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October 1990

Based on work undertaken by:
El-Huda National Sheep Research Station, Animal Production Research Administration, Ministry of Livestock Resources, Sudan; and the International Livestock Centre for Africa, Ethiopia

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Evaluation of Shugor, Dubasi and Watish subtypes of Sudan Desert sheep at the El-Huda National Sheep Research Station, Gezira Province, Sudan

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ABSTRACT

Data on Shugor, Dubasi and Watish subtypes of Sudan Desert sheep, collected at El-Huda National Sheep Research Station, Sudan, in the period 1975–84, are analysed. There were subtype differences in weights of ewes at first conception, at first parturition and at weaning of the first lamb(s) at 120 days after first parturition, the Watish being lighter than the other two subtypes. There were no differences among subtypes in age at first lambing (689 days). Litter size was bigger in Shugor (1.30) than in Watish (1.17) or Dubasi (1.18) subtypes, but lambing interval was shorter in Watish (403 days) than in Dubasi (425 days) or Shugor (449 days) subtypes. Annual reproductive rate (lambs born per ewe per year) was higher in Shugor (1.18) than in Watish (1.14) or Dubasi (1.01) subtypes. Shugor and Dubasi sheep were generally heavier from birth to one year than Watish. Some Watish crossbreds exhibited heterosis in weight and growth. From 365 to 1095 days weights did not differ among subtypes. Postpartum weights of mature Watish ewes were lower (37.0 kg) than those of either Dubasi (42.2 kg) or Shugor (42.3 kg) subtypes at all parturitions. Watish had lower death rates to weaning (29.7%) than either Shugor (40.5%) or Dubasi (42.6%) subtypes. Productivity indices were 16.8 kg of young weaned (at 120 days) per ewe per year, 419 g of young weaned per kg ewe per year and 1.14 kg of young weaned per $kg^{0.73}$ ewe per year and did not differ among subtypes. Effects of dam origin (station-born or foundation), type of birth or parturition (single or twin), sex, season and year of birth or parturition and parity were also examined.

KEY WORDS

/Sudan//Sudan Desert sheep//sheep//productivity//reproductivity//animal performance/ – /lambing/ /lambing interval//ewes//body weight//growth rate//mortality/

RESUME

Les travaux présentés ici reposent sur l'analyse de données rassemblées de 1975 à 1984 à la station nationale de recherche d'El-Huda (Soudan) sur des ovins Shugor, Dubasi et Watish, trois sous-espèces du mouton Sudan Desert. Le poids de la brebis à la première conception, au premier agnelage et au sevrage du (des) premier(s) agneau(x) (120 jours après la première parturition) dépendait de la sous-espèce, les Watish venant toujours en dernière position. En revanche, l'âge à la première parturition (689 jours) était indépendant de la sous-espèce considérée. La portée des Shugor (1,30) était supérieure à celles des Watish (1,17) et des Dubasi (1,18) mais l'intervalle entre agnelages des Watish (403 jours) était plus court que celui des Dubasi (425 jours) ou des Shugor (449 jours). Le taux de reproduction, c'est-à-dire le nombre de naissances par femelle et par an, était plus élevé pour les Shugor (1,18) que pour les Watish (1,14) et les Dubasi (1,01). Par ailleurs, de la naissance à l'âge de 1 an, le poids des Shugor et des Dubasi était généralement supérieur à celui des Watish. Chez certains métis Watish, on avait enregistré un accroissement pondéral et une accélération du rythme de croissance dus à l'hétérosis. De l'âge de 365 jours à l'âge de 1095 jours, le poids vif de l'animal ne différait pas d'une sous-espèce à l'autre. En outre, le poids postpartum des Watish adultes (37,0 kg) était plus faible que celui de leurs congénères Dubasi (42,2 kg) ou Shugor (42,3 kg). En revanche, jusqu'au sevrage, le taux de mortalité des Watish (29,7%) était plus faible que celui des Shugor (40,5%) ou des Dubasi (42,6%). Les indices de productivité étaient indépendants de la sous-espèce, s'établissant à 16,8 kg de poids vif d'agneau sevré (à 120 jours) par femelle et par an, à 419 g de poids vif d'agneau sevré par kg de poids vif de la femelle et par an et à 1,14 kg de poids vif d'agneau sevré par $kg^{0,73}$ de poids vif de la femelle. Enfin, ces travaux ont également permis d'étudier l'effet, sur les performances, de l'origine de la femelle (selon qu'elle est née à la station ou qu'elle fait partie des animaux fondateurs), du type de naissance (simple ou multiple), du sexe de l'agneau ainsi que de la saison, de l'année et du rang de la parturition.

MOTS CLES

/Soudan//Mouton Sudan Desert//Mouton//Productivité//Reproduction//Performances//Agnelage/ /Intervalle entre agnelages//Brebis//Poids vif//Taux de croissance//Mortalité/.

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1. INTRODUCTION

SUDAN'S SHEEP POPULATION

Sudan is the largest country in Africa, covering an area of more than 2.5 million square kilometres. It also has one of the largest livestock populations on the continent: cattle, sheep, goats and camels were estimated to number about 45 million in the mid-1970s (Watson et al, 1977), and about 55 million a decade later (FAO, 1985).

Over the same period, the number of sheep has grown at 2.8% per year, and so the proportion of sheep in Sudan's livestock population has remained constant at about 36%. Sheep therefore play an important social and economic role in the country, and are a valuable strategic resource for both local and export purposes.

Sudan sheep have been classified by, for example, Bennett et al (1948), McLeroy (1961a; 1961b) and Wilson and Clarke (1975). Based on physical features and ecological distribution, four main local groups have been identified: Sudan Desert, Sudan Nilotic, Sudan Arid Upland and Sudan Equatorial Upland. Fused ecotype groups, resulting from non-systematic crossbreeding at the boundaries of the ecozones of the pure types, have also been recognised.

More than 65% of the sheep in Sudan are of the Sudan Desert breed. Compared with the other types, this breed has remarkable productive and marketing features, and so is given priority in research and development programmes.

Current attitudes to modern agriculture and livestock production in the irrigated areas have stimulated the idea of integrated cereal crop and livestock farming as a means of maximising production. As a result of improved feed resources (natural grazing, agricultural byproducts and grown fodder) due to the presence of abundant water, there is good potential for sheep production in the irrigated areas. This is confirmed by the large number of sheep reared in these areas (about 28% of the national population).

Performance characterisation and evaluation of sheep is a prerequisite to further progress in improving their productivity. The National Sheep Research Station at El-Huda has been working on evaluating the performance of subtypes of the Sudan Desert sheep—Shugor, Dubasi and Watish. This report presents the initial results of this work.

TRIBAL SUBTYPES OF SUDAN DESERT SHEEP (Figure 1)

Shugor

Shugor are moderately large sheep ranging in colour from light to dark brown. They have occasional patches of wool under the hair. They are found mainly along and to the west of the White Nile, and are most common in the western part of the Gezira, where they graze on cotton residues and other agricultural byproducts. Their migratory movements are longer than those of the Dubasi and it is not uncommon to find Shugor flocks deep in the Gezira area.

Dubasi

Dubasi are the prototype sheep of the Gezira area, especially the northern part, and are concentrated in the villages of the Dubaseen tribes (hence 'Dubasi'). These sheep are similar in size to the Shugor but their thin coat is usually particoloured white and black. The distribution of the black patches on the skin varies among regions and breeders. Some breeders select sheep with saddled backs with black plates or patches. It is rare to find Dubasi farther to the west along the White Nile.

Watish

The Watish subtype is somewhat smaller and stockier than either the Shugor or the Dubasi. Three colour groups—fawn, red, and white with light spottings—have been recognise (McLeroy, 1961b). Watish are hardy sheep and live under relatively high rainfall conditions between latitudes 10° and 11°N and mainly along the Blue Nile, south of Wad Medani into the Fung area. They are mainly owned by nomadic and semi-nomadic tribes, including the Kenana, the Rufaa El Hoy and the Beni Meharib.

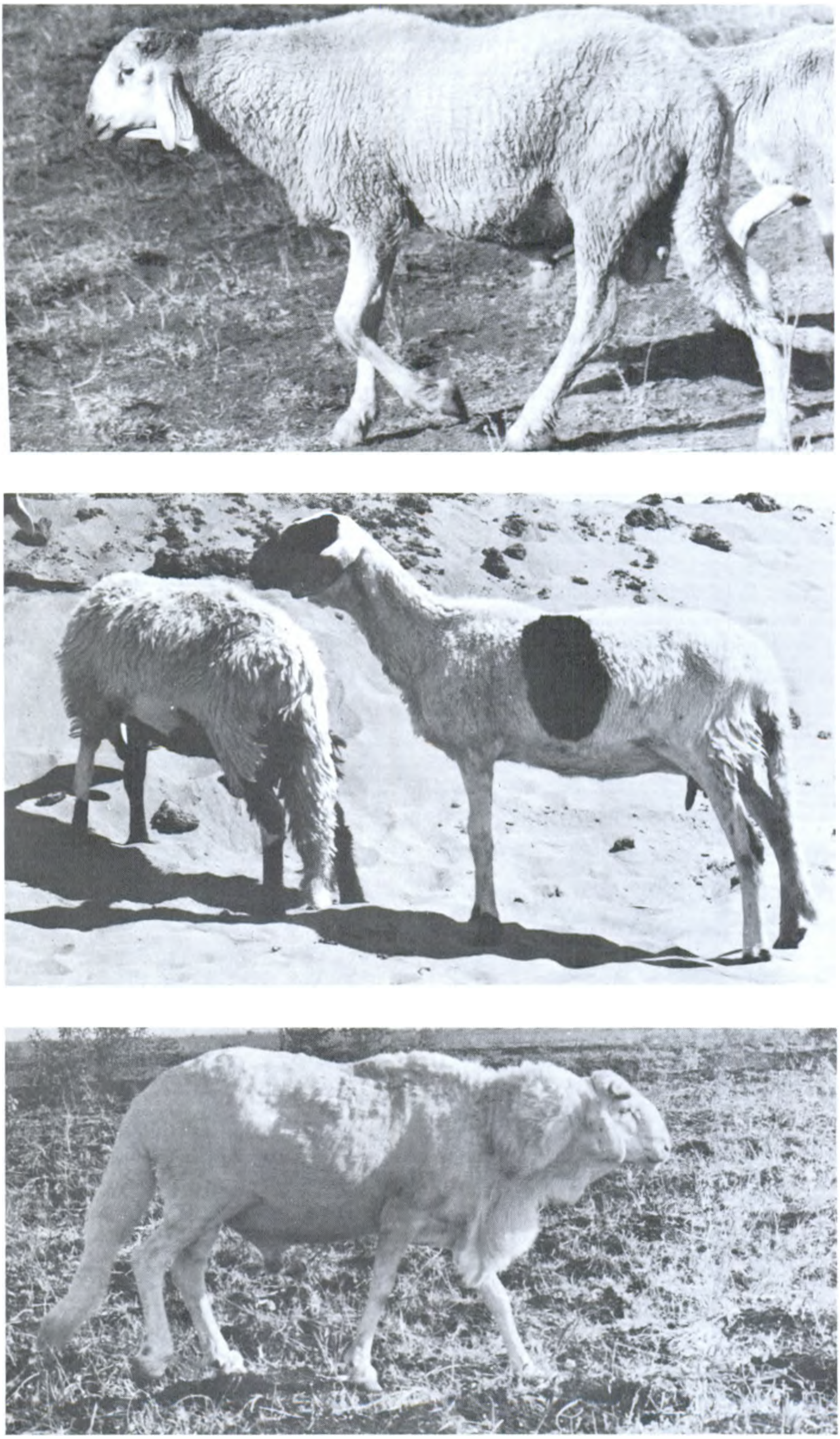


Figure 1.
Shugor (top), Dubasi (middle) and Watish (bottom) subtypes of Sudan Desert sheep

2. MATERIALS AND METHODS

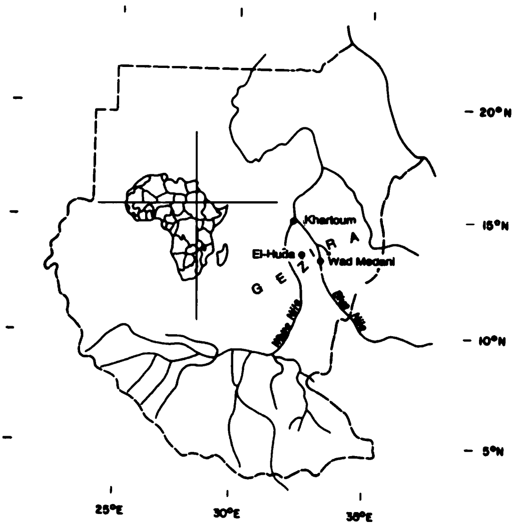
EL-HUDA NATIONAL SHEEP RESEARCH STATION

El-Huda lies at approximately 14°15'N latitude and 32°50'E longitude, at an altitude of about 250 m, about 90 km north-west of Wad Medani and about 150 km south of Khartoum (Figure 2). The station covers an area of about 150 ha of a levelled clay plain, of which 100 ha are available for forage cultivation.

The present sheep research station was previously (1960–71) a division of the community development centre at El-Huda. The objective of that division was to help to improve the nutritional standards of the tenant farmers in the area through services that included the provision of dairy and poultry products.

Recognising the role that the sheep industry can play in the livestock and national economies, the Sudanese Government decided that this division should be concerned only with research work on sheep. Access to several different genotypes of sheep was relatively easy as El-Huda lies central to the main marketing and breeding areas in the region where two of the main subtypes (Shugor and Dubasi) of Sudan Desert sheep are reared.

Figure 2. *The location of El-Huda National Sheep Research Station, Sudan*



The work of the El-Huda National Sheep Research Station includes:

- basic research to characterise the performance of Sudan Desert sheep subtypes
- development research to identify more specialised genotypes for specific production objectives
- development of selected germplasm, for propagation under station or similar conditions
- assessing possibilities for developing the existing sheep production and marketing systems
- studying problems associated with sheep productivity under irrigated conditions with special reference to feeding levels and disease control.

Climate

No meteorological data are available for El-Huda station or town. Meteorological information can be inferred from data collected at Wad Medani Meteorological Station for the period 1951–80 (Table 1).

The year can be divided into three seasons:

- winter (November to February)
- hot summer (March to June)
- wet summer (July to October)

Prevailing winds during November to April are dry and northerly, while southerly winds blow during May to October and are associated with the rainy season.

Feed resources

The feed resources at the station comprise grown forages including pillesesara (*Phaseolus trilobus*), lucerne (*Medicago sativa*), dolichos bean (*Dolichos purpureus*) and several varieties of Sudan grass

Table 1. *Climatological normals for 1951–80 for Wad Medani town (90 km south-east of El-Huda), Sudan*

Month	Temperature (°C) Maximum Mean	Maximum Highest	Minimum Mean	Minimum Lowest	Relative humidity (%)	Rainfall (mm)	Wind direction
January	33.1	40.6	14.0	5.7	32	trace	N
February	35.1	43.3	15.7	3.3	32	0.4	N
March	38.4	44.8	18.7	7.3	19	5.2	N
April	40.9	46.1	21.5	12.0	18	9.4	N
May	41.5	46.2	24.3	15.6	26	47.8	SW
June	39.6	45.2	24.6	16.7	41	48.3	SSW
July	35.7	43.8	22.8	18.5	60	117.7	S
August	33.4	46.0	22.1	18.0	70	79.3	S
September	35.3	41.4	21.9	17.0	63	71.9	S
October	37.8	41.5	21.6	11.1	47	41.7	S
November	36.3	41.5	18.2	8.7	35	6.7	NNW
December	33.4	40.0	14.8	4.1	35	trace	N
Annual	36.7	–	18.2	–	40	428.4	–

(*Sorghum sudanense*), particularly the local cultivar Abu sabaeen. Sorghum (*Sorghum vulgare*) grain and stover, groundnut hay, agricultural byproducts (cottonseed cake, wheat bran, sugar-cane molasses) and natural grasses growing on fallow land and canal banks are also available.

Feed resources are, however, limited. The station does not have its own irrigation capabilities but relies wholly on those of the Gezira Board. This arrangement is inconvenient for summer forage production as priority in water supply is given to cotton.

The station flocks

The research flocks comprise Shugor, Dubasi and Watish tribal subtypes of Sudan Desert sheep. The former two types were collected about 1971 from local private breeding flocks and livestock markets. The Watish was introduced in April 1977 from El-Neisheiba livestock station at Wad Medani. Additional sheep have been bought over the years to increase the flock size for research purposes.

Because the history of purchased, or 'foundation', animals was not known, these animals were originally grouped on the basis of dentition; they were thus initially allocated to one of seven age groups—four for animals having no permanent incisors and three for those having permanent incisors. Animals born on the station could be grouped according to their absolute ages.

FLOCK MANAGEMENT

General management

The three subtypes were usually kept separate from each other to avoid any unplanned cross-breeding. Breeding males and females were separated except at breeding time. Usually there were four separate functional groups: suckling ewes and their young; weaned lambs; flocks with rams; and pregnant ewes. Only suckling lambs and breeding ewes were housed and fed in pens. Other groups were grazed on forage or on the natural range, in one or two flocks within each functional group.

Nutrition

Flock nutrition was based on stored forage and agricultural byproducts, although harvested fields were also grazed before being irrigated for regrowth or ploughed for the next sowing season. Concentrate supplementation was provided only to suckling ewes, breeding ewes and ewes close to lambing. Breeding ewes were allowed a rising level of concentrate supplement for two weeks before the introduction of rams. A mineral salt lick and water were always available. The animals were allowed about 1 kg each of a concentrate mixture of wheat bran (40%), cottonseed cake (30%) and crushed sorghum grain (30%). Stored forage and straw were provided to animals that were confined for breeding and suckling. During rainy days and when there was a shortage of forage and straw, all animals received an extra 0.45 kg of wheat bran. During the drought years of 1981–84, when there was a severe shortage of cereal grain for human consumption, sheep were fed sugar-cane molasses and urea combined with wheat bran.

Breeding and mating plans

Sudanese sheep are not seasonal breeders and may have lambs throughout the year. Many local breeders, however, have attempted to establish two main breeding seasons, one during the wheat and cotton harvest in the winter and the other during the rainy season. Nutritional conditions at these periods provide natural flushing. There are therefore two lambing seasons, in summer (July–August), when the majority of flocks lamb, and in winter (December–January). Because of the soaring cost of living and of keeping sheep, some breeders are now turning to more intensified rearing so that lambs are available at all periods of the year. To achieve this, they spend more money on supplementary feed and allow rams to run freely with recently lambed ewes.

The general policy at the station was to maintain purebred flocks, except for very limited inter-flock breeding in 1978 and 1979. The usual practice at the station was to carry out summer and autumn matings to produce autumn and winter lamb crops. Most parturitions occurred from July through December (Figure 3).

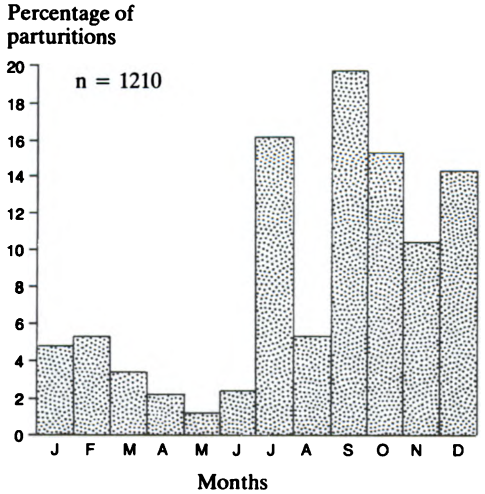
In each breeding season ewes were grouped by age and randomly allocated to breeding rams, so that each ram was mated to about 20–25 ewes of similar age. These breeding groups were maintained for six weeks following which the ewes were reassembled into one flock and the rams joined the breeding rams' flock.

Weaned ewe lambs joined the breeding flocks at about seven to eight months of age. Continuous culling of barren, old and sick ewes, old and heavy rams and surplus young males was a normal practice.

Lamb rearing

Lambs were given special attention at birth and during the first two weeks of life. Newly lambed

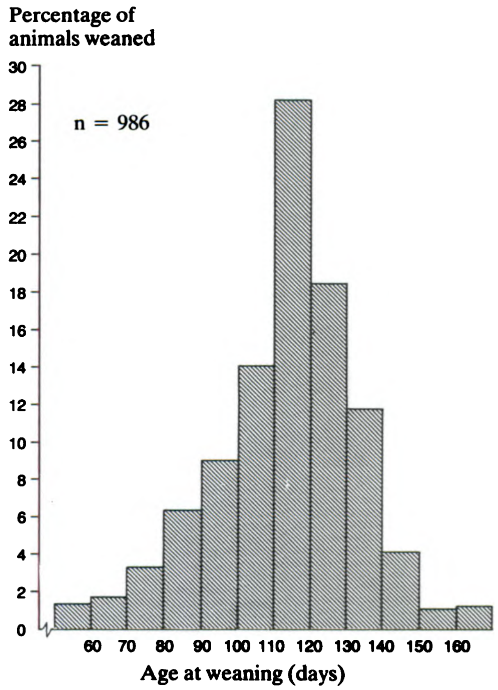
Figure 3. *Frequency distribution of month of parturition of Sudan Desert sheep at El-Huda, Sudan*



ewes were kept in confinement and fed with their lambs for at least the first week following lambing. During this period, great care was taken to ensure that the lambs were well fed. After the first week, lambed ewes were taken to graze for a short period each day and then returned to the pens. While the ewes were away the young lambs were given small quantities of hay.

Two weaning practices were followed during the period of study: group weaning at an age of about 16 weeks; or individual weaning at exactly 16 weeks of age. Age at weaning was quite well controlled, the most common weaning age being between 110 and 120 days (Figure 4). Weaned lambs were kept together until they were about six months old: thereafter the sexes were segregated and reared separately.

Figure 4. *Frequency distribution of age at weaning of Sudan Desert lambs at El-Huda, Sudan*



Disease control

Routine disease control measures comprised vaccination against endemic diseases, drenching against internal parasites and ectoparasite and tick control.

Occasional tests for brucellosis were carried out. Newly purchased sheep were medically treated and quarantined before joining the flock.

DATA COLLECTION AND INITIAL PREPARATION

Physical and performance data were regularly entered into performance registers.

Physical measurements on the live animal were made with a tape and a measuring stick. The measurements were:

- body length (from the tip of the scapular to the pin bone)
- heart girth (the circumference of the chest)
- chest depth (between the breast and the withers)
- height at withers (from the highest point on the dorsum of the animal to the ground surface at the level of the front feet)
- ear length (from the base of the ear at the skull along the dorsal surface to the tip of the ear).

Performance data from the registers were transferred to computer coding sheets in preparation for statistical analysis. Three coding sheets were used:

- a "Basic Record" containing information on an animal's identity, subtype, source and pedigree, sex, colour, parity, birth and weaning dates, and reasons for entry and exit and dates at which these occurred
- a "Weight Record" showing an animal's identity, date of birth and weight at birth and at each subsequent (dated) weighing
- a "Birth Record" showing a dam's identity, and the birth dates, numbers, identities, sexes and parities of her offspring.

STATISTICAL ANALYSIS

Data were initially tested for completeness and conformity using commercial software (Dixon et al, 1985; SPSS Inc, 1983). The major analyses were carried out using least-squares fixed- and mixed-model procedures (Harvey, 1977). Unequal and disproportionate subclass numbers gave unbalanced factorial designs for which conventional analysis of variance techniques would not have been applicable.

The models used included: the random effects of sire within subtype; the random effects of the dam (where she appeared in the analytical matrix more than once); and the fixed effects of origin (foundation or born on station), parturition number, year of birth or parturition, season of birth or parturition, type of birth or parturition, and sex of young. Parturition number was the true parity for station-born ewes, but for foundation ewes whose previous reproductive history was not known, "parity" was taken as the number of parturitions on the station: in both cases, fourth and subsequent parturitions were treated as a single effect (>3).

The residual mean square was used as the error term to test the significance of all differences evaluated among groups except in analyses where sires were used, when the error term for breed was sire-within-breed. Linear contrasts of least-squares means were computed to determine the significance of differences within groups for all characters where the difference was significant in the analysis of variance.

None of the foundation animals had sire or dam records, so sire could not be used in analyses involving these animals. Heritabilities were calculated by the paternal half-sibling method. Repeatabilities were calculated using the variance components among and within ewes.

Productivity indices were constructed for individual ewes from data on litter weight at 120 or 150 days, parturition interval and young survival (the death of a litter resulting in a zero index for a particular female). Three indices were calculated:

Index I = Weight (kg) of young produced per female per year

$$= \frac{\text{Litter weight (kg) at 120 or 150 days} \times 365}{\text{Subsequent parturition interval}}$$

Index II = Weight (g) of young produced per kg liveweight of female per year

$$= \frac{\text{Index I} \times 1000}{\text{Female postpartum weight}}$$

Index III = Weight (kg) of young produced per kg metabolic weight of female per year

$$= \frac{\text{Index I}}{\text{Female postpartum weight}^{0.73}}$$

3. RESULTS

BODY MEASUREMENTS

Determination of the degree of relationship between physical measurements in sheep may help to provide means for predicting traits which are not normally easily measured under field conditions. In the present study, determinations were made by regressing the measurements of ear length, heart girth, body length, chest depth and height at withers on the age of the animal. The regression coefficients of these measurements are shown in Table 2. As might be expected, the relationship between ear length and age of the animal is poor. There were highly significant (P<0.001) regression coefficients between the remaining live measurements and age in all three subtypes.

These relationships were further classified using the significance of the regression coefficients, as indicated by t- values (the regression coefficient (b) divided by the standard error of b; see Table 2). For Shugor and Dubasi chest depth showed the best relationship with age, followed by heart girth, body length and withers height. For Watish the ranking was heart girth, chest depth, body length and withers height. Heart girth is the most variable live measurement since it reflects condition (and, in some cases, physiological status) in the animal. Chest depth, body length and height at withers are skeletal measurements and are less variable than heart girth.

Table 2. *Regression coefficients for estimates (cm) of ear length, heart girth, body length, chest depth and withers height for three subtypes of Sudan Desert sheep at El-Huda, Sudan*

Physical measurement and coefficient[a]	Value of coefficient for subtypes		
	Shugor	Dubasi	Watish
Ear length			
a	16.6	16.5	15.3
b	0.27	−0.95	2.50
SE(b)	0.95	1.1	1.5
Heart girth			
a	74.0	74.8	72.6
b	56	47	73
SE(b)	6.2	7.2	8.1
Body length			
a	52.4	52.3	51.4
b	30	37	34
SE(b)	3.8	5.8	5.3
Chest depth			
a	28.0	28.0	27.2
b	28	24	24
SE(b)	2.7	3.1	3.5
Height at withers			
a	66.2	67.2	63.1
b	35	32	33
SE(b)	4.6	5.6	6.6

[a] a and b are the parameters of the equation $y = a + b(\text{age} \times 10^{-4})$, where y is the physical measurement, and age is measured in days. SE(b) is the standard error of the regression coefficient

All regressions, except for ear length, were highly significant (P<0.001)

REPRODUCTIVE PERFORMANCE

The reproductive performance of sheep is a major factor in productivity: it depends on various factors including age at first lambing, litter size, lambing interval and the lifetime productivity of the ewe, this last being related to her longevity. An early age at first lambing is conducive to increased productivity and improvement of breeding value. Intensification of management and early introduction of maiden ewes for breeding will modify age at first lambing. Management and ewe liveweight at weaning play an important role in determining when the first postpartum heat occurs and hence the length of the lambing interval.

Early reproductive traits

Weight at first conception

The occurrence of sexual maturity in sheep is related to a target weight which can be intrinsic to the animal or influenced by nutritional level and management (Allen and Lamming, 1961; Younis et al, 1978; Suleiman, 1982). Such effects also influence the ovulation rate and the intensity of heat in maiden ewes at puberty.

In the present study, the mean weight at first conception of the Shugor, Dubasi and Watish ewe lambs was 35.1 kg (Table 3). The subtype of the ewe and the season and year in which she first conceived had significant influences on this weight: in addition there were significant differences in weight of ewes which subsequently gave birth to singles or twins. Differences between years are, however, confounded with seasonal variations and the specific managements and rearing procedures followed in different years.

In an earlier investigation into characteristics of ewes lambing for the first time at El-Huda (Sulieman et al, 1985) lambs conceived for the first time when they weighed about 20 kg.

Table 3. *Least-squares mean weights (kg) associated with first lambing of Sudan Desert ewes at El-Huda, Sudan*

Factor	Weight (kg) at first conception		Weight (kg) at first parturition		Weight (kg) at 120 days after first parturition	
	n	Mean	n	Mean	n	Mean
Overall least-squares mean	151	35.1	135	37.9	124	37.0
SE		0.95		0.83		0.76
Subtype						
Shugor	38	35.8a	38	39.3a	35	38.5a
Dubasi	64	36.8a	54	40.4a	51	37.7a
Watish	49	32.7b	43	34.0b	38	34.7b
Significance of F-test		**		**		**
Parturition type						
Single	132	33.0a	121	37.4	109	36.2
Twin	19	37.2b	14	38.3	15	37.8
Significance of F-test		*		ns		ns
Season						
Winter	17	35.9a	56	37.1	46	35.3
Hot summer	87	37.2b	12	39.7	13	37.2
Wet summer	47	32.2a	67	36.8	65	38.3
Significance of F-test		***		ns		ns
Year						
1978	12	32.1a	10	39.7a	17	36.4a
1979	34	39.0b	26	40.1a	23	37.5a
1980	22	35.4ac	14	39.5a	6	41.6b
1981	–	–	9	34.3b	4	30.9c
1982	61	36.8bc	39	35.6bc	36	36.4a
1983	22	32.3a	22	38.5ac	25	39.1ab
1984	–	–	15	37.5ab	13	36.8ab
Significance of F-test		**		**		**
Residual SD		6.25		5.20		4.36

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

*** P<0.001 ** P<0.01 * P<0.05 ns = not significant

Weight at first parturition

The weight of a gimmer at first lambing has an important effect on her future reproductive performance. This is particularly so because while the ewe lamb is still growing, pregnancy could cause a growth check unless adequate nutrition is provided. A growth check in the pregnant gimmer may delay return to oestrus after parturition and hence extend the lambing interval. Underweight pregnant gimmers may abort the foetus.

In the present study, the mean weight at first parturition was 37.9 kg (Table 3). Only subtype and year of parturition exerted significant influences on this weight.

In an earlier investigation (Sulieman et al, 1985) liveweights of Shugor, Dubasi and Watish ewes at first parturition were 31.8, 31.1 and 25.4 kg respectively.

Weight at 120 days after first parturition

The mean weight of a gimmer 120 days after her first parturition, that is, when her litter was weaned, was 37.0 kg (Table 3). Only subtype and year of parturition had significant effects on this weight.

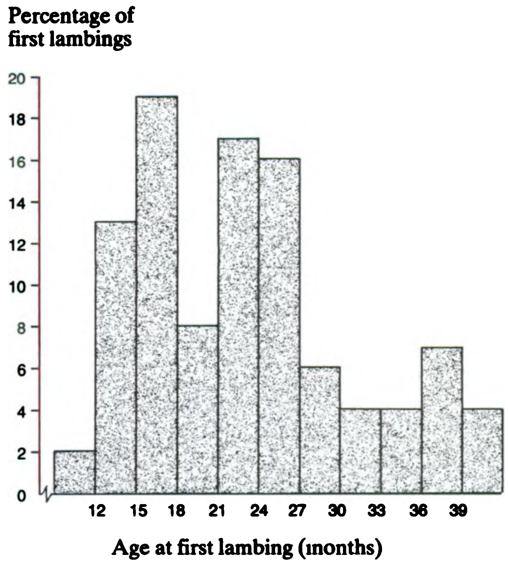
Age at first lambing

The unadjusted mean age at first parturition in the present study was 758 days (SD = 238.1; n = 237). Figure 5 shows the distribution of ages at first lambing. The least-squares analysis showed that only the year in which a gimmer was born had an effect on the age at which she bore her first lamb.

The least-squares mean age at first lambing was 688.8 days (SE = 42.51). The linear contrasts of year of birth effects (1976–80) showed that gimmers born in 1977 were youngest of all at first lambing (583.2 days) while gimmers born in 1979 were oldest (810.9 days). Animals born in 1978 and 1980 were also younger at first lambing than the overall average while those born in 1976 were older. These between-year variations resulted mainly from variations in management of weaned ewe lambs.

In a previous study (Suleiman, 1982), mean age at first lambing for Shugor, Dubasi and Watish ewe lambs was calculated as 605.3 days (SE = 12.0). None of season of year, nutritional treatment or subtype exerted a significant influence on age at first lambing. In a more recent investigation, Sulieman et al (1985) found a mean age at first lambing of 421.0 days for a similar group of gimmers which were joined to a ram immediately after weaning.

Figure 5. *Frequency distribution of ages at first lambing of Sudan Desert ewes at El-Huda, Sudan*



Litter sizes

The unadjusted mean litter size was 1.18 (SD = 0.40; n = 1090). The analysis of variance showed that subtype, season of parturition, year of parturition and the parity of station-born ewes significantly influenced this trait (Table 4).

The least-squares mean litter size was 1.22 (Table 4). A polynomial analysis of litter size in relation to parity in station-born ewes showed the increase to be linear from first to fourth parity.

Introducing ewe weight at conception as a covariate on a reduced sample (n = 363) indicated that heavier weights at conception led to increased litter sizes. For every additional kilogramme of liveweight at conception the increase in litter size was 0.01 lambs (P<0.001) but it is probable that this increase is related as much to ewe age as to weight *per se* and also to the larger litter sizes of the heavier Shugor ewes.

Results of earlier analyses of litter size in Sudan Desert sheep, usually on smaller samples and over shorter time periods, are inconsistent. Differences among tribal subtypes have, however, been similar to those demonstrated in the current study. In the only previous three-breed analysis (Sulieman and Eissawi, 1984a), Shugor had larger litters (1.25) than either Dubasi (1.16) or Watish (1.16) although the differences between groups were not significant. A recent two-breed analysis for ewes born in 1979–81 (El-Karim and Owen, 1987) showed that Shugor had significantly larger litters (1.25) than Watish (1.13). An earlier two-breed analysis of Shugor and Dubasi ewes (Sulieman et al, 1978) indicated a litter size of these two types combined of about

Table 4. *Least-squares mean litter sizes (numbers of lambs), lambing intervals (days) and annual reproductive rates (lambs/ewe/year) of Sudan Desert ewes at El-Huda, Sudan*

Factor	Litter size (number of lambs)		Lambing interval (days)		Annual reproductive rate (lambs/ewe/year)	
	n	Mean	n	Mean	n	Mean
Overall least-squares mean	1090	1.22	452	426	452	1.11
SE		0.022		20.0		0.071
Subtype						
Shugor	386	1.30a	161	449a	161	1.18a
Dubasi	394	1.18b	201	425ab	201	1.01b
Watish	310	1.17b	90	403b	90	1.14ab
Significance of F-test		***		+		*
Dam origin						
Station-born	347	1.24	94	427	94	1.06
Foundation	743	1.20	358	425	358	1.16
Significance of F-test		ns		ns		ns
Parturition type						
Single	–	–	362	428	–	–
Twin	–	–	90	423	–	–
Significance of F-test		ns		ns		ns
Season of parturition						
Winter	348	1.19ab	62	447a	62	1.08
Hot summer	93	1.28b	54	445a	54	1.09
Wet summer	649	1.19a	336	385b	336	1.15
Significance of F-test		+		**		ns
Year of parturition						
1975	24	1.18ab	24	369a	24	1.11
1976	102	1.20ab	93	404a	93	1.17
1977	103	1.23ab	84	429ac	84	1.04
1978	149	1.31a	132	449bc	132	1.17
1979	157	1.24ac	119	478b	119	1.04
1980	190	1.23ac	–	–	–	–
1981	106	1.17bc	–	–	–	–
1982	139	1.26ac	–	–	–	–
1983	120	1.13b	–	–	–	–
Significance of F-test		*		*		ns
Parity (Station-born ewes)						
1	175	1.13a	54	435	54	1.02
2	92	1.21ab	30	421	30	1.17
3	50	1.24ab	7	408	7	1.29
>3	30	1.36b	3	443	3	0.75
Significance of F-test		*		ns		ns
Parity on station (Foundation ewes)						
1	246	1.17	140	458a	140	1.11
2	193	1.20	111	403bc	111	1.19
3	151	1.21	69	387b	69	1.22
>3	153	1.22	38	451ac	38	1.12
Significance of F-test		ns		**		ns
Residual SD		0.389		146		0.542

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

*** P<0.001 ** P<0.01 * P<0.05 + P<0.1 ns = not significant

1.30 lambs. The only detailed analysis of reproductive performance of Sudan Desert sheep from a traditional system (in Darfur, western Sudan) showed the potential of Sudan Desert sheep for greater output in the litter size of 1.45 lambs (Wilson, 1976).

Lambing intervals

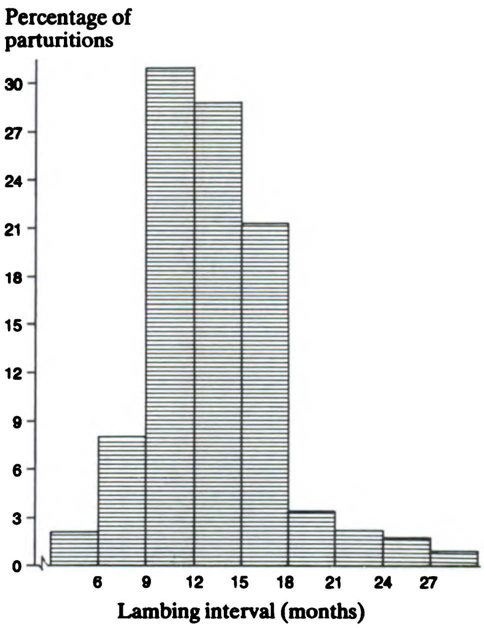
The unadjusted mean interval between successive lambings was 421 days (SD = 150.1; n = 452). The frequency distribution of lambing intervals is shown in Figure 6. The analysis of variance showed significant differences in the interval resulting from the season and year of the parturition and the parity on the station of foundation ewes, and barely significant (P = 0.08) differences among breeds (Table 4).

The least-squares mean lambing interval was 426 days (Table 4).

Ewe postpartum liveweight did not have a significant effect on lambing interval, although there was a trend that indicated that lambing interval decreased by about 4.4 days for every 1 kg increase in postpartum liveweight.

The only previous analysis of lambing intervals of all three types at El-Huda station (Sulieman and Eissawi, 1984a) found much shorter lambing intervals of 293 (SD = 48.0), 311 (SD = 58.5) and 367 (SD = 100.1) days for Shugor, Dubasi and Watish ewes. The relatively long intervals between births at El-Huda station should not be taken as an indication of inherent performance of Sudan Desert sheep or of any photoperiod-induced seasonality. In southern Darfur an unadjusted interval of 272 days (SD = 58.6) has been calculated (Wilson, 1976), the longer periods between births at El-Huda resulting from management restrictions on breeding.

Figure 6. *Frequency distribution of lambing intervals of Sudan Desert sheep at El-Huda, Sudan*



Annual reproductive rates

The unadjusted annual reproductive rate, calculated as litter size×365/subsequent parturition interval, was 1.15 lambs per ewe per year (SD = 0.547; n = 452). The analysis of variance showed that annual reproductive rate was significantly affected only by subtype (Table 4).

The least-squares mean annual reproductive rate was 1.11 lambs per ewe per year (Table 4). Shugor and Watish types had a similar output of young per year. The Watish did not differ significantly from the Dubasi in annual lamb output but the Shugor was clearly superior to the Dubasi, producing, on average, 0.17 more lambs per year. Interactions between litter size and the intervals between births led to their being no differences in annual output of lambs per ewe in relation to the season or the year of production. A tendency to shorter intervals at third true parity of station-born ewes and third lambing on station of foundation ewes followed by an increased interval was responsible for a slight quadratic trend of increasing annual reproductive rate to that point in the reproductive career of ewes followed by a reduced output: this tendency was more marked in station-born than in foundation ewes.

Summary

Watish ewes had the lowest weights at first conception, at first parturition and at weaning after first parturition, although they did not lose weight during the lactation period as the two other subtypes did.

Season affected weight at first conception—gimmers conceiving during the hot summer were heavier than those conceiving during the winter or wet summer—but not weight at first parturition or at weaning after first parturition.

Shugor produced larger litters than Dubasi or Watish. Ewes lambing in the hot summer (ie, conceiving in the late wet summer/early winter (post-rains period)) produced larger litters than ewes lambing in other seasons.

Ewes lambing in the wet summer had shorter intervals to the next parturition than ewes lambing in other seasons.

Watish and Shugor had higher annual reproductive rates than Dubasi.

WEIGHT AND GROWTH

Weight and growth are important aspects of overall productivity, especially where meat is the main product. Heavier birth weights provide lambs with a good start in life and rapid growth in the pre- and postweaning periods ensures resistance to disease as well as early maturity. Faster growing lambs, of heavier weights at a given age, reach puberty earlier than slower growing ones. Early puberty and successful early breeding reduce the generation interval, enabling faster genetic gains to be made, this in turn enabling a faster rate of improvement of total flock productivity.

Birth weight

The unadjusted mean weight at birth for all three subtypes was 3.64 kg (SD = 0.77; n = 728). Distributions of birth weights are shown in Figure 7. The analysis of variance showed that birth weight differed significantly among subtypes, between birth types (single or twin), among seasons and years of birth and in relation to parity (Table 5).

The least-squares mean birth weight for the three subtypes and four types of crossbreds among them was 3.29 (Table 5).

Winter-born lambs were heavier than lambs born during the hot summer and lambs born in the wet summer were heavier than those born in either of the other two seasons. These seasonal weight differences of lambs at birth are related in part to the dam's actual weight at parturition, but more specifically to the changing condition—rising or falling weight—of the ewe in the immediate prepartum period.

For station-born ewes, birth weights increased linearly with parity. For foundation ewes, a polynomial regression showed this relationship to be non-linear.

On a reduced sample of 343 lambs of the three purebred genotypes the heritability of birth weight was estimated at 0.25 (SE = 0.156). Repeatability of birth weight for 334 ewes with an average of 1.77 lambings each was 0.31 (SE = 0.058). Lamb birth weight increased ($P<0.001$) by 32.5 g for every kilogramme increase in ewe postpartum weight but it is probable that this was directly related to the observed effects of subtype on birth weight and on dam postpartum weight.

Birth weights found in this study are at about the middle of the range of 2.5 kg to 4.2 kg for birth weights of Sudan Desert sheep from El-Huda and elsewhere found in earlier studies (El-Amin and Rizgalla, 1976; El-Amin and Sulieman, 1979; Sulieman et al, 1985).

Figure 7. *Distribution of weights at birth of Shugor, Dubasi and Watish subtypes of Sudan Desert sheep at El-Huda, Sudan*

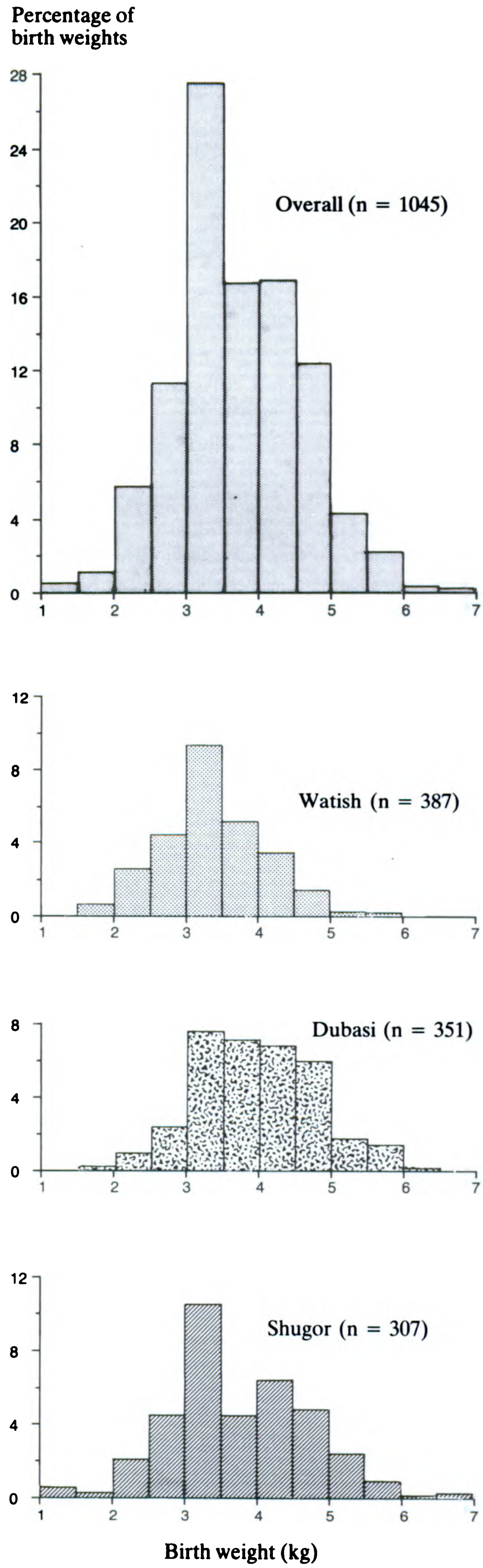


Table 5. *Least-squares mean weights (kg) and average daily weight gains (g) from birth to 120 days of Sudan Desert lambs at El-Huda, Sudan*

Factor	n	Weight (kg) at age (days)				Average daily gain (g) for period (days)		
		0	30	90	120	0–30	30–120	0–120
Overall least-squares mean	728	3.29	7.4	14.0	16.7	136	103	111
SE		0.059	0.17	0.28	0.33	5.5	2.9	2.7
Subtype								
Shugor	189	3.62a	7.7abc	14.1ab	16.9a	136	101a	110a
Shugor × Watish	16	3.10b	7.1abcd	14.1abc	17.0ab	132	110ac	115a
Dubasi × Shugor	36	3.28bc	7.7be	14.7ab	17.1a	147	104ac	115a
Dubasi	207	3.47c	7.8ab	13.9a	16.3a	145	94bc	107a
Watish × Shugor	28	3.13b	7.3abd	14.4ab	17.0a	139	107a	115a
Watish × Dubasi	57	3.24b	7.1cde	14.1b	17.2a	128	112a	116a
Watish	195	3.17b	6.9d	12.7c	15.2b	125	91b	99b
Significance of F-test		***	***	***	***	ns	**	**
Dam origin								
Station-born	304	3.25	7.3	13.8	16.4	133	101	109
Foundation	424	3.32	7.5	14.2	16.9	139	104	113
Significance of F-test		ns	ns	ns	ns	ns	ns	ns
Sex								
Female	412	3.24	7.1a	13.4a	15.7a	128a	96a	104a
Male	316	3.33	7.7b	14.6b	17.6b	144b	109b	118b
Significance of F-test		ns	***	***	***	***	***	***
Birth type								
Single	520	3.64a	8.4a	15.8a	18.9a	158a	116a	126a
Twin	208	2.94b	6.4b	12.1b	14.5b	114b	89b	96b
Significance of F-test		***	***	***	***	***	***	***
Season of birth								
Winter	194	3.33a	7.5a	13.6a	15.7a	138a	91a	103a
Hot summer	34	3.02b	6.3b	12.6b	16.0b	110b	108b	108a
Wet summer	500	3.51c	8.3c	15.8c	18.2c	159c	109b	122b
Significance of F-test		***	***	***	***	***	***	***
Year of birth								
1976	28	3.79a	7.7ab	16.0a	20.7a	130ac	144a	140a
1977	37	3.28bce	7.3a	14.2bd	16.7bc	134ac	104bc	111bc
1978	114	3.52ab	7.6a	14.6b	16.9bc	136ac	103b	111b
1979	139	3.50b	8.2b	14.1b	16.5c	155a	93c	108b
1980	132	2.97d	7.5a	13.0c	14.4d	151ac	77d	95d
1981	66	2.88d	7.4a	12.3c	14.4d	152ac	76d	95de
1982	120	3.30e	6.2c	13.1cd	15.9c	97b	107b	104be
1983	92	3.07cd	7.1a	14.7ab	17.8b	134c	119e	122c
Significance of F-test		***	***	***	***	***	***	***
Parity (Station-born ewes)								
1	119	3.09a	6.6a	12.8a	15.6a	117a	99	104
2	98	3.21ab	7.2b	13.6ab	16.2ab	134b	99	108
3	55	3.41b	7.8c	14.4b	17.1b	147bc	103	114
>3	32	3.30ab	7.4bc	14.3b	16.8a	135c	104	112
Significance of F-test		*	***	**	*	*	ns	ns
Parity on station (Foundation ewes)								
1	105	3.12a	6.6a	13.1a	15.6a	117a	99a	103a
2	108	3.42b	8.0b	15.2b	18.0b	151b	111b	121b
3	104	3.43b	8.0b	14.6bc	17.2bc	151bc	102a	114bc
>3	107	3.33b	7.4c	14.0c	16.7c	135c	104ab	111ac
Significance of F-test		**	***	***	*	***	*	***
Residual SD		0.616	1.82	2.97	3.46	57.4	30.7	27.9

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

*** P<0.001   ** P<0.01   * P<0.05   ns = not significant

Weight and growth from birth to 120 days

Unadjusted mean weights (n = 728) were 8.4 kg (SD = 2.25) at 30 days, 15.2 kg (SD = 3.83) at 90 days and 17.4 kg (SD = 4.58) at weaning at 120 days. Unadjusted mean growth rates were 159 g/d (SD = 66.04) for 0–30 days, 99 g/d (SD = 39.26) for 30–120 days and 114 g/d (SD = 35.43) overall from birth to weaning.

The analysis of variance showed that subtype, sex, birth type, season and year of birth and birth order within dam origin all affected weight at 30, 90 and 120 days (Table 5).

Growth rates from birth to 30 days did not differ among subtypes, nor were they influenced by dam origin; but they were influenced by all the other sources of variation tested. From 30 to 120 days there were differences in growth rates among genotypes, between sexes, between single and twin lambs and among lambs born in different seasons and different years. Lambs out of station-born and foundation ewes did not show differences in daily rates of gain and parity did not influence gain in lambs of station-born ewes but lambs born of foundation ewes having given birth a different number of times on the station grew at different rates. Average daily gains of lambs from birth to weaning at 120 days were influenced by the same sources of variation as for the period 30–120 days.

The least-squares mean weights at 30, 90 and 120 days were 7.4, 14.0 and 16.7 kg (Table 5). The least-squares mean daily weight gains (Table 5) were 136 g for the period 0–30 days, 103 g for the period 30–120 days and 111 g for the period from birth to weaning at 120 days.

Heterosis at 90 days was 6.0% in Watish × Dubasi, 7.4% in Watish × Shugor and 5.2% in Shugor × Watish lambs. At 120 days heterosis was 9.7% for Watish × Dubasi and 5.9% for both Watish × Shugor and Shugor × Watish. Dubasi × Shugor showed 5.0% heterosis at 90 days and 2.4% at 120 days. Heterosis in growth rates to 120 days was 11.0% for Watish × Dubasi and 10.0% for both Watish × Shugor and Shugor × Watish, but only 6% for Dubasi × Shugor.

Differences among years in weights-at-age and in growth rates appear to be related as much to management and to feed supply problems as to natural climatic conditions.

The linear and quadratic forms of the differences in birth weights in relation to parity and number of birth at El-Huda of station-born and foundation ewes were maintained for early weights up to weaning. This resulted from similar differences in growth in the different classes of parity and number of lambings in the lambs of the different types of ewe.

Heritability estimates for weights at 90 days and 120 days were 0.405 (SE = 0.181) and 0.238 (SE = 0.154). Genetic correlations between birth weight and 90-day and 120-day weights were 0.319 (SE = 0.443) and 0.346 (SE = 0.569). Heritabilities of growth rates were 0.234 (SE = 0.153) for 30–120 days and 0.264 (SE = 0.158) for 0–120 days. Repeatabilities of weights at 90 and 120 days, and of growth, were very low.

Weaning weights in this analysis are somewhat lower than have been previously recorded for selected and specially fed groups of lambs of the three purebred genotypes. Weaning at 120 days in these last groups has resulted in weights of 22.4 kg (SE = 0.31) for the three purebred types (Sulieman and Eissawi, 1984b), and Shugor and Dubasi lambs on experimental treatments attained weights at 90 days (17.2 kg (SE = 0.81) and 18.8 kg (SE = 0.87 kg)) superior to those attained by the naturally reared lambs analysed in this study. Earlier records for Watish lambs (El-Amin and Rizgalla, 1976) of 12 kg at 90 days do seem, however, to be similar to those recorded in the present analysis.

Weight and growth from 120 to 365 days

Unadjusted mean weights (n = 361) were 17.2 kg (SD = 3.89) at 120 days, 19.1 kg (SD = 4.57) at 150 days, 24.8 kg (SD = 6.55) at 240 days and 29.9 kg (SD = 7.23) at one year. Daily gain averaged 52 g for the period 120–365 days.

The analysis of variance (see Table 6) showed that weight at 120 days was influenced by genotype, sex, birth type and year of birth but not by dam origin, season of birth or parity. At 150 days the season in which a lamb had been born also had an influence on its weight. Season also affected weight at 240 days but at 365 days lambs born in different seasons did not show any differences in weight. Differences in the rate at which animals gained weight were evident in relation to subtype, sex and year.

Least-squares mean weights were 16.5 kg at 120 days, 18.4 kg at 150 days, 25.3 kg at 240 days and 31.7 kg at one year. The least-squares mean daily gain was 61 g for 120–365 days (Table 6).

All the crossbred genotypes except Watish × Shugor showed heterosis in weights at different ages, this being considerable at one year, and in growth rates. Watish × Dubasi lambs weighed 33.1 kg at 365 days, exhibiting heterosis of 7.5% in weight and heterosis of 13.3% in growth from 120 to 365 days. Shugor × Watish lambs showed heterosis of 10.1% in weight at one year and of 15% in growth in the period from weaning to one year. Dubasi × Shugor were superior to the mid-

Table 6. *Least-square mean weights (kg) and average daily weight gains (g) from 120 to 365 days of Sudan Desert sheep at El-Huda, Sudan*

		Weight (kg) at age (days)				Average daily gain (g) for period (days)
Factor	n	120	150	240	365	120–365
Overall least-squares mean	361	16.5	18.4	25.3	31.7	61
SE		0.47	0.53	0.72	0.81	2.7
Subtype						
Shugor	89	16.6a	18.6a	25.1ad	32.5a	64a
Shugor × Watish	14	16.8ab	19.2ab	28.3b	33.9a	69a
Dubasi × Shugor	15	17.5a	20.0a	28.3abd	34.1a	67a
Dubasi	118	15.8ab	17.3b	23.4ce	29.9b	57b
Watish × Shugor	7	17.4ab	18.3ab	24.4abcd	29.4ab	49b
Watish × Dubasi	17	16.3ab	18.3ab	24.5de	33.1a	68a
Watish	101	15.1b	17.0b	22.9ce	29.1b	56b
Significance of F-test		*	**	***	***	**
Dam origin						
Station-born	145	16.4	18.3	25.6	31.6	62
Foundation	216	16.7	18.5	24.9	31.8	61
Significance of F-test		ns	ns	ns	ns	ns
Sex						
Female	269	15.8a	17.4a	23.0a	29.0a	54a
Male	92	17.3b	19.4b	27.5b	34.4b	69b
Significance of F-test		***	***	***	***	***
Birth type						
Single	253	18.7a	20.8a	27.3a	33.4a	59
Twin	108	14.4b	16.0b	23.2b	30.0b	63
Significance of F-test		***	***	***	***	ns
Season of birth						
Winter	84	17.0	18.3ab	24.4a	30.9	56
Hot summer	12	15.1	17.3b	24.1a	32.1	69
Wet summer	265	17.4	19.6a	27.2b	32.1	60
Significance of F-test		ns	*	**	ns	ns
Year of birth						
1977	30	18.0a	20.0a	26.5a	33.9a	64a
1978	44	17.3a	19.2a	27.2a	33.3b	65a
1979	88	17.0a	18.7a	23.9bf	27.5c	42b
1980	56	15.6b	16.7b	21.1cd	28.8c	53c
1981	44	13.3c	14.8c	22.4df	28.5c	61ac
1982	83	16.6ab	19.5a	29.2e	37.0d	83d
1983	16	17.8a	20.0a	26.5abe	32.9ab	61ac
Significance of F-test		***	***	***	***	***
Parity (Station-born ewes)						
1	62	16.2	18.5	25.1	31.7	63
2	44	16.0	17.7	24.4	30.1	57
3	27	16.7	18.7	25.5	31.1	58
>3	12	16.5	18.3	27.2	33.4	69
Significance of F-test		ns	ns	ns	ns	ns
Parity on station (Foundation ewes)						
1	40	15.9	17.8	24.3	31.7	64
2	57	17.2	18.7	24.6	31.5	58
3	55	16.7	18.5	25.1	32.2	63
>3	64	16.9	18.9	25.7	31.9	61
Significance of F-test		ns	ns	ns	ns	ns
Residual SD		3.13	3.55	4.83	5.42	18.4

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

*** P<0.001 ** P<0.01 * P<0.05 ns = not significant

parental value by 9.0% in weight at 365 days and grew faster by 10.7%.

Differences in weights related to season of birth changed throughout this growth phase, presumably due to changes in nutrition and feed availability as animals moved through the seasons. The differences in weight of lambs in relation to year, already noted for the preweaning period, persisted until 365 days. Lambs born in 1980 and 1981, lightest at weaning, remained among the lightest at one year although growth rates of lambs born in 1981 were not worse than the average, presumably due to efforts to supply adequate feed during 1982. Lambs born in 1979 were the lightest at 365 days and had exhibited very slow growth rates due to feed shortages during 1980. As a result of corrective nutritional management, 1982 lambs were by far the heaviest of all years at 365 days and had the fastest growth rates.

A significant subtype × sex interaction found in a subsidiary analysis appeared to be due to a greater difference in weights between males and females of the Shugor subtype than the effects of sexual dimorphism in the other two types.

Repeatabilities of weights were 0.23 (SE = 0.111) at 150 days, 0.25 (SE = 0.109) at 240 days and 0.17 (SE = 0.117) at 365 days.

There are few comparative data on weights in the range of 120–365 days for Sudan Desert sheep. Weights of 22 to 27 kg at six months and of 30 to 32 kg at one year appear to cover the general range (Wilson, 1976; Osman et al, 1988; Sulieman et al, in press).

Weight and growth of females from one to three years

Unadjusted mean weights (n = 81) of females were 27.5 kg (SD = 5.12) at one year, 34.4 kg (SD = 5.60) at 18 months, 36.5 kg (SD = 6.05) at two years and 40.8 kg (SD = 6.25) at three years. The unadjusted growth rate was 18 g/d (SD = 10.1) for the period 1–3 years.

The analysis of variance showed that very few of the sources of variation tested had any influence on female weights at these relatively advanced ages (Table 7). The effects of type of birth persisted to 18 months but weights of single and twin-born gimmers did not differ thereafter. Weight differences related to year of birth were evident at 18 months and two years and gimmers out of foundation ewes with different numbers of parturitions on the station had different weights at one year. Growth rates of this last class of animal also differed.

The least-squares mean weights of females at one year, 18 months, two years and three years were 25.6 kg, 32.6 kg, 35.6 kg and 38.9 kg (Table 7). The least-squares mean growth rate was 18 g/d.

Associations between weight and growth at different ages

Phenotypic correlations among weights and weight gains are shown in Tables 8 to 10. All correlations at the preweaning stage were positive and significant. In the postweaning period only the correlation between weaning weight and gain to one year was negative, and non-significant; all other correlations were positive and significant. There were negative correlations between weight at 365 days and growth in the period 365–1095 days and between 550-day weight and growth over the same period. All other correlations among weights and growth from one year to three years were positive and significant.

An explanation for the negative correlations between weight and growth rate is that as the body approaches maturity its growth slows. An additional reason for the negative correlation is that increased maintenance requirements at heavier weights result in less feed being available for growth.

Postpartum weights and dam weights at weaning of young

The unadjusted mean weight of females immediately postpartum was 39.5 kg (SD = 6.43). When lambs were weaned at about 120 days the unadjusted mean weight of their dams was 39.1 kg (SD = 5.69). The analysis of variance showed that genotype, year of parturition and parity significantly affected the postpartum weight (Table 11). Postpartum weights did not differ between dams of different origin, those which had given birth to singles or twins, or those giving birth in different seasons. Weights of ewes when their lambs were weaned were affected by the same sources of variation as parturition weight but, in addition, the season in which the parturition had taken place also affected the ewe's weight four months later.

The least-squares mean postpartum weight was 40.5 kg and weight at lamb weaning, 120 days postpartum, was 38.9 kg (Table 11). A slight loss of weight occurred between parturition and weaning due to the demand of lactation. Effects of the variables considered were similar at both stages.

The poor management and nutrition identified in 1981 and 1982 in the growth performance of lambs was also manifest in ewe weights. Postpartum weights were lighter in these two years

Table 7. *Least-squares mean weights (kg) and average daily weight gains (g) from 365 to 1095 days of Sudan Desert ewes at El-Huda, Sudan*

		Weight (kg) at age (days)				Average daily gain (g) for period (days)
Factor	n	365	550	730	1095	365–1095
Overall least-squares mean	81	25.6	32.6	35.6	38.9	18
SE		0.99	1.11	1.06	1.25	2.0
Subtype						
Shugor	21	27.2	33.7	36.2	39.1	16
Dubasi	40	24.7	33.5	36.9	40.7	21
Watish	20	24.9	30.6	33.8	36.9	16
Significance of F-test		ns	ns	ns	ns	ns
Dam origin						
Station-born	29	25.3	32.5	36.2	39.4	19
Foundation	52	25.9	32.7	35.0	38.4	17
Significance of F-test		ns	ns	ns	ns	ns
Birth type						
Single	68	28.8a	34.8a	37.3	41.0	16
Twin	13	22.4b	30.4b	33.9	36.9	19
Significance of F-test		***	*	ns	ns	ns
Season of birth						
Winter	16	26.4	32.5	36.7	39.2	17
Wet summer	65	24.8	32.7	34.6	38.6	18
Significance of F-test		ns	ns	ns	ns	ns
Year of birth						
1977	17	27.8	35.9a	41.0a	41.1	18
1978	12	26.8	33.1ab	37.4ac	39.8	17
1979	17	23.7	28.8b	30.8b	36.8	17
1980	26	26.7	32.7ab	34.7c	38.8	16
1981	9	22.9	32.4ab	34.2abc	38.1	20
Significance of F-test		ns	*	***	ns	ns
Parity (Station-born ewes)						
1	16	27.5	32.9	36.9	39.2	16
2	6	24.7	33.6	37.2	42.0	23
3	7	23.7	30.8	34.6	37.0	18
Significance of F-test		ns	ns	ns	ns	ns
Parity on station (Foundation ewes)						
1	9	26.7ab	33.4	33.2	36.3	13a
2	19	23.3a	31.6	36.4	41.6	25b
3	13	29.1b	34.1	36.0	37.4	11a
>3	11	24.4a	31.9	34.6	38.5	19ab
Significance of F-test		*	ns	ns	ns	**
Residual SD		4.71	5.28	5.09	5.96	9.58

In the same column, and within a factor, means followed by the same letter do not differ significantly ($P>0.05$)

*** $P<0.001$ ** $P<0.01$ * $P<0.05$ ns = not significant

Table 8. *Phenotypic correlations among weights and average daily weight gains from birth to 120 days for Sudan Desert sheep at El-Huda, Sudan (n = 728)*

	Weight at age (days)				Average daily gain for period (days)		
	10	30	90	120	0–30	0–120	30–120
Weight at:							
Birth	0.77**	0.50**	0.50**	0.49**	0.17**	0.35**	0.32**
10 days		0.92**	0.73**	0.65**	0.74**	0.56**	0.26**
30 days			0.76***	0.66**	0.94***	0.62**	0.22**
90 days				0.93**	0.66**	0.90**	0.72**
120 days					0.55**	0.99***	0.88**
Average daily gain for:							
0–30 days						0.57**	0.12*
0–120 days							0.89**

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

Table 9. *Phenotypic correlations among weights and average daily weight gains from 120 to 365 days for Sudan Desert sheep at El-Huda, Sudan (n = 361)*

	Weight at age (days)			Average daily gain for period (days)
	150	240	365	120–365
Weight at:				
120 days	0.93**	0.67**	0.53**	–0.01ns
150 days		0.80**	0.66**	0.19*
240 days			0.83**	0.55**
365 days				0.84**

** P<0.01 * P<0.05 ns = not significant

Table 10. *Phenotypic correlations among weights and average daily weight gains from one to three years for Sudan Desert sheep at El-Huda, Sudan (n = 81)*

	Weight at age (days)			Average daily gain for period (days)
	550	730	1095	365–1095
Weight at:				
365 days	0.71**	0.43**	0.17*	–0.54**
550 days		0.44**	0.44**	–0.11ns
730 days			0.69**	0.28*
1095 days				0.74**

** P<0.01 * P<0.05 ns = not significant

Table 11. *Least-squares mean weights (kg) postpartum and 120 days postpartum of Sudan Desert ewes at El-Huda, Sudan*

Factor	Postpartum weight (kg)		Weight (kg) at 120 days postpartum	
	n	Mean	n	Mean
Overall least-squares mean	432	40.5	435	38.9
SE		0.51		0.45
Subtype				
Shugor	95	42.3a	92	41.2a
Dubasi	174	42.2a	185	40.0a
Watish	163	37.0b	158	35.4b
Significance of F-test		***		***
Dam origin				
Station-born	213	41.0	197	38.9
Foundation	219	40.0	238	38.8
Significance of F-test		ns		ns
Parturition type				
Single	376	40.1	371	38.6
Twin	56	40.9	64	39.1
Significance of F-test		ns		ns
Season of parturition				
Winter	148	40.9	143	39.2a
Hot summer	34	40.1	35	37.1b
Wet summer	250	40.5	257	40.3a
Significance of F-test		ns		***
Year of parturition				
1978	48	44.2a	80	40.0ac
1979	71	42.4ae	94	40.6a
1980	62	41.0be	43	39.0acd
1981	58	38.1cd	31	36.4be
1982	111	38.0d	105	38.7cf
1983	65	39.5bd	67	40.2a
1984	17	40.2de	15	37.2bdf
Significance of F-test		***		***
Parity (Station-born ewes)				
1	125	37.5a	124	35.8a
2	48	41.2b	44	37.9b
3	25	42.4b	18	40.5c
>3	15	43.0b	11	41.2c
Significance of F-test		***		***
Parity on station (Foundation ewes)				
1	10	35.5a	21	36.4a
2	64	41.4bc	73	39.0b
3	70	40.3b	78	39.0b
>3	75	42.6c	66	41.0c
Significance of F-test		***		***
Residual SD		5.18		4.42

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

*** P<0.001 ns = not significant

than in any of the others, as (with the exception of 1984) were 120-day-postpartum weights. There was, however, a greater loss in weight during the lactation period for ewes lambing in 1978 than for those lambing in any other year.

Seasonal and long-term weight changes of breeding females

Adult female weights, excluding ewes from two months prepartum to one month postpartum, averaged 41.6 kg on an annual basis for the period late 1979 to early 1984. Fluctuations throughout the year were of the order of 2.4 kg with greater weight changes being shown by Watish ewes than by the other two subtypes (Figure 8). Ewes lost weight rapidly in the hot summer season and regained this throughout the wet summer and into the first part of the winter. Over the period 1979 to 1984 there was an apparent increase in mature ewe weights (Figure 9).

Figure 8. *Seasonal weight changes in Shugar, Dubasi and Watish adult females at El-Huda, Sudan*

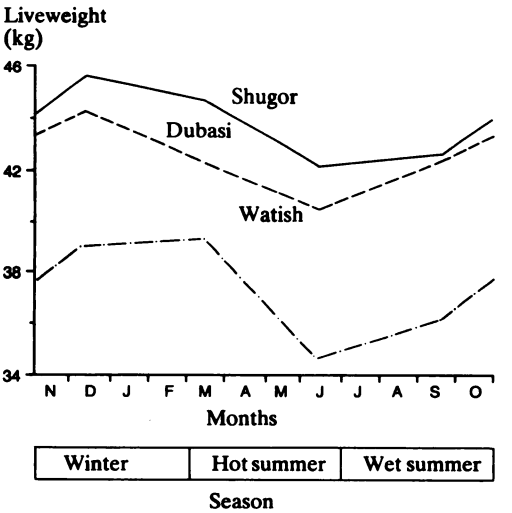
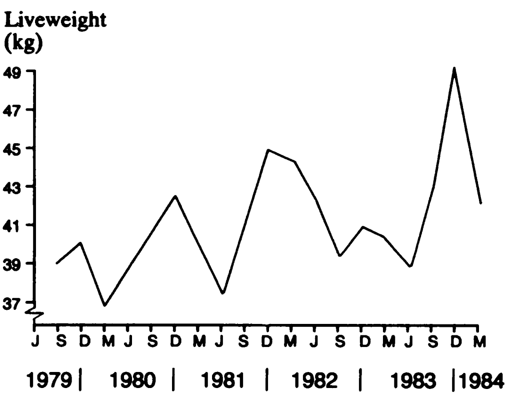


Figure 9. *Long-term changes in weight of Sudan Desert ewes at El-Huda, Sudan*



Summary

Shugor lambs were heavier at birth than all other pure- and crossbred genotypes. Lambs out of Watish ewes (whether by Watish or Shugor sires) were slightly lighter at birth than other genotypes (and significantly lighter than other purebreds). Purebred Watish remained lighter than the other purebred genotypes to weaning and were lighter than all of the genotypes from weaning to 365 days of age. Thereafter subtype effects on weight were insignificant.

Lambs born as singles were heavier at birth than twin lambs, and this advantage was maintained up to 18 months of age, after which there were no significant differences.

Males were heavier and grew faster than females from birth to one year of age.

There were no subtype differences in growth rate in the first 30 days. From 30 to 120 days, growth rates of Dubasi and Watish were lower than those of other genotypes, and overall from birth to weaning Watish grew slowest.

Lambs born in the wet summer were heavier at birth than those born in other seasons, and this superiority was maintained to weaning. By one year, however, differences in weight were not significant.

OFFTAKE AND MORTALITY

Advantages obtained from improved reproduction and growth in a flock of sheep are better maintained if high survival rates of young and adults can be assured. High survival rates also help progress in the flock by making more animals available for genetic studies from which superior germplasm might be selected. Various factors affect the survival rate in a flock from conception to marketing or breeding age.

Exit reasons of 1605 sheep from the station and the proportion of animals removed for each reason are shown in Table 12.

Mortality from birth to 365 days

Unadjusted mean mortality rates were 5.9% on the first day (excluding abortion), 15.2% at 30 days, 28.5% at 120 days, 32.1% at 150 days, 41.5% at 240 days and 45.1% at 365 days. The analysis of variance (see Table 13) showed subtype effects to be significant at weaning at 120 days and at all ages thereafter. Dam origin did not significantly affect mortality rates at birth, 30, 120 and 365 days. Sex influenced mortality rate very considerably up to 365 days. The type of birth began to influence the mortality at 120 days. Season and year of birth greatly influenced mortality at all ages from 30 days. The parity of station-

Table 12. *Flock removals from El-Huda, Sudan, 1975–86*

Reason	Number	Per cent of total
Experimental slaughter[a]	235	14.6
Death	531	33.1
"Lost"	205	12.8
Slaughter for guests	15	0.9
Breeding insufficiency	1	0.1
Abortion/Stillbirth	49	3.1
Laboratory experimentation[b]	21	1.3
Sold and culled	548	34.1
Total	1605	100.0

[a] Slaughtered on station for carcass evaluation or for other experimental reasons

[b] Transferred off the station to Central Veterinary Laboratory and University of Khartoum

born ewes had some effect on the mortality rate at birth, had highly significant effect at 30 to 120 days, showed a reduced effect at 150 days and ceased to influence mortality altogether after that. The number of times a foundation ewe had lambed on the station had no influence on the mortality of her lambs.

The least-squares mean mortality rates were 6.43, 22.60, 37.61, 43.18, 52.77 and 55.50% at birth, 30, 120, 150, 240, and 365 days (Table 13). At all ages from weaning at 120 days Watish had significantly lower mortality rates than the other two purebreds. In relation to dam origin, death rates were higher in young of station-born ewes than in those out of foundation ewes at 150 days and at 240 days. Males had a greater mortality rate than females throughout and lambs born as part of a multiple litter had a higher death rate at weaning and thereafter than those born as singles.

At 30 days lambs born in the stressful hot summer season had a higher death rate than those born in the cooler winter or wet summer seasons. Year of birth had an effect on mortality starting at 30 days. In general, death rates were highest in lambs born in the early years of the study. Higher death risks were encountered at older ages, however, in the previously noted poor years of 1980 and 1981 and there was also a relatively high mortality rate in animals at 240 days and at 365 days for lambs born in 1983.

Lambs born to station-born dams at their second parity had the lowest death rate of young of ewes in that group. Lambs of first parity station-born ewes had the highest death rate of all.

There were differences ($P<0.001$) among sires in the ability of their offspring to survive. The heritability of mortality was 0.501 ($SE = 0.19$) at weaning. Repeatabilities within dams were low. Lamb birth weight influenced ($P<0.01$) mortality at all age from 30 days to 365 days. For every kilogramme extra birth weight, mortality was reduced by 3.7% at 30 days, 6.8% at 120 days, 7.3% at 150 days, 8.4% at 240 days and 8.2% at 365 days.

Earlier studies have shown similar levels for early death rates. Mortalities of 47.0 and 40.5% to weaning at 120 days have already been recorded for Shugor and Dubasi lambs (Sulieman et al, 1978; 1983). The lower mortality rate of Watish sheep noted in this study is similar to the 29.4% mortality rate at weaning already recorded for this subtype (El-Amin and Rizgalla, 1976). The higher mortality of males in this study differs from earlier results which tended to show equal mortalities in both sexes (El-Amin and Rizgalla, 1976; Sulieman et al, 1978; 1983). Higher death risk in twins compared with singles is as expected.

Seasonal effects analysed in previous studies have been conflicting: highest death rates to weaning were recorded in winter-born lambs (50.0%) while those born in the hot summer (22.5%) and the wet summer (27.5%) had lower but similar rates (El-Amin and Rizgalla, 1976) but other studies (for example, Sulieman et al, 1983) failed to show any seasonal differences. Effects of year on mortality support evidence from reproductive and growth performance that 1980 and 1981 were extremely poor years at El-Huda.

Adult mortality

Mortality in sheep older than one year averaged 10.4% per year in females and 12.8% per year in males over the nine-year period 1975–83. A total of 81 adult female sheep died for 781 ewe-years and 14 adult males for 110 ram-years. Mortality rates varied among years (Figure 10) with very high death rates occurring in 1980 and 1981.

Previous studies carried out at the station also underline the high death rates in 1980 and 1981, with average adult mortality rates of 16.2% (Sulieman, 1983) and 25.4% (Sulieman et al, 1983).

PRODUCTIVITY INDICES

Unadjusted indices at 120 days were 16.9 kg of weaned lamb per ewe per year ($SD = 9.50$), 425.3 g of weaned lamb per kg ewe per year ($SD = 247.28$) and 1.15 kg of weaned lamb per kg of ewe metabolic weight per year ($SD = 0.656$). At 150 days the three indices were

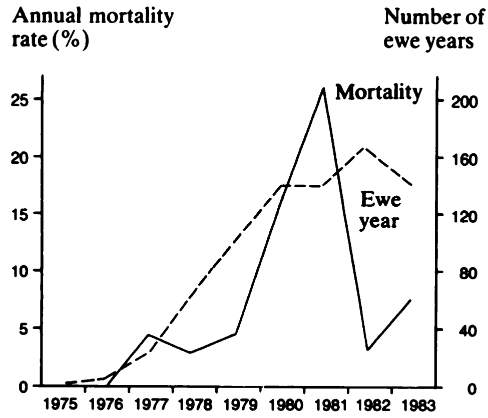
Table 13. *Least-squares mean mortality rates (%) at specified ages from birth to 365 days of Sudan Desert sheep at El-Huda, Sudan*

Factor	n	Mortality (%) at age (days)					
		0	30	120	150	240	365
Overall least-squares mean	708	6.43	22.60	37.61	43.18	52.77	55.50
SE		1.48	2.13	2.60	2.64	2.80	2.83
Subtype							
Shugor	238	6.77	23.88	40.51a	48.52a	57.29a	59.99a
Dubasi	272	8.74	25.56	42.57a	46.34a	48.40ab	55.48a
Watish	198	3.76	18.36	29.74b	34.68b	45.53b	46.84b
Significance of F-test		ns	ns	**	**	**	*
Dam origin							
Station-born	282	5.97	25.37	41.25	48.53a	57.98a	59.64
Foundation	426	6.88	19.82	33.96	37.83b	47.55b	51.35
Significance of F-test		ns	ns	ns	*	*	ns
Sex							
Female	449	4.58a	18.04a	29.73a	33.90a	40.09a	42.02a
Male	259	8.27b	27.16b	45.48b	52.46b	65.45b	68.98b
Significance of F-test		*	***	***	***	***	***
Birth type							
Single	490	6.70	20.71	32.37a	37.37a	48.38a	50.88a
Twin	218	6.15	24.49	42.84b	48.98b	57.15b	60.12b
Significance of F-test		ns	ns	**	**	*	*
Season of birth							
Winter	256	5.42	19.33a	44.18a	51.11a	55.99a	57.69a
Hot summer	63	8.55	34.90b	48.83a	54.69a	66.36a	67.72a
Wet summer	389	5.31	13.57a	19.81b	23.73b	35.95b	41.09b
Significance of F-test		ns	***	***	***	***	***
Year of birth							
1976	57	8.06	42.09a	60.29a	69.64a	69.50a	69.78a
1977	74	1.50	23.66bc	48.89ab	55.44b	65.07a	64.49abd
1978	78	10.44	29.90b	40.93b	49.19bc	63.10a	61.41abd
1979	86	9.24	23.46bd	37.42b	44.30bc	47.78bc	52.94b
1980	171	6.61	18.74cd	38.23b	41.83c	56.78ab	62.06abd
1981	101	1.63	14.34cd	35.22b	39.42c	58.08ab	62.71abd
1982	107	2.90	11.04c	21.37c	24.81d	25.35c	25.26c
1983	34	11.04	17.55bc	18.49c	20.80d	36.48	45.35d
Significance of F-test		ns	***	***	***	***	***
Parity (Station-born ewes)							
1	148	11.74a	34.90a	54.08a	60.28a	67.09	67.91
2	61	2.82b	11.98b	28.10b	37.81b	51.23	54.33
3	51	8.02ab	26.20a	44.21a	46.37b	55.04	55.76
>3	22	3.31ab	28.42ab	38.60ab	49.65ab	58.57	60.57
Significance of F-test		*	***	***	**	ns	ns
Parity on station (Foundation ewes)							
1	129	6.51	25.84	36.43	39.00	48.47	51.75
2	118	6.34	16.64	25.68	29.65	43.59	49.49
3	74	7.60	14.99	31.51	36.64	43.47	47.81
>3	105	7.07	21.81	42.23	46.03	54.68	56.36
Significance of F-test		ns	ns	ns	ns	ns	ns
Residual SD		7.35	10.6	13.0	13.2	14.0	14.1

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

*** P<0.001 ** P<0.01 * P<0.05 ns = not significant

Figure 10. *Annual adult mortality rates and number of years of ewe-presence at El-Huda, Sudan, 1975–83*



18.6 kg (SD = 10.90), 466.8 g (SD = 282.56) and 1.26 kg (SD = 0.752). There were 146 observations in each case.

The analysis of variance showed that only season and year of parturition influenced the 120-day indices. The parturition type almost exerted a significant influence on the 120-day indices having slightly more effect on Index I (P = 0.055) and Index III (P = 0.059) than on Index II (P = 0.063). At 150 days the indices were influenced by type, season and year of parturition but not by any of the other sources of variation.

The least-squares mean indices I, II and III at 120 days were 16.8 kg, 419 g and 1.14 kg; at 150 days the least-squares mean values were 18.5 kg, 461 g and 1.25 kg (Table 14).

There were no differences among subtypes in any of the indices at either 120 or 150 days. Shugor had the largest litter size of the three purebreds but had a longer lambing interval than Watish. The reproductive component of the productivity index did not differ between Shugor and Watish overall (Table 4) but the Shugor was superior to the Dubasi in reproductive performance while there were no differences between Dubasi and Watish. The contribution of lamb weight to the indices did not differ between Shugor and Dubasi at 120 days, nor between Dubasi and Watish at the same age but Shugor lambs were heavier than Watish ones (Table 6). At 150 days Shugor lambs were heavier than both Dubasi and Watish ones, between which there was no difference. Mortality at 120 and 150 days was less in the Watish than in the Shugor and the Dubasi, between which there were no differences (Table 13). The different effects of these components of the indices resulted in there being no differences in the breed indices. The lighter post-partum weight of the Watish ewes did, in fact, lead to apparently slightly higher Indices II and III for this subtype.

There were no differences in indices between dams of different origins. Ewes giving birth to singles did not have indices that were significantly different from those giving birth to twins, at 120 days. At 150 days, however, ewes that produced twins produced more weight of young than those that produced single lambs. This was probably mainly due to a change in relative growth rates between single and twin lambs after weaning. Growth was significantly faster in singles before weaning than in twins (Table 5) but after weaning there were no differences in growth rates. Indeed, there was some indication that twins grew faster than singles after weaning (Table 6) probably because singles suffered more from lack of milk after being weaned than did twins.

Indices of ewes that gave birth in the wet summer were superior to those that gave birth in the hot summer. Ewes that lambed in the winter were intermediate between ewes lambing in either of the other two seasons. This was mainly due to better growth and lower mortality rates of lambs born in the wet summer as reproductive performance was similar for ewes lambing in all seasons. Effects of year on indices show the expected results based on reproductive performance, lamb growth and mortality, with 1980 and 1981 providing indices generally well below the mean and 1982 and 1983 indices generally greater than the mean.

Table 14. Least-squares mean productivity indices[a] at 120 and 150 days of Sudan Desert sheep at El-Huda, Sudan

Factor	n	120 days			150 days		
		Index I (kg)	Index II (g)	Index III (kg)	Index I (kg)	Index II (g)	Index III (kg)
Overall least-squares mean	146	16.8	419	1.14	18.5	461	1.25
SE		1.81	47.4	0.126	2.04	53.2	0.141
Subtype							
Shugor	35	17.1	421	1.15	18.9	468	1.27
Dubasi	58	16.4	395	1.08	18.2	437	1.20
Watish	53	16.9	443	1.19	18.3	479	1.28
Significance of F-test		ns	ns	ns	ns	ns	ns
Dam origin							
Station-born	64	17.7	436	1.19	19.3	472	1.29
Foundation	82	15.9	403	1.09	17.7	450	1.21
Significance of F-test		ns	ns	ns	ns	ns	ns
Parturition type							
Single	123	14.7	366	0.99	16.0a	397a	1.08a
Twin	23	18.9	473	1.28	21.0b	525b	1.42b
Significance of F-test		ns	ns	ns	*	*	*
Season of parturition							
Winter	37	17.6ab	454ab	1.22ab	18.5a	475ab	1.28ab
Hot summer	7	12.1b	280b	0.77b	13.3a	310b	0.85b
Wet summer	102	20.8a	525a	1.42a	23.7b	598a	1.62a
Significance of F-test		*	*	*	*	*	*
Year of parturition							
1978	23	17.1ab	384ab	1.07ab	17.5ab	393ab	1.10
1979	35	15.6a	372ab	1.02ab	16.4ab	389ab	1.07ab
1980	25	12.2a	299a	0.81a	12.7a	313a	0.85a
1981	16	11.8a	297ab	0.80ab	13.4ab	339ab	0.92ab
1982	42	17.0a	431b	1.16b	19.5b	496b	1.34b
1983	5	27.3b	734c	1.95c	31.3c	837c	2.23c
Significance of F-test		*	*	*	*	**	**
Parity (Station-born ewes)							
1	38	15.2	405	1.08	16.2	434	1.16
2	16	16.8	407	1.11	18.0	436	1.19
3	8	18.2	449	1.22	20.2	494	1.34
>3	2	20.8	485	1.34	22.3	526	1.47
Significance of F-test		ns	ns	ns	ns	ns	ns
Parity on station (Foundation ewes)							
1	5	10.1	285	0.75	11.7	331	0.87
2	27	17.2	430	1.17	18.6	467	1.26
3	26	18.2	459	1.24	20.5	519	1.41
>3	24	18.1	436	1.20	20.0	483	1.32
Significance of F-test		ns	ns	ns	ns	ns	ns
Residual SD		28.6	748	6.28	32.1	840	7.05

[a] Productivity indices are calculated as follows:

$$\text{Index I} = \text{Weight (kg) of young produced per female per year} = \frac{\text{Litter weight (kg) at 120 or 150 days} \times 365}{\text{Subsequent parturition interval}}$$

$$\text{Index II} = \text{Weight (g) of young produced per kg liveweight of female per year} = \frac{\text{Index I} \times 1000}{\text{Female postpartum weight}}$$

$$\text{Index III} = \text{Weight (kg) of young produced per kg metabolic weight of female per year} = \frac{\text{Index I}}{\text{Female postpartum weight}^{0.73}}$$

In the same column, and within a factor, means followed by the same letter do not differ significantly (P>0.05)

** P<0.01   * P<0.05   ns = not significant

4. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The main objectives of this research on Sudanese sheep were to characterise performance and development of certain production traits. The findings have confirmed previous observations on the superiority of the Shugor in litter size over Dubasi and Watish under farm conditions. This should be taken into account in selection for development of dam lines. Age at first lambing was confounded with management. These influences have led to a late age at first lambing, whereas it is desirable that ewe lambs should have their first lambs when they are 16–18 months old. This could be attained by paying more attention to ewe lamb rearing and feeding, especially in the immediate postweaning period. Ewe lambs could be joined to rams in a separate flock and not included in adult ewe breeding programmes until after they have produced their first lamb. Lambing intervals recorded here are also quite long.

The current weight performance is considered poor and does not reflect the potential of these animals. Subtype differences are most marked for the Watish. Combination of Watish with either Dubasi or Shugor, however, has the advantage that the progeny develop heterotic effects in weight. Survivability at birth and thereafter should also be improved in both Shugor and Dubasi as the Watish has been shown to have the lowest mortality up to one year. Weight gains have not been satisfactory, which is most probably due to nutritional limitations, both during suckling and in the postweaning period. Correct feeding might alter the present picture in liveweight and weight gains.

Unless the very high mortality at all ages can be controlled, the possibilities for better productivity and development are poor. Nutritional, disease and management factors need proper investigation on the farm and within the breeders' flocks in the area in order to determine the major factors influencing mortality, and hence find solutions to this problem.

RECOMMENDATIONS

The results presented in this report indicate the need for the following investigations:

1. Flock health and mortality. A series of investigations on individual sheep and flock health should be carried out in collaboration with the Central Veterinary Research Laboratory in Khartoum. A disease survey in the local area and case studies in specific flocks should be undertaken.
2. Investigations on early weaning. Weaning could be carried out at about eight weeks under improved nutritional conditions.
3. Additional selection and crossbreeding should be carried out to develop and test further this report's findings on crossbreeding. This may be extended to include other subtypes of sheep which have economic potential and presently contribute to the livestock trade.
4. Applied nutrition trials at all levels of feeding and for all aspects of sheep productivity, mainly by using forages and agricultural by-products, should be conducted. In particular, the effects of pre- as opposed to postweaning supplementation and the relative merits of the particular periods of the dry season at which limited feed resources should be used, require detailed study.

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APPENDIX

A BIBLIOGRAPHY ON SUDAN DESERT SHEEP

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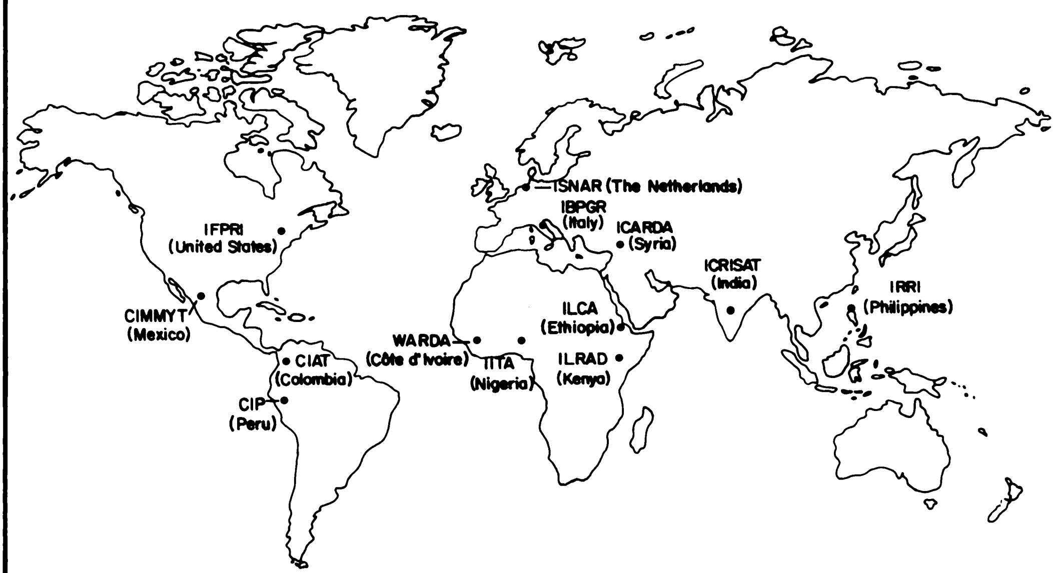

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