes).They are distributed north of latitude 10N,extending eastward into Eritrea and westward into Chad ,Wilson(,1991)and are raised under rangeland conditions in the eastern and western regions of the country .

Water requirements of sheep and goats are based on, but not limited to ,physiological state , dry matter in take , climatic conditions, and environment .A comprehensive discussion of water requirements is beyond the scope of this chapter , but NRC(2007) contains thorough descriptions of water use , sources , quality , and requirements for sheep and goats .Except under extremely hot temperatures, sheep that consume sufficient fresh forage to meet nutrient requirements also obtain enough moisture from the forage to meet their water requirements (Lynch et al..1972) .

A major exogenous regulator of thyroid gland activity is the environmental temperature,Dickson,( 1993), so an inverse relationship between ambient temperature and blood TH concentration has been found in sheep (Valdosta et al., 1982; Webster et al. ,1991;Starling et al., 2005).

During heat stress, blood T3 and T4 concentrations, as well as metabolic rate, feed intake, growth and milk production were decreased (Silanikove,2000).on the other hand ,cold stress in ewes Hocguette et al.,(1992)ram lambs (Eke and christopherson,2000;Doubek et al., 2003).The seasonal pattern of blood TH levels often showed maximal values during winter (cold months)and minimal during summer (hot months)(Salem et al .,1991;Webster et al., 1991;OKab et al., 1993;Menegatos et al .,2006).

## Research Problem

low production of sheep due to lack of fodder in the summer

## The objective of this Research:-

1-To study the effect of water Restriction and feed supplementation on the performance of desert sheep.(Reproductive characteristics )

2-Biochemical blood components .

3-Blood hormonal (T3---Estradiol ).

4-Some blood minerals (calcium and phosphorus )

# CHAPTER TOW

## Literature Review

### 2.1 Origin:

Classified Sheep of Sudan into eight distinct ecotypes according to locality, tribe and origin. Of these ecotypes in the Sudan Desert Sheep constitute 65 percent of the Sheep population in the whole country. Sudan Desert sheep are strictly confined to the semi-arid climatic zone. Their homeland is roughly bound in the south by latitude 12oN which is considered as the southward advance of the desert. The western border is marked by the range of rocky hills from Jebal Marra in the south to the Zaghawa plateau in the north. To the east , the area extends to the Red Sea Hills and to the north it fades away with an undulating border in the Nubian deserts. Topographically this area is dominated by sandy plains and stabilized and dunes in the west, extensive plains of dark cracked soil in the centre and strip of sandy plains with stabilized sand dunes in the east. Nevertheless, the area undergoes very intensive solar radiation from March to the end of June and has a mild, moist temperature from July to the end of October. The rainfall varies from 75 mm in the far north to 400 mm in the south. The vegetation varies from a mixture of grasses and herbs with no woody vegetation whatsoever, to a scattered shrub bush separated by bare areas (Mufarrih 1991).

### 2.2 Factors affecting sheep production

#### 2.2.1. Management factors

The management system has many effects on the production features of the Sudan Desert sheep El-Hag et al., (2001). Many researchers reported that mortality rates in breeding dams were significantly higher in nomadic one than sedentary flock, while ewes lambed under sedentary system had lower lambs birth weights than those lambed in nomadic system (3.38 vs.4.08 kg) and lambs body weight at 30 days of age (8.05 vs. 9.42 kg), whereas lambs weights from 60-150 days of age were not different in the two systems. In contrast, in other study, Wilson (1976) reported that death rates between sedentary and migratory flocks of Southern Darfur were not differing. The mortality rate was almost same in both systems.

**2.2.2.** Nutrition enhancing live weight at mating had an effect on ovulation and litter size (West et al., 1991; Nawaz and Meyer 1991). Moreover, Njoya et al. (2005) noted that, protein complementary additions to ewes browsing low quality pasture improved their body weight, body condition score and reproductive performance. Also Muskasa-Mugerwa and Lalhou-Kassi (1995) reported that sufficient nutrition is important on the reproductive trait in ewes in Ethiopia furthermore, Stephenson and Bird (1992) pointing out a valuable response in productivity of supplemented ewes eating low quality grass in Australia. During the late gestation period pregnant ewes received feed supplementation with balanced and adequate energy and protein to support developing of embryonic and fetal growth, maintain physiological requirements of the animal, mammary gland growth, colostrum and milk production (Oeaket al., 2005). Eighty percent of fetal growth arises through the last 60 days of pregnancy and it is due to 35% significant increase in nutrient requirements of the ewes 8 (Dawson et al., 1999). Thus, lamb survival is related to nutrition of ewes during late gestation (60 days) (Binnset al., 2002). The capability of nutrition during mating time to change ovulation and lambing rates of ewes in several breeds is well recognised (O'Callaghan and Boland, 1999). In a study on some British breeds, Rhindet al. (1989) mentioned that decreasing in ovulation rate prior mating time resulted from low animals feed intake, in addition, ova wastage rate occurs due to lower feed intake after mating time. On the other hand, Landau and Molle(1997) stated that numerous Mediterranean breeds of sheep, a short period of feed flushing before mating definitely affected ovulation. In the same issue Lassouedet al. (2004) reported that higher rates of feeding before and through mating time were related to improve reproductive performance in accordance with the literature reported for several sheep breeds. Lambing rates were affected by the dietary treatment. Emam and Malik, (2009) reported that the most additional feeds were cotton seed cake, groundnut hulls and sorghum grains.

**2.2.3. Animal factors**

**2.2.3.1.** Breed Animal breed and genotype had significantly affected the birth weight, daily weight gain and 90 day weights of the animal (Cochran et al., 1984 and Hassen et al., 2002.), besides, Boujenane and kansari, (2002) mentioned that lamb weight and survival to 70 days differed depending on genetic composition of lamb. They also found that effects of breed were significant for fecundity, number of lambs born alive, litter size at weaning, litter weight weaning per ewe joined and lamb weight at 60 days.

**2.2.3.2.** Age of dam Age of dam had significant effects on many reproductive traits such as birth weight, prolificacy, twining rate and litter size (Tauh and Baah, 1985; Ali et al., 1999).In more details Al-Shorepy and Notter (1996) noted average fertility of 0.59 for third lambing and older ewes, 0.45 for second lambing ewes, 0.18 for 19 months old ewes and 0.11 for yearlings old ewes. Likewise, Boujenane (2002) reported that dam age had significant effect on birth weight and 90 days.

**2.2.3.3.** Type of birth Analla et al., (1998) reported that birth type had noticeable effect on birth weight and consequent live weights as 30, 60 and 90 days, so that, single lambs were heavier than twin lambs, additionally, growth rate of single lambs was faster than twins (Macit et al., 2001). Moreover Tuah and Baah, (1985) found that weaning weight, pre-weaning growth rate were influenced by birth type, similar findings were obtained by Cloete et al. (2007) in crossing Dorper ewes with Ile de France, Merino Land sheep and SA Mutton Merino rams. Also Dimsoskiet al., (1999) noted that single lambs had higher daily gain than twins in the pre-weaning period.

Mortality rate of single born lambs was lower than twins (Nawaz and Meyer, 1991).

**2.2.3.4.** Sex of lamb Both sexes of lambs almost had the same weights at birth, 30 and 90 days of age, but it differ in late stages (El-Hag et al., 2001 and Hassen et al., 2002). These results are in contrast to Analla et al. (1998) and Boujenane, (2002) who found that male birth weights were heavier than those of the female and these results are applicable for 30 and 90 days. Also Cloete et al. (2007) mentioned that birth weight of male was higher than female lambs. Several researchers have found significant differences in body weight between male and female lambs at entirely 11 ages (Bichard and Cooper, 1966; Gjedrem, 1967 and Mavrogenis 1996a,b). Moreover Ali et al. (1999) stated that male lambs were heavier than females at birth, weaning and 6 months of age. However, (Rastogi 2001; Boujenane and Kansari 2002) noted that sex of lamb was not an important source of variation.

**2.2.4.** Breeding season Lambing season significantly affected the prolificacy and twinning rate, birth weight and on consequent live weights and survival age of lambs (El-Hag et al., 2001; Rastogi, 2001; Hassen et al., 2002; Boujenane and Kansari 2002; Tuah and Baah, (1985). Lambs born in rainy season had the highest birth weight (3.83 kg), while those born in the early dry season (3.52 kg) were higher than those born in late dry season (3.17 kg), hence the lamb weight at 30 days of age and growth from 90-150 days were higher in lamb born in the rainy season. Moreover, El-Hag et al. (2001) reported that breeding season had significant effects on desert sheep reproductive performance. The rainy season recorded higher lambing and mortality rates numbers of serviced ewes than in the late dry season. El-Hag et al., (2001) Reported that the weights and mortality rate of lambs born under the nomadic system and those born during the rainy season were higher comparing to other rearing system and season. Mortality rate of lambs are an essential constituent of total flock Death (Wilson, 1976). About 30 % of mortality rate was to the age of six months, while, half of the deaths lambs happening in the first four weeks and deaths were rare during the late dry season., moreover, higher records of serviced ewes were noted in the late dry season however, higher lambing and mortality rates occurred during the rainy season (El-Hag et al., 2001). In study of seasonal effects on birth weight (BWT) on prolific Assaf flock kept under intensive management, BWT of born lambs on April (4.6 kg) was significantly differs from BWT of born lambs on September (3.8 kg).BWT was 11 inversely affected by day length among the early stage of gestation, while it was directly related with rate of changes in day length during the latter stages of gestation (Gootwine and Rozov, 2006).

**2.7.5.** Climatic factors both genetic and environmental factors and the interaction between them could effect on birth weight of lambs. Along with the environmental factors, season was also found to have an effect on birth weight with lambs born in the rainy season being smaller than spring-born lambs. Ewes pregnant in the summer season could have lower food intake, and increase heat load (Shelton and Huston, 1968) which is high during the hot season then it influences the birth weight. Furthermore, seasonal variation in gestation length (Jenkin and Young, 2004) may also be related to seasonal variation in BWT.

**2.7.6.** Disease factors Makawi, (1999) stated that infectious diseases were divided into three main groups; specific genital diseases, non-specific genital, and general infectious diseases. The main reasons of reduced productivity in sheep are the infectious reproduction diseases, and it is generally categorized into these mainly affecting the venereal tract of rams and those mainly affecting ewes causing abortion and pre-natal lamb mortality (Rahaley, 1984). Higher rate of gastro-intestinal and respiratory disease problems noted during the dry season for lactating ewes in transhumant sheep comparing to dry open, were probably a reflection of the greater nutritional stress experienced by lactating animal (Cook and Fadlalla, 1987).

**2.8.** Sheep marketing Sudanese sheep is considered as one of red meat sources for local consumption and export, about 5.4million heads of live sheep were exported (MARFR, 2016). Animal resources sector and especially sheep play a vital role in Sudanese people live as source of food, income by providing food, profits and supply soil with natural manure. Also, it provides the country with hard currencies. Many factors participate in determination of sheep price such as season (Elrasheed et al., 2010), taxes (Elrasheed et al. 2008), transportation fees, production cost beside distance from production to consumption areas of sheep and veterinary charge (Faki and Taha, 2007 and Emam and Malik, 2011). In spite of low cost of sheep production due to use of traditional production system, the prices of Sudanese sheep are high compare to international prices (Elrasheed et al., 2010). Rams are the most preferred group in the market followed by ewes (Dahab et al., 2014).

## 2.3 Population size:

. The sheep population of the Sudan was 19.5millions in the year 1982/83. This population dropped to 18.8millions in the year1986/87 as a result of 1984 drought conditions .But with an estimated annual increase of 0.6 percent ,sheep population recovered and continued to grow Table (1.1) to reach almost 3 folds the number reported in 1987.

**Table (1.1) Annal increase in sheep population (million) between 1997- 2002 –Source: M.A.R. (2002).**

| YEAR | NO OF SHEEP |
|---|---|
| 1997 | 39.835 |
| 1998 | 42.363 |
| 1999 | 44.802 |
| 2000 | 46.095 |
| 2001 | 47.043 |
| 2002 | 48.136 |

**Table (1.2) Estimate of sheep population by States (2002) States No. of sheep**

| | |
|---|---|
| North Kordofan | 3.870.183 |
| South Kordofan | 1.939.881 |
| West Kordofan | 3.740.167 |
| North Darfour | 3.475.419 |
| South Darfour3 | 3.552.437 |
| West Darfour | 3.610.200 |
| Elgedarif | 1.963.949 |
| Kassala | 904.957 |
| Red Sea | 336.952 |
| Blue Nile | 4.621.056 |
| Sennar | 1.270.790 |
| Elgezira | 2.286.460 |
| White Nile | 2.334.596 |
| North State9 | 904.957 |
| River Nile | 953.093 |
| Khartoum | 409.156 |
| North Upper Nile | 640.209 |
| Unity | 1.487.402 |
| Gongoli | 1.400.758 |
| North Bahr Elgazal | 1.285.231 |
| West Bahr Elgazal | 1.164.891 |
| Albohairat | 1.232.282 |
| Bahr Elgabal | 1.265.977 |
| East Equatoria | 1.025.297 |
| West Equatoria | 1.169.705 |
| Warab | 1.290.045 |
| Total | 48.136.000 |

Source: M.A.R. (2002). Ministry of Animal Resources and Fisheries, Department of Statistics.

## 2.4 Geographical distribution and phenotypic characteristics:

Sudan Desert sheep are generally described as long-legged thelength of the legs is dictated by management and climate. In thenorthern ranges where the scarcity of grazing imposes walking longdistances, the sheep have developed long legs and a light body. Thesheep of the southern regions (such as the Hamari type), have shorterlegs and a heavy body, imposed by availability of grazing ranges anddrinking water and hence distance and the seasonal migration arecomparatively short (Mufarrih 1991). The locality and tribal origin of Desert sheep are identified inlocal markets by their colours. In the central and southeastern parts ofthe irrigated Gezira and Rahad, the sheep population is dominated bythe Dubasi variety. These carry a black patch on the back (saddle) themuzzle and legs. The rest of the coat is white with coarse hairy fibres. Further north towards Khartoum, on the eastern bank of the Blue Nileand the Nile, the Shugur variety predominates. These are uniformly yello wish brown. The Hamari variety in southwestern Kordofan and southeastern Darfur are predominantly brown and dark brown. TheKabashi of northern Kordofan and northern Darfur, the Shambali of eastern Kordofan, the Gash and eastern Butana are all multi colored. The different colours of tribal varieties might have been brought about through prolonged selection toward colours preferred by particular groups or tribes (Mufarrih 1991).

## 2.5 Meat production potential:

Hassan and Mukhtar (1970) investigated the feedlot performance of Sudan Desert sheep on high concentrate, medium concentrate and all-roughage rations. The all-roughage ration wasgood quality dried berseem (Medicago sativa). The average dailygains were 0.25, 0.24 and 0.15 for high concentrate, mediumconcentrate and all-roughage ration groups, respectively. El Aamin and Suleiman (1983) fed a ration of 25 percent sorghum grains and 25 percent cottonseed cakes to weaner lambs ofthe Sudan Desert type. They

obtained a daily gain of weight of 240gm .`The feed conversion efficiency was 5.4 Kg feed intake/Kgweight gain. Lambs fed this ration dressed higher (42 percent) thanthose not given this ration (35 percent). Guma and Gaili (1983) reported on the carcass composition ofa range-fed group of Sudan Desert sheep. The live weights werebetween 32 – 40 Kg, the average warm carcass weight was 14.5 Kg, left carcass side 6.7, total side muscle 3.9 Kg, total side bone 1.8 Kgand total side fat 0.6 Kg. The effect of different molasses levels (30, 35, 40 and 45%) inthe diet of sheep was investigated. Four rations were formulated so asto be iso-caloric and iso-nitrogenous, and in which the differentmolasses levels replaced groundnut hulls in a basal ration of wheatbran and groundnut cake. The results revealed that dry matter intakedecreased steadily with the increase of molasses levels but nosignificant differences could be detected. Body weight gain increased ($P< 0.05$) with 30% and 40% molasses levels although the amount ofnitrogen retained decreased ($P< 0.05$) with the 40% molasses levelsuggesting that the gain in weight could be due to fat deposition
(Muna *et al*. 2002). Mansour *et al*. (1993) studied the effect of breed, and differentratios of groundnut hay to sorghum grains on performance and carcasscomposition from three different ecotypes of Desert sheep namely Shugor, Dubasi and Watish. These males were five to seven months of age and weighed 18.59+2.47 Kg on average. The experimental period lasted for seventy days. Watish lambs had better carcass composition than the Dubasi and Shugor lambs as evidenced by lean to bone ratio. The mean values of lean to bone ratio for these breeds were 2.81, 2.62 and 2.44 respectively.

## 2.6 Energy

A minimal requirement for energy is a minimal nutritive requirement for an animal to meet its needs for maintenance and production, therefore most feeding systems are based on the animal’s energy requirements. Both Blaxter

(1967) in Britain and Oddy (1978) in Australia have suggested that a system of estimating energy requirements based on calculations of metabolizable energy (ME) has the greatest flexibility andpotential for development to meet existing and changing circumstances. However, in the United States preference is given to the Californian net energy system advocated by Lofgreen and Garrett ( 1968). Energy is used by animals to maintain life processes. The arbitrary minimal cost (referred to as “fasting metabolism”) is relatively constant per unit of metabolic weight. In addition to maintenance requirements, animals must meet their energy costs of finding, eating, digesting, and assimilating food (Graham 1967). These energy requirements will be influencedby live weight, the physiological state of the animal, and environmental factors such as temperature, wind, precipitation, and incident radiation. Oddly (1978) has outlined allowances that should be made for these factors. Young and Corbett (1972) related more precisely maintenance energy requirements to live weight by the equation: M = 4.5 1W + 256, where *W* is mean live weight and M the estimated meta boilable energy (ME) required in kcal per 24-hour period. During reproduction additional energy is required for fetal development. A series of equations relating energy requirements (ME) to live weight at various stages of ewe pregnancy have been developed by the Ministry of Agriculture, Fisheries, and Food (1975) in Britain. On average, late pregnancy requirements increase to about 1.5 times that of a dry ewe. The further energy required for milk production is substantial, amounting to 3.2 times the dry ewe requirement. Although energy may be inadequate on browse range (Stoddart et al. 1975), supplying carbohydrate should be done with caution since the provision of easily digested carbohydrate can depress the utilization of fiber (Topps 1972). A useful rule is to supply only enough energy supplement to increase forage consumption, but not to replace it. Thus, when calculating feed requirements it is necessary to know the energy concentration in the diet and the required or minimal live weight of the animal. Seville (1978) has formulated a calculator which enables feed requirements on an energy basis to be identified quickly and simply

## 2.7 .Protein

One of the important characteristics of low-quality roughage is its low protein content. Although sheep have the ability to select high protein forage, low protein levels in pasture will affect their performance because dietary protein deficiency is associated with a relatively low voluntary feed consumption. With protein-deficient diets, the metabolism of the rumen micro-biota may be depressed by a deficiency in rumen nitrogen; this limitation will retard the rate of removal of organic matter from the rumen which, in turn, may reduce intake In terms of voluntary intake and the performance of lambs, it appears that little is to be gained by increasing protein levels beyond 15%. The minimum crude protein percentages in the diet range from 6% for dry ewes and withers to 12% for weavers weighing about 20 kg (Ministry of Agriculture, Fisheries and Food 1975). The need for supplementation of protein can be determined by evaluating the nutritional quality of range forage by digestion techniques or by field experiments in which suspected deficiencies are supplied and animal responses measured (Stod dart et al. 1975). Allen and Jennings (1969) reported that protein deficiencies can be detected by fecal nitrogen analysis and set 1.6 to 1.7% as the threshold, below which supplements are required.

## 2.8 .What Sheep Should Be Supplemented?

In addition to a detailed knowledge of the economic considerations of supplementary feeding and the nutrient requirements of grazing sheep, the pastoralist must have an appreciation of the responses that are likely to emanate from feeding sheep for specific purposes such as wool production, reproductive performance, or live weight gains.

## 2.9. Supplementary Feeding and Reproductive Performance

Low lambing percentages relative to the annual maintenance cost of the breeding flock has, for many years, been accepted as the main reason for the low efficiency of sheep production enterprises on rangelands. Reproductive wastage occurs not only through physical losses at critical breeding phases such as mating, late pregnancy, and lactation, but also through a failure to attain full reproductive potential. While some variation in wastage is due to seasonal influences, breed of sheep, and age, nutrition can also significantly influence the reproductive performance of both rams and ewes. While the effects of adequate nutrition on the subsequent reproductive performance of ewes have been widely recognized, relatively few studies have highlighted the importance of the effects of under-nutrition on libido and semen quality of rams. Watson et al. (1956) stressed the importance of flushing rams, with results showing a positive correlation between ram puberty and live weight. The relationship was independent of age. Poor nutrition significantly delays sexual maturity. Further, semen production is significantly reduced by inadequate nutrition (Tilton et al. 1964) such as is commonly associated with dry pasture, and libido will also decline (Parkerand Thwaites 1972). The feeding of supplements has proven successful in ensuring early maturation of rams and high subsequent fertility. Under nutrition of ewes during the first year or so of their life may have a detrimental effect on subsequent fecundity), although such nutritional conditions are likely to be experienced only during drought (Watson 1962). Nevertheless, McDonald ( 1962) commented that ewes fed to produce a rapid increase in live weight prior to joining resulted in higher mating and weaning percentages. It appears, however, that for good flushing results, ewes should be on a below-optimum plane of nutrition before the flushing period followed by an above-optimum plane of nutrition during the flushing period (Clanton 1957). At the other extreme, fatness resulting from excessive supplementation prior to joining may lead to conception failure. Nutrition during early pregnancy needs to be sufficient to either maintain or slightly increase live weight. In contrast, a plane of nutrition that does not produce gain or causes actual live weight loss during late pregnancy will lead to high ewe losses through *pregnancy toxaemia*, severely reduce the birth weight, survival rate, and subsequent growth of lambs, and cause a low conception rate at the next mating period of the ewes (Thompson and Thompson 1968). Hovers land ( 1954) observed the highest number of premature births, lambs born dead and post-parturition mortality in ewes fed low levels of nutrition throughout gestation. Provision of adequate nutrition either at pasture or by supplementary feeding have great economic potential in reducing ewe and lamb mortality, as well as increasing the subsequent growth potential of lambs.

## 2.10. Water Stress in Sheep Raised Under Arid Conditions.

Sheep breeds which are indigenous to arid and semi-arid regions are known for their ability to adapt to rustic environments, to climatic variations as well as to shortages in resources. Water scarcity, often combined with heat stress, is a common challenge facing these animals, causing physiological perturbations and affecting the animal's productivity. This review reports the effect of different forms of water stress on physiological indicators, blood parameters, thermoregulation and immunological status in sheep. Although the breed effect may be significant, the following are generally observed common responses: drop in feed intake and weight loss, increase in evaporative cooling through panting, production of a small volume of highly concentrated urine, haemo concentration, high blood osmolality, and immunosuppression. Prolonged water shortage may affect lamb birth weight and survival, and lead to a decrease in milk production, especially in non-adapted breeds, which could lead to important economic losses, as reported in heat-stressed sheep husbandries. Novel stress alleviation approaches are also presented, such as vitamin C supplementation.

Sheep production is a major economic activity in the arid and semi-arid regions of the globe. Sheep can make use of low-quality biomass in times of scarcity and transform it into useful products, such as milk, meat and wool. Native sheep breeds in arid and semi-arid areas demonstrate better performance under harsh environmental conditions than their non-native counterparts. Therefore, proper breed selection is a very valuable tool for sustaining animal production under an increasingly challenging environment (Silanikove 1992; Iňiguez 2005).

Water scarcity is a growing problem in arid and semi-arid regions with global warming and changing patterns of rainfall, which limit water resources and affect feed quality and quantity in addition to increasing heat stress. This challenging situation causes a wide array of physiological responses in sheep with a negative impact on production, immunity and welfare (Barbour et al. 2005; Jaber et al. 2011).

The objective of this review is to highlight the physiological and immunological changes in sheep when faced with water restriction, and in particular their responses during pregnancy and lactation. The additional burden of heat stress is also considered as well as the novel approach of vitamin C supplementation to alleviate water stress.

### 2.10.1 Sheep Breeds Adapted TO Arid And Semi-Arid Regions

Sheep breeds differ in their capacity to overcome water shortages; the desert bighorn sheep (*Ovis canadensis nelsoni*) can withstand water deprivation for up to 15 day (Farid et al. 1979; Turner 1979), while the Barki sheep in Egypt could not withstand 3 day without drinking (Farid et al. 1979). Reports on other breeds like the Awassi (Jaber et al. 2004), Yankasa (Aganga et al. 1989), Merino (MacFarlane 1964) and Barbarine sheep (Ben Salem et al. 2011) lie between these two extremes.

Dehydration corresponds to a negative water balance, which means that the water inputs (water drunk+water in the feed+metabolic water linked to the oxidation of carbohydrates, protein and fat) are lower than water outputs (urinary water+faecal water+water lost by evaporation from both the skin and respiratory tract). In order to avoid dehydration, sheep resort to various forms of adaptation. At the behavioural level, nocturnal feeding has been documented in bighorn sheep (Dwyer 2008); by foraging at night, sheep minimize their exposure to high thermal loads, reducing the need for evaporative cooling and thereby minimizing water loss. In the same way, sheep seek the protection of shelters and cool microclimates, when available, to hide from solar radiation during the day (Cain et al. 2005). Timing reproductive events may be affected by dehydration; water-stressed animals often decrease feed intake, which is reported to cause retardation of ovarian follicular growth (Blanc et al. 2004). In arid and semi-arid regions (in the northern hemisphere), where differences in daylight, as well as in food and water availability, are well defined, the breeding season usually spans from June to November (Amoah et al. 1996; Hamadeh et al. 1996). Consequently, lambing mostly occurs between February and April, when food and climate become more favourable for newborn survival and for dam milk production.

Morphological adaptations are also observed in sheep adapted to arid and semi-arid regions. Fleece type (Eyal 1963) and colour (Kay 1997) contribute to protection against heat and minimize water lost due to evaporative cooling. Indigenous breeds in arid and semi-arid areas such as the Marwari (Narula et al. 2010), Omani (Mahgoub et al. 2010), Barbarine (Ben Gara 2000) and Awassi sheep (Gootwine 2011) all have carpet-type wool. This type of wool, as compared with denser wool types, seems to confer protection from solar radiation while at the same time allowing effective cutaneous evaporative cooling (Mittal and Gosh 1979; Rai et al. 1979; Cain et al. 2006). In comparison, hair-type sheep seem to be less thermoresistant under hot conditions when compared with their wool-bearing counterparts (Symington 1960). In contrast, under tropical conditions of high temperature and high humidity, McManus et al. (2009) concluded that hair-type sheep were better adapted than wool-type breeds. Moreover, a light coloured fleece allows better reflection of solar radiation thus keeping the skin underneath relatively cooler compared with darker fleeces (Cain et al. 2005; McManus et al. 2009). Another anatomical characteristic of indigenous sheep breeds from arid and semi-arid regions is the fat-tail. This external localization of the fat allows better heat dissipation from the rest of the body (Degen and Shkolnik 1978), since the body will become less insulated by the fat tissue. In addition, the fat stored in the tail represents an energy store that can be mobilized in times of dietary shortfall (Chilliard 2000; Atti et al. 2004). The concept of the fat-tail as a store of metabolic water has been questioned (Epstein 1985), and it is now believed that its main role is to supply energy whenever dietary energy intake is insufficient, which results in some metabolic water formation that could partially help in filling the animal's water requirements. The contribution to water intake that could be derived from metabolic sources was found to be around 8.5% in Yankasa sheep (Aganga 1992), while others reported a contribution of up to 15% in sheep in general (Sileshi et al. 2003). This contribution is affected by the level of reliance on the catabolic mobilization of body fat and protein tissue (Sileshi et al. 2003).

At the physiological level, water-stress-adapted sheep show a high capacity to concentrate urine. This is accomplished by the kidney, which has a thick medulla (Schmidt-Neilson and O'dell 1961) that can produce highly concentrated urine of up to 3900 mOsm $L^{-1}$ in the bighorn desert sheep (Horst and Langworthy 1971; Turner 1973) and 3244 mOsm $kg^{-1}$ in the Awassi sheep (Laden et al. 1987) as compared with values around 769 mOsm $kg^{-1}$ in urine of Awassi watered ad libitum (Degen 1977). At the same time, faecal water losses are minimized, as dehydration leads to slower feed transit in the digestive tract leading to greater water reabsorption and dryer faeces (Robertshaw and Zine-Filali 1995). The rumen plays an equally important role in water conservation in arid-adapted animals whereby it can act as a water reservoir to replenish the lost volume in the blood. Rehydration of water-deprived adapted sheep activates a coordinated chain of events from the rumen, the kidneys and the salivary glands, under hypothalamic control, to preserve the water, restore homeostasis and appetite, and prevent water toxicity. These processes are described by Silanikove (1994).

Finally, arid-adapted animals may allow small increases in body temperature during the hottest parts of the day, followed by body cooling at night through conduction and radiation. The capacity to tolerate this increase in body temperature means that less water is needed for evaporative cooling (Kay 1997).

## 2.11. Physiological Changes IN Response TO Water Stress

### 2.11.1 Feed Intake and Body Weight

Feed consumption is highly related to water intake (Silanikove 1992). An adequate level of water intake is necessary for proper digestive function (Hadjigeorgiou et al. 2000). In contrast, Kay (1997) states that drinking water is not needed for swallowing and moistening feed, since water can be circulated from the blood to maintain high salivation; it is, however, needed to replace the inevitable water loss by excretion and evaporation. When Awassi sheep experienced a 3- to 4-d intermittent watering regimen voluntary feed intake was reduced to approximately 60% of controls (Jaber et al. 2004; Hamadeh et al. 2006). The effect of this reduction in feed intake caused by dehydration is dependent on the type of feed that is available for the animals. Van der Walt et al. (1999) observed that sheep kept on a low protein diet and subjected to water restriction showed a smaller reduction in feed intake as opposed to those given a medium protein diet, and they had better urea recycling through the digestive tract. However, the group on low protein had a slightly lower growth rate than the medium protein group. Similarly, water-restricted desert goats fed low-quality forage lost more weight than their well-fed counterparts (Ahmed Muna and El Shafei Ammar 2001). Therefore, the negative effect of water restriction is more pronounced when sheep are kept on low- versus high-quality forage (Morand-Fehr 2005). Because of this relationship, it is often difficult to differentiate the effects of water restriction, per se, from those due to low feed intake. Pulina et al. (2007) suggested that feed restriction of 50% for a period of only 3 d is enough to cause metabolic changes in lactating dairy Sarda ewes. Prolonged reduction in feed intake may eventually affect the reproductive potential of sheep (Rhind and McNeilly 1986; Maurya et al. 2004) and, consequently, reduce production.

The direct consequence of water restriction and the associated decrease in dietary intake is a reduction in body weight (Jaber et al. 2004, 2011; Hamadeh et al. 2006). Part of the reduction in weight is due to body water loss, while the other part is caused by the consequent mobilization of fat (and possibly muscle) used for energy metabolism to compensate the decrease in dietary intake (Jaber et al. 2004) and rumen fill is also reduced due to the decrease in feed intake. Furthermore, it was observed that water restriction leads to more weight loss than feed restriction alone (Ahmed Muna and El Shafei Ammar 2001; Chedid 2009; Karnib 2009). The decrease in body weight in the Awassi sheep is aggravated at peak lactation, high ambient temperature and in young animals (Hamadeh et al. 2006; Jaber et al. 2011). Moreover, dry mature Awassi ewes can tolerate a 3-d intermittent watering regimen for a month or more, although a weight loss of up to 17% would be expected (Karnib 2009).

### 2.11.2 Blood Chemistry

Dehydration in warm weather leads to haemoconcentration as highlighted by increased haemoglobin and packed cell volume levels (Li et al. 2000; Ghanem 2008), although some authors reported no variation in these parameters in water-restricted sheep (Igbokwe 1993; Jaber et al. 2004). More consistently, serum protein and albumin are reported to increase (Jaber et al. 2004; Alamer 2005; Casamassina et al. 2008; Ghanem et al. 2008; Hamadeh et al. 2009) due to the decreased blood volume (Cork and Halliwell 2002). However, albumin and protein levels tend to decrease after prolonged water restriction (Hamadeh et al. 2006; Ghanem et al. 2008), which reflects dietary deficiency. Serum albumin serves as a labile protein reservoir providing a readily available source of amino acids until an alternative source is secured through diet or by mobilizing body sources such as skeletal muscle (Moorby et al. 2002). Albumin also plays an important role in osmoregulation and fluid movement control between different body compartments since it is a major contributor to blood colloid osmotic pressure; for this reason the rates of albumin breakdown and synthesis are regulated in response to dehydration to maintain normal colloid osmotic pressure and fluid distribution (Burton 1988).

Water stress causes a decrease in urine output and the production of dry faeces controlled, respectively, by vasopressin and increased water reabsorption from the gastro-intestinal tract (Olsson et al. 1997). Under these conditions, the transfer function of the kidney is altered (Kataria et al. 2007) with slower glomerular filtration and higher urea reabsorption (Silanikove 2000). Consequently, the levels of urea and creatinine in blood are increased (MacFarlane et al. 1964; Laden et al. 1987; Igbokwe 1993; Jaber et al. 2004). However, upon prolonged water restriction and reduced feed intake, urea levels may start to decline reflecting an increase in urea recycling into the gut (Igbokwe et al. 1993; Marini et al. 2004), so it can be used as a nitrogen source by rumen microflora.

Another consequence of decreased blood volume and increased renal retention is hyperosmolality as well as an increase in electrolyte concentrations (Qinisa et al. 2011), mainly sodium, $Na^+$, and chloride, $Cl^-$ (Rawda 2003; Ghanem 2005; Hanna 2006). The chain of events activated under dehydration, in order to preserve homeostasis, is described by Silanikove (1994): renal water and $Na^+$ retention is increased, while saliva production is reduced; to compensate for lost water, the animals mobilize the water from the rumen and the digestive tract; water movement is achieved through active transport of $Na^+$ across the rumen wall; this ruminal fluid is hyperosmotic therefore the excess $Na^+$ is reabsorbed by the kidneys and recycled through saliva, to preserve the blood $Na^+$ levels. Rehydration in water-deprived sheep is equally challenging since they can drink a large volume of water in one bout, therefore risking haemolysis. However, adapted animals respond by producing large volumes of hypotonic saliva (Dahlborn and Holtenius 1990; Silanikove 1994) that channels the excess water in the blood back to the rumen. At the same time it is important that the animal minimizes the loss of this water, since the next watering may be days away; therefore kidney water retention is maintained immediately after rehydration. Finally, in order to keep body fluids at the correct tonicity, appetite is activated to ensure that $Na^+$ and energy requirements are met to restore normal transport of water and electrolytes across different body compartments.

### 2.11.3 Fat Mobilization

As previously mentioned, along with restricted water intake comes a reduction in feed consumption, leading to undernutrition. In order to compensate for the energy shortfall, sheep mobilize body reserves. Subcutaneous fat is mobilized first, but when energy deficiency is lengthy, native breeds turn to their specialized fat depots such as the fat-tail. The fat-tail adipocytes deposit fat when feed is available and fat mobilization was demonstrated in energy deficient Barbarine (Atti et al. 2004) as well as the Awassi sheep (Jaber et al. 2011), thus buffering fluctuations in dietary intake. Increased cholesterol levels are another indicator of fat mobilization in water-restricted sheep such as the Awassi (Jaber et al. 2004; Hamadeh et al. 2006) and Yankasa ewes (Igbokwe 1993). This reflects a deficit in dietary energy intake leading to body fat mobilization. Similarly, free fatty acid (FFA) levels were reported to increase in Awassi (Ghanem et al. 2008; Jaber et al. 2011) and the Sudanese desert sheep (Abdelatif and Ahmed 1994) indicating that fat is being mobilized from adipocytes to be used as fuel (Varady et al. 2007). Results of different experiments describing the effect of intermittent watering supply on changes in fat mobilization parameters in Awassi ewes are summarized in Table 1. These findings show the significant increase in cholesterol and FFA, while glucose levels remained practically the same between water-restricted and control groups.

Interestingly, the variations in energy intake following water restriction do not appear to be consistently mirrored by changes in glucose levels. Most reports indicated no significant variation in glucose levels in water-restricted sheep (Igbokwe 1993; Jaber et al. 2004; Casamassima 2008; Ghanem et al. 2008). Moreover, Ahmed and Abdelatif (1994) observed a direct relationship between plasma glucose and dry matter intake in feed- and water-restricted sheep. In ruminants, diet-derived volatile fatty acids are the main source of energy; however, glucose is needed for key processes in the body, hence the importance of maintaining blood glucose at a constant level (McDowell 1983). Additionally, insulin and leptin concentrations, key hormones in energy metabolism, tended to decrease in water-restricted Awassi ewes (Jaber et al. 2011). Low insulin levels are thought to facilitate lipolysis (Vernon 1992) needed to compensate the dietary energy shortfall. Leptin levels are usually related to animal fatness; indeed, fat-tail adipocyte diameter is strongly correlated to leptin in water-restricted Awassi sheep (Jaber et al. 2011). According to Chilliard et al. (2000, 2005), the decrease in leptin activates a mechanism that will eventually control lipolysis to prevent FFA from reaching toxic levels; at the same time, this will ensure the preservation of fat stores for longer survival under conditions of fluctuating feed availability.

### 2.11.4 Thermoregulation

Thermoregulation under water restriction is of particular importance since, in sheep, evaporation is the major route of heat dissipation, at a time when the animal is challenged to maximize water preservation. It is estimated that 60% of heat is lost by respiratory evaporation and 40% through cutaneous evaporation (Brockway et al. 1965; Jenkinson 1972). The thermoregulatory aptitude of sheep to react to different environmental conditions varies according to the breed and its capacity to tolerate heat or cold (Degen and Shkolnik 1978; Srikandakumar et al. 2003). Thermoregulation traits include respiration rate, rectal (core) temperature, thyroid activity and water and feed consumption (Bhattacharya and Hussain 1974), which will be discussed in the following sections.

### 2.11.5 Evaporative Cooling

Sheep in semi-arid regions need to adopt special physiological functions to sustain thermal equilibrium (Maurya et al. 2004). Under neutral environmental temperature (12°C), sheep lose about 20% of their total body heat through respiratory moisture; this rate increases to about 60% at an ambient temperature of 35°C (Thompson 1985), which sometimes leads to respiratory alkalosis due to increased respiratory rate (Cain et al. 2006). Hales (1973) observed that sheep could maintain normal respiratory and cardiovascular functions when subjected to mild heat stress, while severe hyperthermia greatly affected the respiratory function, although cardiovascular activity remained mildly altered.

When dehydrated, arid-adapted sheep (and goats) tend to reduce their thermoregulatory evaporative cooling mechanisms (panting and sweating) in order to maintain their body water and prevent further dehydration (Baker

1989; McKinley et al. 2009). McKinley et al. (2009) reported that water-deprived sheep have a slow panting rate that increases twofold after rehydration. Different breeds demonstrate different panting and sweating rates reflecting different adaptive potential to tolerate heat stress. Alamer and Al-hozab (2004) observed that the Awassi and Najdi sheep could tolerate water deprivation, with the Awassi demonstrating a better capacity at water conservation under heat stress, through a lower sweating rate, than Najdi sheep. In a comparative study, Rai et al. (1979) found that breeds with denser fleece, such as the Rambouillet, were less effective in heat dissipation through cutaneous evaporative cooling and had to rely more on respiratory cooling; furthermore, in this breed, sweating started at lower environmental temperatures than in adapted breeds such as the Chokla, leading to higher water losses. Unlike the camel (Schmidt-Neilsen et al. 1956), dehydrated sheep and goats shift to preferential heat dissipation through the respiratory path rather than by sweating (Hales and Brown 1974; Baker 1989; Robertshaw 2006). It was suggested that this may be a way of obtaining evaporative cooling of the brain area while minimizing total water losses in dehydrated animals (Robertshaw and Dmi'el 1983). In fact, Fuller et al. (2007) concluded that dehydration leads to selective brain cooling, which is usually followed by inhibition of evaporative heat loss thus preserving body water. Selective brain cooling is probably achieved by transferring heat from arterial blood in the carotid to the venous blood cooled by respiratory evaporation in the nasal passages (Taylor and Lyman 1972; Cain et al. 2006; Fuller et al. 2007). Brain cooling maybe also responsible for the observed temporary hyperthermia that is often reported in dehydrated sheep, activated by the hyperosmolality observed in dehydrated animals (Fuller et al. 2007). This could allow for temporary heat storage at peak day temperatures, followed by passive body cooling at night when ambient temperatures drop (Alamer and Al-hozab 2004). This adaptive feature, allows the maintenance of homeothermy while minimizing water loss (Silanikove 1992) by increasing the core temperature threshold and delaying the time at which evaporative cooling mechanisms are activated (Cain et al. 2006) As observed in desert-adapted goats (Ahmed and El-Kheir 2004), water lost through panting for evaporative cooling is compensated for by an increased capacity to conserve water through the production of small volumes of highly concentrated urine. To achieve this, sheep resort to high $Na^+$ and water retention in the kidneys. More and Sahni (1978) reported that dehydrated sheep maintained positive balances for cations, particularly $K^+$, based on the comparison of electrolytes input through feed and water and their output through faeces and urine. The highly positive $K^+$ balance led them to conclude that it is being lost through sweating, since it cannot be stored in the body, in order to maintain osmotic pressure and acid-base balance within different body fluid compartments. Therefore, cutaneous evaporative cooling also plays a role in maintaining electrolyte and acid-base balance under arid conditions.

**Rectal Temperature**

Sheep are homeotherms (MacFarlane 1964; Degen 1977); they try to maintain their body temperature within a fixed range even under harsh climatic conditions. Normal rectal temperatures range between 38.3 and 39.9°C under thermo-neutral conditions, but when exposed to heat stress (33–38.5°C), the rectal temperature increases significantly and when surrounding temperatures exceed 42°C, it becomes life threatening to the sheep (Marai et al. 2007). A high variation (increase) in rectal temperature indicates lack of thermal equilibrium and increased water ingestion in order to replace evaporative losses (Mohamed and Johnson 1985); it also involves a marked reduction in feed intake and will negatively influence reproductive function of the sheep (Eltawill and Narendran 1990).

Reports on the effect of water restriction on rectal temperature in sheep are not consistent. While some (Ghanem et al. 2005, 2008; Sevi et al. 2009) reported that dehydration was found to cause an increase in rectal temperature in sheep, others (MacFarlane 1964; Degen 1977; Jaber et al. 2004; Hamadeh et al. 2006; Chedid 2009) found that sheep, such as the Awassi, retain thermostability even under water suppression. On the other hand, Ahmed and Abdelatif (1994) pointed out that dehydration causes a slight decrease in rectal temperature, while reduced feed intake considerably reduces it, especially when combined with a reduction in water intake. When studying the effect of water deprivation on unshorn sheep, McKinley et al. (2009) found that the core temperature was maintained during the first day (24 h) of dehydration, but a significant increase was noted on the second day without water.

### 2.11.6 Thyroid Activity

Thyroid hormones, T3 and T4, play a major role in thermoregulation and metabolic homeostasis of energy and proteins, as well as in the metabolic response of animals to different nutritional and environmental conditions (Huszenicza et al. 2002; Latimer et al. 2003; Thrall 2004). Levels of T3 and T4 were found to decrease in water-limited healthy Marwari, non-lactating Awassi ewes and Butana desert rams (Abdelatif and Ahmed 1994; Kataria and Kataria 2006; Jaber et al. 2011); this effect was reversed upon rehydration in Marwari sheep (Kataria and Kataria 2006). The reduction in thyroid hormone activity under dehydration is associated with the animal's attempt to minimize water losses by reducing general metabolism (Nazifi et al. 2003; Kataria and Kataria 2007). It also reflects the reduction in feed intake since T3 and T4 were reported to decrease in feed-restricted pregnant Whiteface Western ewes (Ward et al. 2008), while T4 increased following the afternoon meal in water-restricted Butana rams (Abdelatif and Ahmed 1994). The decrease in thyroid activity is further reinforced under heat stress

(Hamadeh et al. 1994; Khalifa et al. 2002). In arid adapted animals, changes in thyroid activity may be affected more by the physiological activity (pregnancy or lactation) of the animals than by seasonal changes in temperature as has been noted in Awassi and Finn×Texel×Awassi sheep (Hamadeh et al. 1994). Furthermore, the authors noted the importance of the production system under which the animals are raised, whereby extensively raised animals of both breeds were shown to be less sensitive to ambient heat than their intensively raised counterparts due to better adaptation to the environmental conditions. Bernabucci et al. (2010) further described the importance of metabolic and hormonal acclimation to heat stress in order to limit its negative consequences.

Many aspects of thermoregulation in situations of dehydration remain to be studied. In a recent review, Alamer (2011) noted that prolactin is a hormone that is found to be increased in blood in response to heat stress. In this review, the author summarizes the role of prolactin in thermoregulation including its possible effects on fluid balance and distribution in hydrated and dehydrated animals, modulation of sweat gland activity, regulation of seasonal pelage growth, etc. Research on this topic will be valuable in understanding how different sheep cope with the combined effects of heat and dehydration.

### 2.11.7 Immunosuppression

In general, immune response and stress are negatively correlated. Exposure to stressful environmental conditions can modify a host's resistance by affecting its immune system, mainly through the mediation of immunosuppressant hormones such as glucocorticoids (Ewing et al. 1999). Although it is obvious that water stress, as any other form of stress, would cause perturbations in the general health status and welfare of the animal, research dealing with the effect of dehydration and immunity is very limited. This might be due to the fact that sheep native to arid regions, where occasional water shortages are most common, are known to be well-adapted to dehydration, thus directing scientists’ attention to other research topics.

The effect of heat stress on sheep immunity, milk production as well as udder health was reviewed by Sevi and Caroprese (2012): heat stress reduced cellular immunity by decreasing cellular proliferation. The mechanism of action is unclear and may involve heat shock proteins, altered cytokines profiles as wells as changing cortisol levels. Sevi et al. (2009) reported a severe drop in immunity in ewes exposed to high ambient temperatures; this immuno-reduction was accompanied by a significant mineral imbalance and an increase in milk neutrophil levels, and higher counts of *Staphylococci*, coliforms and *Pseudomonas*, thus showing how heat stress can negatively influence both an animal's health and milk quality.

In 2004, Barbour et al. studied the effect of water restriction on the humoral antibody response of Awassi ewes to *Salmonella* Enteritidis; they found that immunity in the dehydrated animals was significantly lower than in Awassi receiving water 24 h a day. Moreover, the study showed that the humoral antibody response to *Salmonella* Enteritidis fimbriae and other polypeptides decreased by 38.5% in the water-restricted sheep as compared with their daily watered counterparts. Marked immunosuppression was also observed in water-deprived lactating Awassi ewes, which showed a significant drop in their immunity to polypeptides >21 kDa as compared with non-lactating ewes (Barbour et al. 2005).

Differential leukocyte counts are sometimes used as a combined indicator of the immune status and stress level of animals. Kannan et al. (2007) reported that a leukogram is a good indicator of prolonged stress in transported goats. Glucocorticoid levels have been linked to leukocyte profiles of the immune system where high ratios of heterophils or neutrophils to lymphocytes in blood samples indicate high concentrations of glucocorticoids and therefore high levels of stress (Dhabhar et al. 1995; Kannan et al. 2007; Davis et al.

2008). However, it was also observed that glucocorticoids may not always suppress leukocytes but rather induce a re-distribution of the immune cells to certain organs such as the skin, thought to be the first line of defence against pathogen entry (Dhabhar 2006; Martin, 2009).

In a review about the mechanisms of stress-induced immunity modulation, Moynihan (2003) summarized the possible routes for immune suppression and even stimulation following stress. The author describes four main compounds that can modulate stress: corticotropin-releasing hormone, endogenous opioids, catecholamines and glucocorticoids, with glucocorticoids being the most widely studied. He further notes the complex relationship between stress and immunity, highlighting differences in the response based on the nature, duration and severity of the stressor on one hand and on the immune function or organ that is being assessed on the other. To these factors, Salak-Johnson and McGlone (2006) add the effects of social status and genetics, which also play an important role in determining how an animal's immune system responds to a certain stressor.

The specific effects of water stress, particularly in sheep, are poorly understood. This line of research would be of great interest to determine the consequences of short-term and long-term water shortages on sheep defence systems during different critical production and reproductive periods.

### 2.11.8 Changes IN Relation To Physiological Status

Pregnant and lactating animals have 40–50% higher water turnover rates than non-lactating animals (Cain et al. 2005) with a greater need for feed, water and electrolytes in order to meet the requirements of the foetus and the mammary gland (Olsson 2005).

#### 2.11.8.1 Pregnancy

The reported changes in pregnant water-restricted sheep are usually similar to those observed in non-pregnant animals, including haemoconcentration (More and Sahni 1980), which denotes a reduction in the extracellular fluid space. However, in contrast to non-pregnant sheep, pregnancy seems to reduce the urine concentrating capacity of animals in response to dehydration, probably due to the high concentrations of circulating prostaglandins, which cause a reduction in sensitivity to arginine-vasopressin (Benlamlih et al. 1985; Rodriguez et al. 1996).

The effect of water restriction during pregnancy on lamb weight and survival is an important aspect to consider, since it affects productivity and sustainability of the farm operation. The desert-adapted Magra and Marwari sheep could sustain a twice weekly watering regimen imposed for an extended period with no effects on lamb birth weight (Mittal and Gosh 1986). Furthermore, pregnant Chokla ewes watered once every 4 d gave birth to lambs of lower weight compared with ewes that were watered daily or once every 3 d; however, after birth at 12 wk of age, lamb weights were similar between the different groups (More and Sahni 1980). Further studies to assess the long-term consequences of water restriction during gestation on the growth and later performance of offspring are necessary.

### 2.11.8.2 Lactation

Water restriction in lactating Awassi ,Hamadeh et al.(2006) and Comisana ewes (Casamassima et al. 2008) led to a greater weight loss than in non-lactating animals since they have higher metabolic requirements necessitating greater mobilization of fat deposits Sevi et al.(2002). Lactating sheep have a relatively higher blood volume due to the high water demand by the mammary gland (El-Nouty et al. 1991). Consequently, water restriction led to lower haemoglobin levels in lactating Awassi sheep when compared with their non-lactating counterparts (Hamadeh et al. 2006). Reports indicate that blood chemistry indicators such as glucose, cholesterol, protein, albumin and globulin, show little variation between lactating and non-lactating sheep beyond the first month of lactation (Hamadeh et al. 2006). When subjected to water restriction, the changes in blood indicators of lactating sheep were similar to those of non-lactating animals including significant increases in serum concentrations of triglycerides, albumin, total proteins and cholesterol, urea and creatinine (Rodriguez et al. 1996; Hamadeh et al. 2006; Casamassima et al. 2008). Lactation did not seem to modify the response to water restriction. Moreover, differences in pH and electrolyte levels were observed between water-restricted lactating and non-lactating Awassi ewes. An increase in pH was noted in water-restricted lactating Awassi sheep; it was related to a drop in $Ca^{++}$ and $K^{+}$ needed for milk production and a corresponding increase in $Na^{+}$ and $Cl^{-}$ needed for nutrient transport (Fig. 1) (Hamadeh et al. 2006). Dehydration usually causes a decrease in milk production due to reduced blood flow to the mammary gland (Hossaini-Hilali et al. 1994; Dahlborn et al. 1997; Mengistu et al. 2007). In contrast, milk osmolality, density and lactose content appear to increase under water restriction (Dahlborn 1987; Hossaini-Hilali et al. 1994). Lactose is the major osmotic component of milk, and its concentration is strictly controlled to keep milk isotonic with the blood (Dahlborn 1987).

View larger version

### 2.11.9 Economic Impact of Heat Stress ON Sheep Production

Loss in production due to water stress is similar to that observed under heat stress, especially since the two occur together under arid and semi-arid environments; heat stress leads to decreases in milk production, reproduction and feed intake, causes infertility and increases the risks of lameness and culling (Alhidary et al. 2012; De Vries 2012; Lucy 2012). Heat stress in cattle causes loss of appetite and weight gain (Sackett et al. 2006), it negatively affects the oestrus cycle and hence reduces reproduction (Monty and Wolf 1974; Hansen et al. 2001) leading ultimately to economic losses.

Most of the literature investigates the economic impact of heat stress on dairy and beef cattle production. According to Sackett et al. (2006) economic losses in feedlot beef cattle in Australia is estimated around 16.5 million

AUD when 30% of the cattle is subjected to heat stress during summer, whereas losses in dairy and beef cattle in the United states is estimated to be \$897–1500 million and \$370 million, respectively (St-Pierre et al. 2003). While St-Pierre et al. (2003) attribute these losses to welfare expenses, such as infrastructure and shading, others (Sackett et al. 2006; Lucy 2012) suggest that heat stress problems can be solved by investing in heat reduction systems, modifying animals' genetics and intensifying the reproductive management in heat stress periods.

A decade ago, although heat was acknowledged as a source of stress in sheep, the economic impact of this stress was not well studied, perhaps because sheep are mainly raised in extensive systems rather than in feedlots (that exhibit high rates of respiratory diseases under hot and humid climatic conditions) or because sheep are bred in a variety of environmental conditions and are considered to be rustic animals that can withstand high ambient temperatures (Silanikove 2000). Literature on the economic impact of heat stress on sheep production is still scarce; nonetheless, recent works reported that thermal stress can lead to severe economic losses in sheep husbandry (Pluske et al. 2010; Wojtas et al. 2013). Kandemir et al. (2012) reported that lamb production is seriously affected when pregnant ewes are exposed to heat stress during mid and late gestation: the total of embryo cell number and the placentome size are significantly decreased; lamb birth weight, growth rate and the total body solids and daily solids gain are also reduced.

Economic losses caused by high temperatures could be reduced by protecting ewes from heat waves during the breeding season (Kandemir et al. 2012), and by the addition of shelters and the implementation of fleece length strategies in commercial feeding lots (Pluske et al. 2010). Moreover, the integration of a preventive health program, feed optimization and basic selection of the animals has proven efficacy in improving the economic sustainability of sheep production in semi-arid regions (Tami et al. 2005). The economic impact of water and/or heat stress on sheep production in arid and semi-arid regions warrants further research, especially since it reflects on the livelihoods of the majority of the rural population in these areas.

**2. 11.10. Vitamin C: Stress Alleviator**

Vitamin C administration is not a common practice in adult livestock nutrition (McDowell 2000) since it is normally biosynthesized in ruminants (National Research Council 2007). It is an important antioxidant that helps in the scavenging of free radicals (Jariwalla and Harakech 1996). It also plays a role in modulating the immune response by enhancing neutrophil function and in minimizing free radical damage (Politis et al. 1995) and by improving antibody response to antigens (Cummins and Brunner 1990).

Administration of vitamin C to stressed animals such as weaned pigs (de Rodas et al. 1998), heat stressed Japanese quails (Avci et al. 2005), aluminum intoxicated rabbits (Yousef 2004) and heat stressed broilers subjected to feed restriction (McKee et al. 1997) yielded positive results such as improving performance under stressful conditions, enhancing feed intake, protecting from toxicity and improving body energy storage. Similarly, stress alleviation was reported in vitamin C supplemented goats in hot and dry conditions (Minka and Ayo 2007).

Several studies were performed to assess the effect of vitamin C supplementation on water-stressed Awassi sheep: supplementation tended to decrease weight loss (Ghanem et al. 2008; Karnib 2009) and was linked to improved feed intake (Hamadeh et al. 2009). Similar results were obtained in goats during stressful transportation conditions accompanied by dehydration (Kannan et al. 2000; Minka and Ayo 2007). The effect of vitamin C on weight reduction after water restriction is shown in Table 3. It is clearly seen that vitamin C administration reduces weight loss regardless of the dose given and the water limitation regimen. The reduction in weight loss could have economic significance in large farming operations, warranting further studies.

When assessing haematological effects, packed cell volume levels were reported to decrease in vitamin C supplemented dehydrated Awassi sheep (Ghanem et al. 2008) and transported Red Sokoto goats (Minka and Ayo 2007). In contrast, conflicting observations were reported regarding the haemoglobin concentrations: in transport-stressed goats vitamin C administration decreased haemoglobin (Minka and Ayo 2007), while in water-stressed Awassi sheep there was no effect (Ghanem et al. 2008).

The effects of vitamin C administration on serum protein, globulin and albumin in water-stressed Awassi sheep are not consistent (Hamadeh et al. 2006, 2009; Ghanem et al. 2008). It is worth noting that the water restriction regimen and the amount of vitamin C used in these experiments were not identical. This may explain the variable results. Additionally, it was observed that daily supplementation of water-restricted Awassi sheep with 5 g of vitamin C led to an increase in serum creatinine and urea, while lower levels had no effect (Hamadeh et al. 2009; Karnib 2009)

Vitamin C has an indirect impact on fat mobilization through its role in norepinephrine and carnitine formation, which helps fat mobilization and fatty acid transport, respectively (Ghanem et al. 2005). However, vitamin C administration to water-restricted Awassi sheep did not lead to significant changes in adipocyte diameter and other fat mobilization indicators (Jaber et al. 2011), while cholesterol levels tended to be higher in other experiments (Ghanem et al. 2005; 2008; Karnib 2009).

Blood osmolality and electrolytes are greatly affected by water restriction. However, their response to vitamin C supplementation in water-stressed Awassi ewes is not consistent (Hanna 2006; Ghanem et al. 2008; Hamadeh et al. 2009; Karnib 2009). Cortisol levels, used as indicators of water stress, did not show any differences between vitamin C supplemented and non-supplemented animals (Parrot et al. 1996; Parker et al. 2003; Ghanem et al. 2008), although others demonstrated that vitamin C played a role in decreasing cortisol secretion (Civen et al. 1980; Sivakumar et al. 2010).

## 2.12 Hormonal Changes in the Uterus during Pregnancy

Pregnancy is the most important event in the life of any female organism to reproduce its progeny. It isa very coordinated process among th mammalian species involving reproductive organs andhormones. The endocrine changes, *i.e.* changes in the profile of oestrogens and progesterone in the ewe (female sheep) during the oestrous cycle, pregnancy and parturition dramatically affect the structure of the endometrium as well as the uterine immune system. Hunter (1980), Pineda (1989), Liggins and Thorburn (1994), and Lye (1996) have significant contribution in the sheep reproductive endocrinology. It is to be mentioned here that the hormonal profiles in the ewe varies those from the cow, the buffalo cow and the doe (female goat). Hormonal changes in the uterus might also regulate the immune cells and immunity of the uterus. Therefore, it is important to understand the hormonal interaction that happens in the uterus of the ewe during oestrus cycle, pregnancy and parturition. Therefore, we need to be aware of the scientific information on the hormonal profiles andchanges in the uterus of ewe during pregnancy.

### 2.12.1 EndocrIine Profiles of the Oestrous Cycle

Like other mammals, the uterus of the ewe is subject to morphological and functional changes which span a 17-day estrous cycle. The stages of the estrous and reproductive cycles of the ewe are briefly presented in  Cyclic changes in the circulating levels of the ovarian hormones, progesterone and oestrogen have direct effects on the growth and metabolism of cells in the reproductive tissues. The main events of the oestrous cycle are related to the periods of growth of the ovarian follicles and the corpus luteum. During the 17-day cycle, progesterone dominates for about 13 days and oestrogen dominates for 3□4 days. The endocrine patterns of lutenizing hormone (LH), oestrogen (oestradiol), progesterone and prostaglandin F2 □□(PGF 2 □) during the oestrous cycle in the ewe are presented in changes in the ewe uterus during pregnancy3 Day 0 of the cycle is generally designated as the first day of behavioural oestrus, which is the result of increasing oestrogen levels produced by the developing pre-ovulatory follicles. High oestrogen levels are believed to cause a surge of gonadotropin releasing hormone (GnRH) and consequently an LH peak at oestrus resulting in spontaneous ovulation towards the end of oestrus. Following ovulation the ruptured follicle becomes a functional corpus luteum, which is the main source of progesterone in the cycling ewe. Blood levels of progesterone are low at oestrus (less than 1.0 ng/ml) through to day 3 of dioestrous, and then rapidly increase to maximal levels at day 8, and remain elevated until days 11 □□12 .Regression of the corpus luteum (luteolysis), induced by PGF2□, occurs if an embryo is not present in the uterus, resulting in a rapid drop in plasma progesterone. Ovarian oxytocin stimulates endometrial secretion and release of prostaglandins. The onset of the follicular phase of the next cycle is characterised by low progesterone levels and increasing GnRH and LH levels, while the follicle-stimulating hormone (FSH) levels present at the onset of this phase are progressively decreased. These events are controlled by oestrogen and inhibin, which are produced in increasing amounts by the developing follicles.

### 2.12.2 Endocrine Profiles DurIing Pregnancy

Once mating and fertilization are successfully completed the trophoblast must signal its presence to the maternal system to prevent luteolysis and maintain progesterone production, which is essential for the establishment of pregnancy (Geisert and Malayer, 2000). The blast cyst, before it attaches to the endometrium, secretes substances that directly or indirectly prolong the lifespan of the corpus luteum and prevent a return to ovarian cyclicity

(Jainudeen and Hafez, 2000). The timing of this phenomenon is known as 'maternal recognition of pregnancy'. The substance/molecule that inhibits the synthesis and/or release of luteolytic PGF2 from the endometrial cells and prevent corpus luteum regression (Bazer, 1989; Bazer *et al.*, 1989) is an embryonic protein first known as ovine trophoblast protein-1 (oTP-1) (Imakawa *et al.*, 1987). The oTP-1 was later classified as ovine

interferon-tau (oIFN) (Bazer *et al.*, 1997), when it was found to be a member of the interferon family. The oIFN- is a cytokine that acts locally on the uterine endometrium rather than systemically (Jainudeen and Hafez, 2000). The Oifn has antiluteolytic, immunosuppressive, antiviral and possibly antproliferative properties (Bazer, 1989; Bazer *et al.*, 1989). The anti luteolytic effect of oTP-1 is dependent upon the presence of progesterone and endometrial progesterone receptors (Ott *et al.*, 1992). Granulocyte macrophage-colony stimulating factor (GMCSF), which is produced in the maternal uterine endometrium, stimulates the production of oIFN- by the trophoblast (Imakawa *et al.*, 1993). Secretion of oIFN from the conceptus trophectoderm at 12-15 days post coitus (dpc) in the ewe (Bazer *et al.*, 1997) and 14-17 dpc in the cow and the doe (Bazer *et al.*, 1997; Gnatek *et al.*, 1989) is essential for maternal recognition of pregnancy. Once the trophoblast established the 'maternal recognition of pregnancy' then it proceeds to the next step for implantation into the luminal epithelium of the endometrium of the ewe. The implantation event is accompanied by significant changes in the tissue concentration of various cytokines, adhesion molecules, hormones, enzymes and growth factors, all of which may be crucial in initiating the feto-maternal relationship (Rice and Chard, 1998; Saito, 2000). Like hormones, cytokines are very important for maintaining pregnancy. While IFN is important for 'maternal recognition of pregnancy' other cytokines such as interleukin-1 beta (IL-1), tumor growth factor beta (TGF), IL-6, leukaemia inhibition factor (LIF), IL-10 are important for embryo growth and

development, and IL-6 and LIF are important for elongation of embryo and placentation (Rahman, 2002; Rahman *et al.,* 2004). The reproductive hormones believed to interact and regulate these cytokines in the uterus of the ewe (Rahman, 2002). Progesterone is the key hormone of pregnancy and is thus often called the ‘pregnancy hormone’. It acts to prevent the resumption of cyclicity, prepares the uterus for implantation and maintains myometrial quiescence (Lye, 1996). Actually, myometrial quiescence during pregnancy is achieved
by the combined action of progesterone, relaxin, prostacyclin and nitric oxide (Lye, 1996). In thecow, progesterone is found to stimulate the production of a variety of endometrial secretions, which are required for the successful development of embryos (Geisert *et al.*, 1992). Low concentrations of progesterone in the ewe can lead to poor embryo development (Nephew *et al.*, 1991) andA. N. M. A. Rahman 4 progesterone supplementation enhances embryo growth in both the bovine (Garrett *et al.*, 1988) and the ovine (Kleemann *et al.*, 1994) species. Together with oestrogen, progesterone acts to transform the endometrium into a secretory tissue capable of supporting both the pre- and post-implantation conceptus. The plasma concentration of progesterone during pregnancy in the ewe is depicted in Fig. 3. The progesterone concentration in the peripheral plasma gradually rises from the luteal phase level during the first half of pregnancy, markedly increases at about 90 dpc, peaks at about 125 dpc (Bassett *et al.*, 1969; Liggins and Thorburn, 1994; Thorburn *et al.*, 1977) and falls in the last few days before parturition (Bassett *et al.*, 1969; Challis and Lye, 1994; Liggins and Thorburn, 1994; Stabenfeldt *et al.*, 1972). In the ewe, during the first third of pregnancy, progesterone is produced by the corpus luteum, and as with humans (Lye, 1996), production is taken over by the placenta at about 50 dpc and subsequent removal of the ovaries does not compromise development of the foetus (Casida and Warwick, 1945; Denamur and Martinet, 1955).

Progesterone also believed to aid in the maintenance of uterine immune system during pregnancy in theewe (Rahman, 2002). It has been reported that a systemic hormonal signal of maternal or foetal origin activates and increase the number of a specific immune cells in the uterine endometrium of ewe (Majewski *et al.,* 2001) which protect the foetus from maternal immune rejection. These cells are known as intraepithelial large granulated lymphocytes (LGL) or gamma-delta TcR positive large granulated lymphocytes (TcR+ LGLs). Progesterone could be a prime candidate for this systemic

hormonal signal (Hansen, 1998). These TcR+ LGLs remain highest level in the uterus of the ewe throughout the final stage of pregnancy and even just before the onset of parturition (Rahman *etal.,* 2002). The major oestrogens present in the maternal plasma of the ewe are the sulpho-conjugates of oestrone and oestradiol-17, the concentration of which increases progressively from 70 dpc to parturition (Carnegie and Robertson, 1978; Currie *et al.,* 1973). Until 120 dpc, the concentration of free oestrone and oestradiol-17in the maternal plasma remains at a low level, but then increases gradually, before undergoing a sudden and rapid rise in the last days of pregnancy (reviewed in Liggins and Thorburn, 1994). This dramatic increase in free oestrogens coincides with a major increase in the oestrogen sulpho-conjugates in the foetal and maternal plasma (Liggins and Thorburn, 1994). Prostaglandins, particularly PGF, are very important in the parturition of the ewe and the doe, with increasing levels in the venous plasma in the last days before parturition (Liggins *et al.*, 1972). The concentration of progesterone, oestradiol-17and PGF in the venous plasma of a doe during thelast week of pregnancy, parturition and post-partum is depicted in Hormonal changes in the ewe uterus during pregnancy.

### 2.12.3 Endocrine Profiles At Parturition

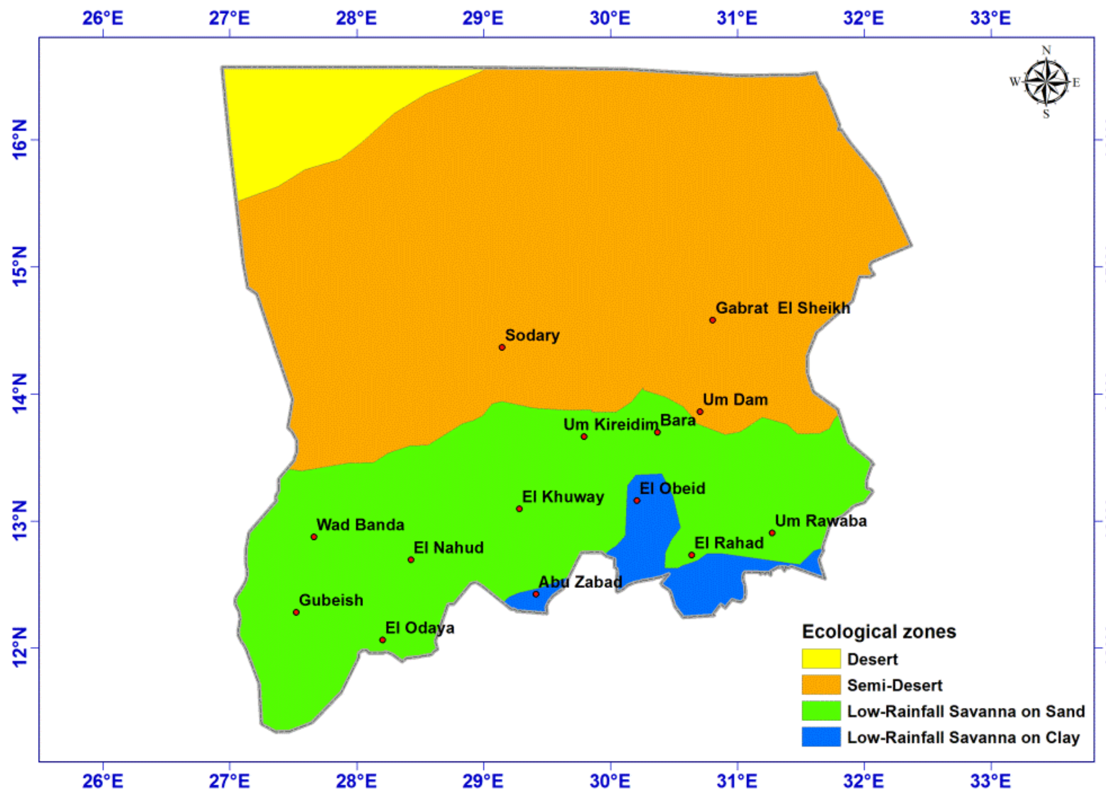
Parturition is the physiological process by which the pregnant uterus delivers the foetus/fetuses and placenta from the mother. The onset of parturition is associated with a switch from a progesterone-dominated state to an oestrogen-dominated state (Liggins and Thorburn, 1994). The foetus of an ewe attains a weight of about 4 kilograms close to parturition. Parturition is triggered by the foetus and is completed by a complex interaction of endocrine, neural, and mechanical factors (Jainudeen and Hafez, 2000) in which both the foetal and maternal mechanisms play essential roles. In the ewe, the foetal endocrine system plays a major role. During the final stage of gestation, the production and secretion of cortisol by the foetal adrenal gland (Bazer and First, 1983; Thorburn, 1991) induces a fall in the maternal progesterone concentration, which initiates parturition. This cortisol induces the placental 17-hydroxylase to catalyse the conversion of progesterone to oestrogen (Liggins and Thorburn, 1994) resulting in increased oestrogen: progesterone ratios, which play an important role in the increased synthesis and release ofprostaglandins, activation of the myometrium and ripening of the cervix (Challis and Lye, 1994). Prostaglandins, particularly PGF, play a central role in myometrial contraction, which begins 6□18 hours before delivery (Lye, 1996). Along with relaxin, oestrogen causes a relaxation of the birth canal, especially the cervix and the vagina (McDonald, 1989), and helps to facilitate the birth of the foetus. Oxytocin is not a pre-requisite for the parturition in the ewe (Liggins and Thorburn, 1994) but it facilitates the delivery of the foetus and placenta by inducing forceful uterine contractions (Glatz *et al.*, 1981). It has been reported that at the onset of parturition □□when progesterone concentration decline in the blood plasma □□a dramatic decline in the proportion of □□□TcR+ LGLs occur (Fox *et al.*, 1998, Rahman *et al.*, 2002). This is mainly due to the apoptosis of LGL in the luminal epithelium and migration of these cells to the uterine lumen (Rahman *et al.*, 2002). Withdrawal of progesterone during the onset of parturition (Basset *et al.*, 1969; Wooding and Flint, 1994), which could in turn cause the onset of apoptosis, would lead to the disappearance of the LGLs (Rahman *et al.*, 2002). It has also been reported that the LGLs seem to play a major role through de-granulation to facilitate detachment of fetal membranes and to protect the uterus from microbial infection at a time when the uterine cervix is open to the environment (Rahman, 2002; Rahman *et al.*, 2002). A. N. M. A. Rahman .Therefore, the interaction of hormones with immune cells have very important roles in the healthy birth of a lamb as well as for the protection of infection and maintenance of uterine integrity in the ewe.

# CHPTER THREE

## Material and Methods

### 3.1 The study Site

This experimental was carried in UM Rawaba locality North Kordofan state it lies within arid and semi-arid ecological zones between latitude 12-25, 13-45 North and longitude 29—35,30—30 East. The topography of the land ranging from sandy soil in the north to Graded soil in the south with some valleys and mountains(ADS,1995).These soils vary from sandy interspaced by silt depressions in the northern parts (Mitchell,1991). Most of North Kordofan state lies within arid and semi-arid ecological zones. The average maximum temperature varies between 30 and 35˚C during most of the year with peaks above 40˚C during hot summer. The rainy season extends from July to October, reaching it peaks in August .The annual rainfall ranges from 75 mm in the extreme north and about 500mm in south with average 280 mm (Technoserve 1987). The northern part of area is covered with sandy soils which is originally either stabilized or mobile sand dunes. The southern part is predominantly silty clay, non-cracking clay soil with small patches of cracking clay. The vegetation varies from north to south. In the north grass land and shrubs predominate while bushes and trees are common in the south (Harrison and Jackson 1958).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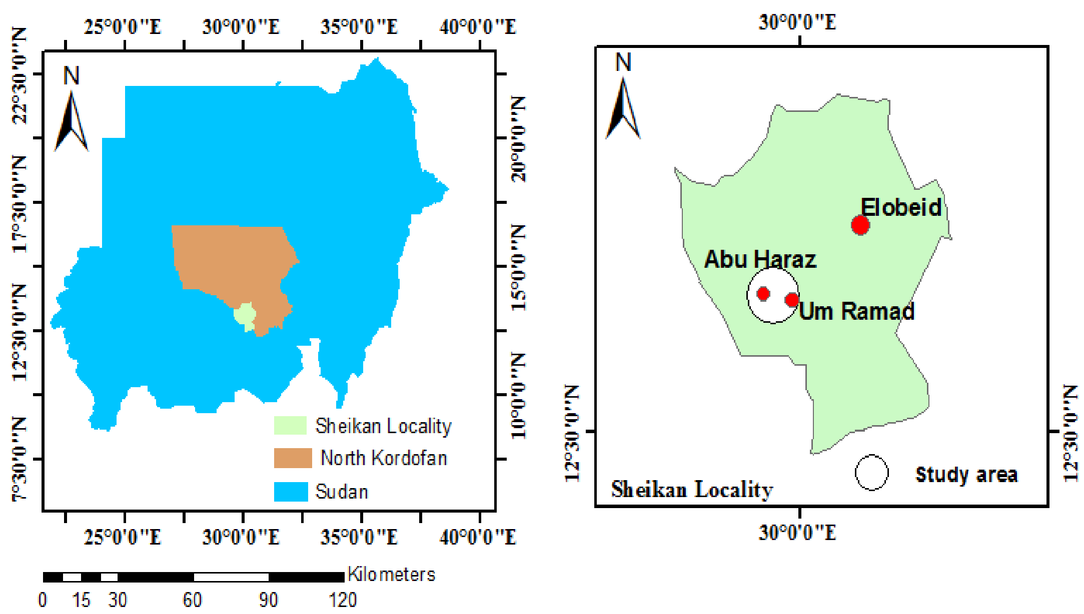
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## 3.2 Duration of the experiment

This experiment extended for one year from April 2016 until March 2017.

## 3.3. Experimental Animals management

Hundred ewes Desert sheep(Hamari bred) at the same age (4---5months)were used in this study" Those experimental animals were selected for hard and by Khologe Company for Livestock Investment .The animals were ear tagged and randomly divided into four groups animal each group according to age and body weight designed as A,B ,C and D. The first group (Group A ) was allowed to drink water every day and supplemented with additional concentrates150g ,consisting of 40%Surgam, 30%groundnut cake, 29%wheat bran and 1%salts. Every head from this group was given concentrates daily .The second group (group B)will be allowed to drinking water every day without supplementation. The third group (C) was allowed water at (2-3) day's intervals and supplementation .The fourth group (group D) were allowed water to drink at 2-3 days intervals and without supplementation. The group D is considered as control. Each group has a separated by sheep shed with nets with space 500 m from the other shed .All the groups were allowed to graze at night on natural grasses available on pasture and kept in shade during the day from 7; 00amto 6; 00pm. All the parameters related to the performance will be recorded regularly. The sheep were allowed to mate with the rams throughout the year; the animals were given the experimental diet for an adaptation period of two weeks during this period the sheep were treated with lives subcutaneously injection of Ivermactin against external and internal parasites. Albendazole drenches for given orally deforming was given orally

## 3.4. Source of draining water

Water is fetched for drinking from a water station in the area (Umm Rawaba) ,this was done by using a 120 barrel tank . Blanker with a 120 barrel capacity were provided, it was placed in the place designated for the experimental herd, where natural pastures are available, this is to reduce stress in searching for pastures and water ,where is enough for a month , 120-barrel water tank was placed in each barn for the herd, and a drinking basin was placed in each barn. Animals were prevented from drinking pond water during autumn days by the worker.

## 3.5. The reproductive measurement

Records were made to record the age of puberty, age at first calving, lambing weight and weaning weight.

**1-concaption age**: - Age at first pregnancy, the date of conception was recorded.

## 3.6. Birth weight

Where newborns were weighed at birth using a circular scale, weighing up to 50 kg. The lambs were weighed after birth using a circular scale weighing fifty kilograms; the scale was raised for weight

## 3.7. Lambs weight after weaning

The lambs were weighed at weaning (3 months) using a special sheep weighing scale belonging to the Kholoj Animal Production Company .As the load was inserted into the scale was closed and the reading was completed ,by a screen above the scale . The lambs were weighed after weaning using a special scale to weigh the sheep, where the load was entered into the scale together. The scale was locked from the direction of entry and exit of the load, then the weight is read via a screen

## 3.8. Blood samples

Hormonal assay was carried in Soba Research Center Veterinary for measuring the Estradiol. Triiodothyronine (T3) and the mineral (ca/p) protein and glucose .Blood samples were collected from the jugular vein, blood was taken at 8.0 a.m. into heparin zed tubes (5 I.U heparin/tube). Plasma was harvested by centrifugation at 3500 rpm for 15 min within an hour of collection. Plasma Estradiol hormones samples were run in a single assay having of 5.6%. Similarly, all Triiodothyronine (T3) samples were run in a single assay having a CV of 7.3%. Both hormones were analyzed using radioimmunoassay kits (Diagnostic Product Company, LOS Angeles, CA).for analysis of the protein, glucose, phosphors and calcium was used digital spectrophotometer.

## 3.9.Blood analysis

**Glucose :---------------**

Wareleneth: 546nm

Optical path: 1cm light path

Temperature: 37c

Reading : Against blank reagend

Assay Type : End point

| | BLANK | STANDRD | SAMPLE |
|---|---|---|---|
| Reagent | 1000ul | 1000ul | 1000ul |
| Distilled water | 10ul | | |
| Standard | | 10ul | |
| Sample | | | 10ul |

Mix in cubage for 10 min at 37c and read sample and stander extinction. Volumes can be proportionally method. This methodology describes the manual procedure to use the Kit .For automated procedure for specific application.

Calculation :------------------

Serum plasma and liquor .

Glucose mg/dl =(A)sample/(A)standard *100(standard vetie)

Trinder P. (1969) Ann.Clin. Biochem,6,24.

**Assay Principle :---**

**Total protein** :------------

Warieienght 530---570nm

Cure the 1 cm light path

Temperature 20—25 or 37c

Zero odinsture against reagent blank

Specimen serum or plasma

| | Blank | Standard | Specimen |
|---|---|---|---|
| R2 | 10ml | 1.0ml | 1.0ml |
| Standard | | 20ul | |
| Specimen | | | 20ul |

Mix incubate for 5 minute in 20-25c measure the absorbance of specimen (A sample )and standard (A standard ) against reagent blank the color is stable for 60 minute .

Calculation: ----calculate the total protein concentration by using the following formulate.

Total protein concentration:--

Absorbance of specimen /absorbance standard*(standard value)

Unit conversion. Mg /dl *1.45mmol/l

Gomal A.C; Bardaill C.J, and David M.M (1949): J. Biol. Chem.177:751.

**Calcium:--**

**Procedure:**

1-Rigute into standard table.

| | Blank | Standard | Sample |
|---|---|---|---|
| Calcium standard | ----------- | 13ul | --------------- |
| Sample | ------ | --------------- | 13ul |
| Waning Rigout | 10ml | 10ml | 10ml |

2-mix poroughy and lest standard the tubes for 4 minds at room temperature.

3-Read the standard (A) of the standerd and the sample at 560rm against the Bank the colour is static for at least 1 hour.

Calculation:-

A sample /A standard *c standard *sample standard *c sample

Gindler M. King J.D.(1972): Am. J. Clin. Path. 58, 376.

**Phosphor test :-**

**Procedure :-**

1-pigatis labeled test tubes (note 1)

| | Ready Blank | Ready Blank | sample | Standard |
|---|---|---|---|---|
| Dated want | 10ul | | | |
| Sample | | 10ul | 10ul | |
| Photostandard | | | | 13ul |
| Reagent (A) | | 11ml | 10ml | |
| Weighty Regard | 10ml | | | 10ml |

2-mix thought and lest against the tubes for 5 mentis at room temperature .

3-Read fx stander (A) of the sample Bank at 340 rm againststandard .

4-Read fx stander (A) at sample 340 m.

Calculations. ---

A Sample –Bystander /A stander *C sample *C stander

References:

El-Merzabani.M.M.;El-Aaser.A.A. and Zakhary, N.I.(1977).J.Clin. Chem. Clin. Biochem. 15: 715-718.

Article 132-EN

Date of Revision 10/2012

**Estradiol (E17-β) assay:**

**Triiodothyronine (T3) assay:**

Serum T3 levels were assayed using kits purchased from immunespec, Germany according to (Hoffenberg, 1978).

**Assay procedure**

1. Secure the desired number of coated wells in the holder make data sheet with sample identification.
2. Dispense 100 µl of standards, specimens and controls into appropriate wells.
3. Thoroughly mix for 10 seconds, and then Dispense 100 µl of enzyme - conjugate reagent into each well.
4. Thoroughly mix for 30 seconds. It is important to have a complete mixing in this step.
5. Incubate at room temperature (18-25 ºC) for 60 minutes.
6. Remove the incubation mixture by flicking plate contents into a waste container.
7. Rinse and flick the micro wells 5times with washing buffer (1x).
8. Strike the wells sharply onto absorbent paper to remove residual water droplets.
9. Dispense 100 µl of TMB reagent into each well. Gently mix for 5 seconds.
10. Stop the reaction by adding100 µl of stop solution to each well.1
11. Gently mix for 15 seconds.
12. Read absorbance at 450 nm on the micro plate reader within 15minu

HUMAN HumaReader HS

Short Descriptions:

HumaReader HS is a semi-automatic, microprocessor-controlled photometer HumaReader HS is a 1 plate (96 well microtiterplate) ELISA reader at ambient temperature, which uses EIA photometric as the measuring mode. Up to 8 standards can be loaded per time

Benefits of the system:

- Has a memory capacity of 1000 patients and 10000 sample records
- Max of 200 tests can be programmed
- Allows for single or double-wavelength simultaneous reading
- Pre-installed with wavelengths of 405, 450, 492,

Human Reader HS (T3 and Estraduial )

## 3.10. Statistical analysis

Data will be analyzed using SPSS version as a completely randomized design (CRD),in arrangement LSD will be used for mean separation by use a computer program.

# .CHAPTER FOUR

## The Result

### 4.1 The Effect of Supplementation and Restriction Water on the Production of Ewes

Table(1) shows the effect of supplements and restriction water on the reproductive performance of desert sheep, as there was no significant (P.>0.05) differences between the treatments Since the age of conception in the first treatment was 257.44 days , the second treatment was 251.20 days and effect of water drinking , 248.24 and267.92 days for the third and fourth transactions. While the age of lambing in the first treatment 409.40 days and 406.16,effect of the drinking water 403.16 and 421.32 respectively for the second, third and fourth transactions. Table (2) The effect of supplementation and Water Restriction on Mortality and Abortion of Ewes. It is clear from Table.( 2) the effect of treatments on abortion, where in the first treatment it was 0%, while in the second treatment 0% and 8% in the third and fourth treatment respectively.

The effect on mortality was 0% in the first treatment and 3%, 0% and 8% for the second, third and fourth, respectively.

**Table (1) The effect of supplementation and Water Restriction on Age of Conception and lambing of desert sheep of desert sheep**

| Items | The treatment | Age of conception(day) | Age of lambing(day) |
|---|---|---|---|
| Supplementation | Supplementation | 257.44 | 409.40 |
| | Un Supplementation | 251.20 | 406.16 |
| Restriction of Water | Drinking daily | 248.24 | 403.160 |
| | Drinking 2-3days | 267.92 | 421.32 |
| | **Sig** | **NS** | **NS** |

**Table (2) The effect of supplementation and Water Restriction on Mortality and Abortion of Ewes**

| Item | The treatment | Mortality% | Abortion% |
|---|---|---|---|
| Supplementation | Supplementation | 0 | 0 |
| | Un Supplementation | 3 | 0 |
| Restriction of Water | Drinking daily | 0 | 8 |
| | Drinking 2-3days | 8 | 8 |
| **Sig** | | * | * |

## 4.2 Effect of supplementation and Water Restriction on weight lambs

The study revealed as in Table (3) the effect of supplementation on the lamb weights of desert sheep, where there were no significant($p.>0.05$) differences between the treatments. Where the weight at birth in the first treatment 2.70 kg while2.89, 2.73 and 2.84 kg in the second, third and fourth, respectively. Where the weight at weaning in the first treatment 12.93 kg while 12.93 kg in the second treatment and 13.28 and 13.00 kilo in the third and fourth. The mortality of group C is 4% while in group D12%, while there were no mortality in group A and C.

Table (4)reasons cause mortality in lamb was significant in testament o% in supplementation ,4% un supplementation while 0% in daily drinking and 12% 2to 3 days drinking.

**Table (3) The effect of supplementation and Water Restriction on Weight of lamb and weight of Weaning desert sheep**

| Item | The treatment | Weight of lamb/ kg | Weight of weaning/kg |
|---|---|---|---|
| Supplementation | Supplementation | 2.70 | 12.93 |
| | Un Supplementation | 2.73 | 13.28 |
| Restriction of Water | Drinking daily | 2.89 | 12.93 |
| | Drinking 2-3days | 2.84 | 13.00 |
| **Sig** | | **NS** | **NS** |

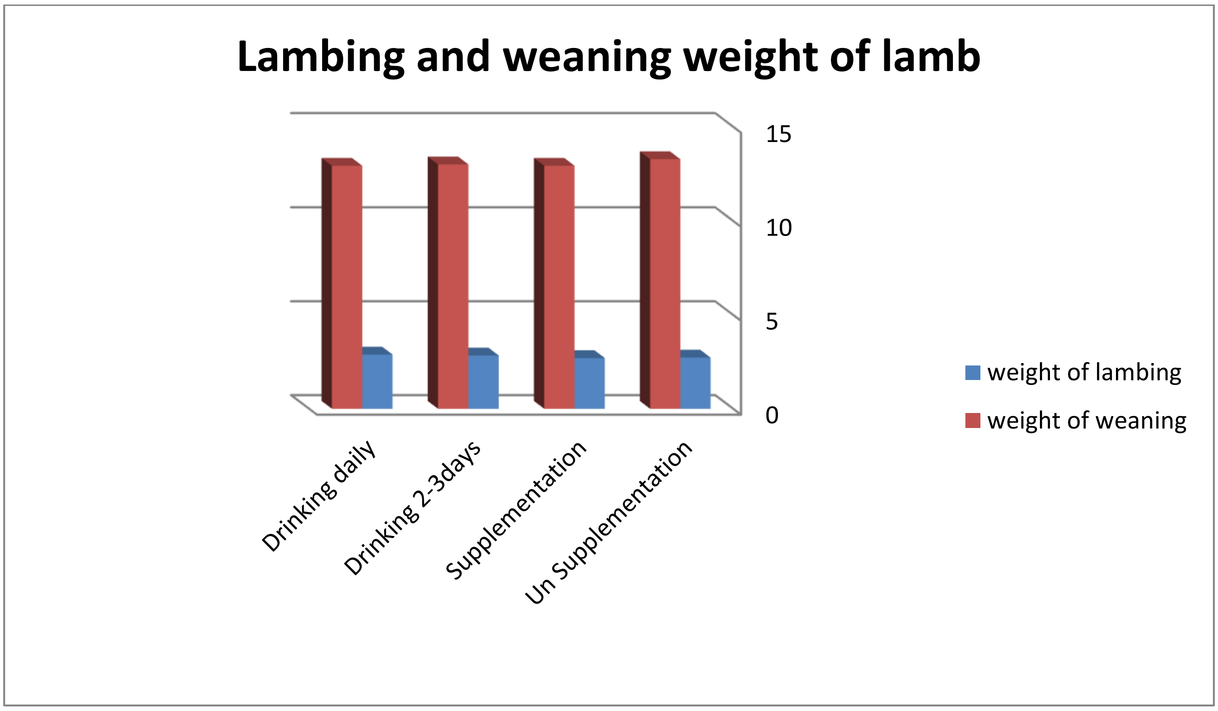


**Figure (1) The effect of supplementation and Water Restriction on Weight of lamb and weight of Weaning desert sheep**

**Table (4) The effect of supplementation and Water Restriction on Mortality of desert sheep**

| Item | The treatment | Mortality % |
|---|---|---|
| Supplementation | Supplementation | 0 |
| | Un Supplementation | 4 |
| Restriction of Water | Drinking daily | 0 |
| | Drinking 2-3days | 12 |
| **Sig** | | * |

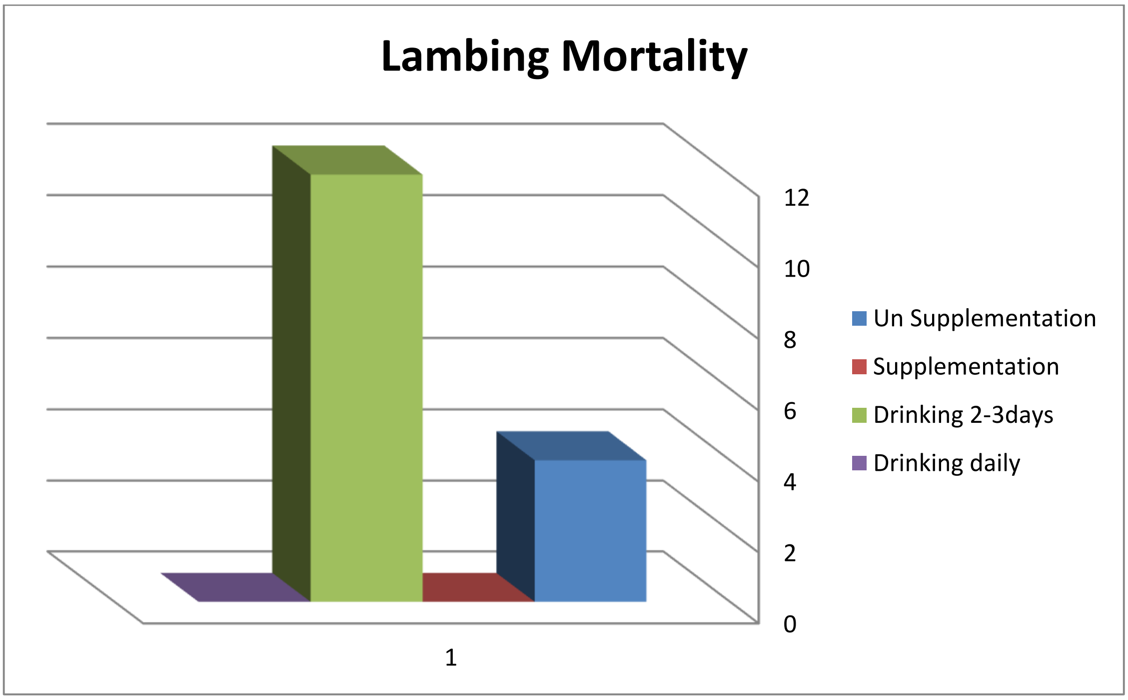


**Figure (2) The effect of supplementation and Water Restriction on Mortality of desert sheep**

Data in table (5) showed that the size and sex of lambs in desert sheep in supplementation size 100% and un supplementation 95% single and 1% twain in un supplementation. Effect of water restriction size 100% single and sex 50% female and 50 % male

**Table (5) The effect of supplementation and Water Restriction on Size of lamb and Sex desert sheep**

| Item | The treatment | Size | | Sex | |
|---|---|---|---|---|---|
| | | Single % | Twain % | Female % | Male % |
| Supplementation | Supplementation | 100 | 0 | 30 | 70 |
| | Un Supplementation | 95 | 1 | 66 | 34 |
| Restriction of Water | Drinking daily | 100 | 0 | 50 | 50 |
| | Drinking 2-3days | 100 | 0 | 50 | 50 |

**Table (6) The effect of supplementation and Water Restriction on Mortality of lambs of desert sheep**

| Item | The treatment | Mortality % |
|---|---|---|
| Supplementation | Supplementation | 0 |
| | Un Supplementation | 4 |
| Restriction of Water | Drinking daily | 0 |
| | Drinking 2-3days | 12 |
| | **Sig** | * |

### 4.3 Effect of Supplementation and Water Restriction on level of minerals in serum

Table(7)in this study that shows the effect of supplements on the level of minerals in the blood, where were no significant(p.>0.05) differences between the treatments, The level of calcium in the first treatment was 8.77 while 8.74, 8.65, 8.57 in the second, third and fourth transaction respectively. The level of phosphorus in the blood for the first treatment was 4.02 and treatment 4.10 in the second treatment, third and fourth, 4.12 and 4.15, respectively. While the level of glucose in the blood for the first treatment 61.52 treatment , the second and 61.70treatment and the third and fourth, 60.62 and 60.45, respectively. The level of protein in the blood for the first treatment 7.87 and treatment 8.07, the treatment of the third and fourth, 7.90 and 7.75, respectively

**Table (7) The effect of supplementation and Water Restriction on Calcium and Phosphors in Serum desert sheep**

| | **The treatment** | **Ca(mg/dl)** | **P (mg/dl)** |
|---|---|---|---|
| Supplementation | Supplementation | 8.77 | 4.02 |
| | Un Supplementation | 8.65 | 4.12 |
| Restriction of Water | Drinking daily | 8.75 | 4.10 |
| | Drinking 2-3days | 8.57 | 4.15 |
| | **Sig** | **NS** | **NS** |

**Table (8) The effect of supplementation and Water Restriction on Glucose and Total Protein in Serum desert sheep**

| Item | The treatment | Glucose (mg/dl) | Total Protein (g/dl) |
|---|---|---|---|
| Supplementation | Supplementation | 61.52 | 7.87 |
| | Un Supplementation | 60.62 | 7.90 |
| Restriction of Water | Drinking daily | 61.70 | 8.07 |
| | Drinking 2-3days | 62.45 | 7.75 |
| **Sig** | | **NS** | **NS** |

## 4.4 Effect of supplementation and Water Restriction on levels of hormones in serum

Table (9) shows the effect of treatments on the level of TriiodothyronineT3 and Estradiol in serum samples of the experiment. There were significant ($p<0.05$) differences between the treatments, The study showed that the level of T3 in the first treatment was 1.30 and 1.37 g 1.60 g1.70 in B ,C,D respectively . The study showed that the level of Estradiol in the first treatment was 209.75, while in the treatment of B.C.D respectively 185.75 g 97.2 g 199.

**Table (9) The effect of supplementation and Water Restriction on Hormons Triiodothyronine (ng/ml) and E Stradiol (ng/ml)in Serum desert sheep**

| Item | The treatment | Triiodothyronine (ng/ml) | EStradiol (ng/ml) |
|---|---|---|---|
| Supplementation | Supplementation | 1.30 | 209.75 |
| | Un Supplementation | 1.60 | 97.25 |
| Restriction of Water | Drinking daily | 1.37 | 185.75 |
| | Drinking 2-3days | 1.70 | 199.0 |
| **Sig** | | **NS** | ***** |

# CHAPTERFIVE

## Discussion, Conclusion& Recommendation

### 5.1 Discussion

The experiment was designed to investigate the effect of supplementary feeding and water restriction on the reproductive performance and some blood biochemical of desert sheep (Hamari type ) ,the result of statistical analysis of reproductive performance showed that there were no significant (P>0.05 ) differences between the treatments in the age at first mating and age at first lambing. Where the age of conception in the first treatment was 257.44 days while in the second treatment was the age of mating 251.20 days and 248.24 and267.92 days for the third and fourth transactions. For the age of lambing in the first treatment 409.40 days and 406.16 , 403.60and 421.32 respectively for the second, third and fourth transactions .Nutritional interventions involving season-specific feeding and micronutrient supplementation may help the animal to sustain its production during adverse environmental conditions (Sejian *et al*., 2013).Also data in Table (1) indicated no significant (P>0.05) effects of supplementation on reproductive traits. These results disagreed with Blumer *et al*. (2015), Sejian *et al*. (2013) and El-Hag *et al*. (2007), who reported that strategic supplementary feeding of ewes increased lambing rates, reduced abortion and mortality of ewes. Differences in nutrition probably account for most of the variation in reproductive performance (José *et al*., 2016 and El-Hag *et al*., 2007).

Abortion and mortality rate for ewes steamed-up and feed supplementation with available drinking water were very low and high for un supplemented ewes (Table 2), this result is agreed with El-Toum (2005) who found that supplementary feeding had resulted in a 21.0% decrease in abortion rate.

Also agreed with El-Hag *et al*. (2007) and Youder *et al*. (1990)who mentioned that poor nutrition leads to reduced conception, embryonic losses, reduced lambing rates and high ewe mortality. The effects of pregnancy stress on ewes are manifested in increased abortions, weight loss and mortality (Sirohi *et al.*, 2014).

The size and sex of lambs in desert sheep in supplementation size 100% and un supplementation 95% single and 1% twain in un supplementation**,** this result disagree with El-Hag *et al*. (2007) who reported that the highest twinning rates were in ewes that had been both flushed and steamed-up, where other with no twinning and Flushing and steaming-up had significant ($P<0.05$) increased prolificacy, the biggest prolificacy was secured by ewes had flushed and steamed-up compared with ewes un supplemented, similar results obtained by Mekuriaw *et al*. (2013) and El-Hag *et al*. (2006). Youder *et al.* (1990) reported that poor nutrition leads to reduce conception, embryonic loss, and reducing lambing rates.

**FOR effect of supplementation and water Restriction on weigh lambs**

Table(3)in this result shows the effect of supplementation on the lambing weights of desert sheep, where was no significant(p.>0.05) differences between the treatments For the first treatment weight at lambing was 2.70 kg while2.73, 2.89and 2.84 kg in the second, third and fourth, respectively. Where the weight at weaning in the first treatment 12.93 kg while 12.93 kg in the second treatment and 13.28 and 13.00 kilo in the third and fourth, this result was disagreed with findings of El-Hag *et al*,(2007 and 1998). Supplementations of pregnant ewes during late gestation are to provide adequate energy and protein to support embryonic and fetal growth, maintenance of animal physiological needs, mammary gland growth, colostrums and milk yield. disagreed results obtained by Idris *et al*. (2014) and Mellor and Murray (1985) whom stated that inadequate feed intake during late pregnancy has been found to cause a reduction in birth weight, mammary gland development and milk production. May be these supplements had higher nutritive value. This result were disagree with findings of Idris *et al*. (2014) and El-Hag *et al*. (2007 and 1998). Lambs from supplemented ewe's growth faster than un supplemented one this may be due that inadequate feed intake during late pregnancy may cause a reduction in mammary gland development and milk production, so lambs suckling non supplemented ewes obtained low growth rates. Similar results were obtained by Njoya *et al*. (2005).

**For the Effect of Supplementation and water restriction on Blood Serum of The Minerals**

The effect of supplements and water restriction on the level of minerals (calcium, phosphorus) in the blood and the level of glucose and protein , where was are no significant (p.>0.05) differences between the treatments **,** disagreed results were reported by other researchers (Raoofi et al 2013). While higher plasma glucose levels were recorded in dry period during the reproductive cycle of the ewe, late pregnancy and lactation are critical periods; they represent a physiological load to the female body, which activates adaptation mechanisms in order to maintain normal homeostasis during the peri-partum period. Knowing the metabolic profile in this period is very important to specify nutritional status as well as to prevent health disorders which lead to production and reproduction disturbances. Blood serum biochemical parameters are affected by several factors such as breed, age, under nutrition or season (Swanson et al 2004); [yokus 2044], during pregnancy these levels are naturally affected by the involvement of maternal tissues in providing energy for foetal growth. Lactation is a very demanding period for females confronted with increased nutritional needs. During this period, especially in its initial phase, characterized by high milk production, it is difficult to satisfy the nutritional requirements of lactating animals. This is due to their increased need for energy and minerals for milk synthesis. As a result, there will be a significant change in animals' metabolism leading to the modification of blood biochemical parameters and minerals concentration. These variations not only affect animal's performances, but also lead to certain metabolic disorders reflecting a real metabolic stress for animals during lactation(Azab 1999).

Blood glucose is known as metabolic profile test, thus, it has distinguishable value in pregnancy toxemia, retorted growth, weight loss, production and reproduction defects [Hamadeh et al 1998]; [Ramin 2005]. same results were reported by other researchers [Raoofi 2013]. While higher plasma glucose levels were recorded in dry period. In ewes, some other authors [Al-dewachi 1999]; [charismiadoa 2002] reported greater blood glucose levels in pregnant ewes. While several studies showed that serum glucose levels were higher during lactation than pregnancy [Henze et al 1994]; Thus, low concentrations of blood glucose during late pregnancy and the onset of lactation could be explained by its consumption ,Scott et al( 1995 )

It was reported a decrease in blood protein concentrations during the latter stages of gestation, and these low blood protein levels reach normal concentration as the lactation period advances (Brozostowski 1996). Total protein concentration was significantly lower on late gestation and early lactation compared to the dry period; a similar results to ours were reported by other studies (Karapeh et al 2007). This decrease in serum total protein during late pregnancy may be attributed to the fact that the foetus synthesises all its proteins from the amino acids derived from the mother, and growth of the foetus increases exponentially reaching a maximum level, in the last third of gestation ,Antunovic( 2002). In the beginning of lactation the decrease of total proteins is due to the decrease of the rate of globulin which could be explained by the fast extraction of immunoglobulins for the synthesis of the colostrums ,Antunovic( 2004).

The calcium (Ca) concentration in blood serum of sheep is considered to be deficient when calcium is less than 60mg/l, but above 80mg/l levels are considered adequate ,Abdelrahmen (2008). Present results indicate that (Ca) plasma level increase significantly in late pregnancy and decrease significantly in early lactation to reach normal values in dry period. The enlargement of parathyroid gland during pregnancy causes (Ca) mobilisation from the mother bones, maintaining normal (Ca) level in the mother intracellular fluids as the foetus removes (Ca) for ossifying its owns bones. Accordingly, the significant increase in (Ca) concentration in late pregnancy could be related to an increase of (Ca) mobilization from the skeleton. In goats some researchers obtained different results concerning Ca levels during pregnancy and lactation.,Kadzere( 1997) reported that Ca concentrations in plasma increased as gestation progressed and decreased after kidding while (Tanritanir 2009)said that no statistical differences between before and after parturition at Ca levels in goats.

Phosphorus (P) is also required in large quantities for skeleton mineralization. The present study indicates that the plasma Phosphorus level was significantly lower during late pregnancy and early lactation compared to dry period while in peri-parturition period we have not found a significant difference. Some authors attributed such decrease in serum (P) level during late pregnancy to an increased rate of (P) mobilization out of maternal circulation into the foetus, (P) available in circulation is supplied by increasing (P) absorption from the gut or (P) desorption from the bones of dam. Other researchers found that P levels during late gestation and postpartum period significantly increased in ewes and goats (Tanritanir et al 2009).

**As for the effect of supplementation and water restriction on hormones in serum**

Statistic analysis shows the effect of treatments on the level of **Triiodothyronine** and Estradiol in serum samples of the experiment .where was are significant(p.<0.05) differences between the treatments. The study showed that the level of T3 in the first treatment was 1.30 ng/ml in the treatment of B, C and D respectively 1.37 ng/ml , 1.60 ng/ml and 1.70 ng/ml.

The study showed that the level of estradiol in the first treatment which supplemented was 209.75, while in the treatment of B (un supplemented) 97.25ng/ml, C (Drinking daily) 185.75ng/ml and D (Drinking 2-3days) respectively. The date of blood collection proved to have a highly significant impact on the concentration of hormones. In the current experiment at the same time significantly decreasing the level of Estradiol confirmed the pregnancy of ewes. This was in accordance with the findings of other authors (Ganaie et al., 2009; Roy et al., 2012).

## 5.2 Conclusion

- The results of the present study indicated that, Supplementation and Water Restriction and low stress during breeding period improved the Reproduction Performance of desert sheep of ewes and lambs born from supplemented ewes recorded better production characteristics compared with farmer's traditional practice. These findings emphasize the importance of the nutritional status of the nomadic ewes at mating and in lactation on the productive performance of the animals.
- Significant differences were observed with regard to mortality in the absence of nutritional concentrates
- It was also clear from the study that there were significant differences in abortion with low concentrations
- It was found that there is a clear effect in the Mortality of lambs in the case of limited drinking water

## 5.3 Recommendations

- The regime flowed in this research proved to be guide efficient for improving the reproduction of Hamari sheep in north kordofan and hence can be recommended for all desert sheep in that region.
- The study recommends further study in reducing the stress of desert sheep in requesting drinking water
- More studies on production problems in desert sheep in Sudan

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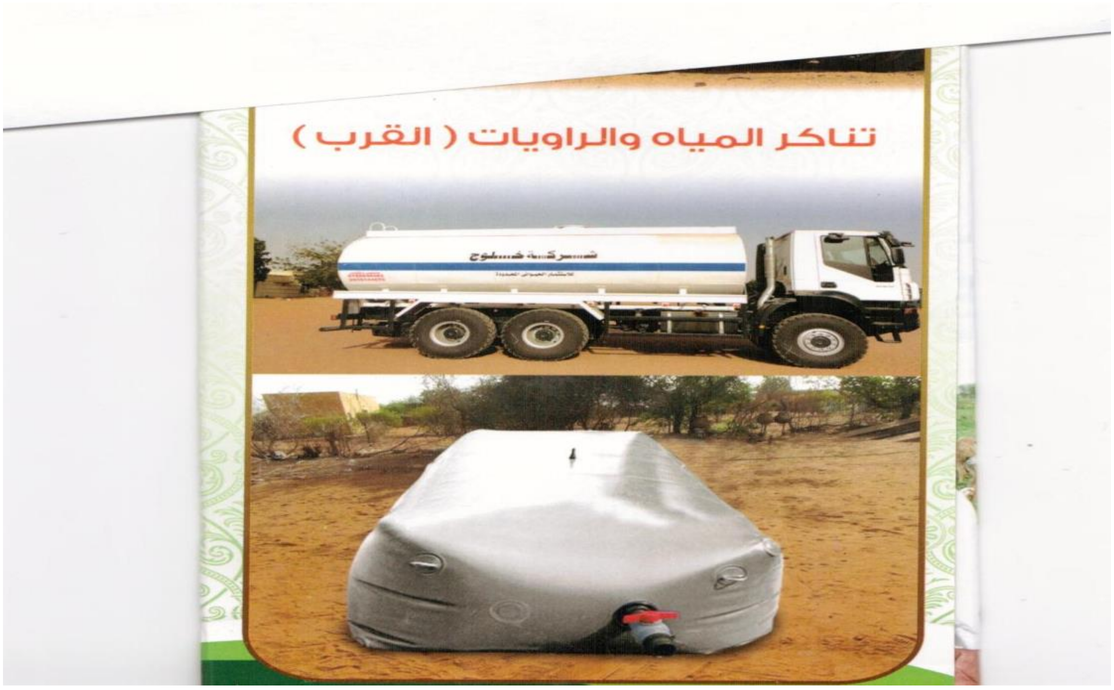
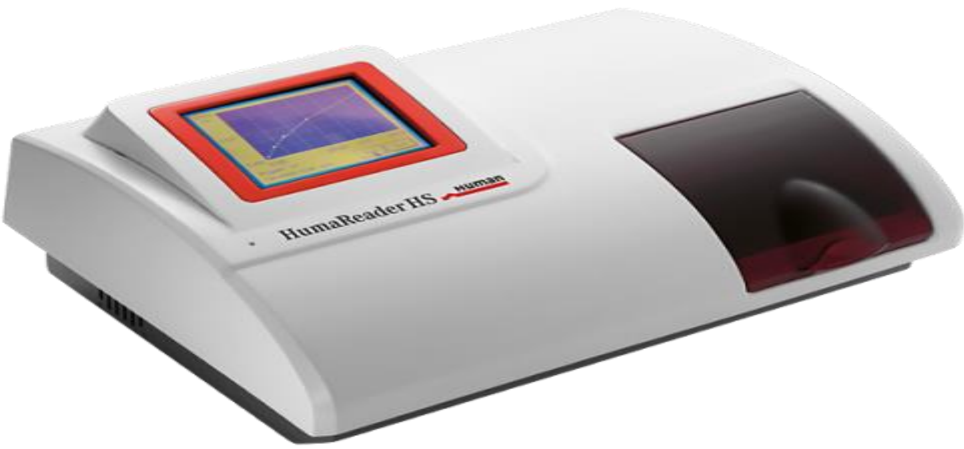
# APPENDIXES


**Tanker water drinking**




Plastic water tank


**Digital Spectrophotometer**




**Human Reader**

**Lamb weighing scale at birth**

**Lamb weighing scale at weaning**