Chapter 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Tropical hair sheep

Tropical hair sheep was reported to be originated from their wild ancestors known as the Asian and European Mouflon (Ovis orientalis and Ovis musimon), the Argali (Ovis ammon) and the Urial (Ovis vignei). Their hair coat are believed to be still sharing the same primitive hair coat of their ancestors, comprising of a hairy outer coat of kemps and woolly undercoat, with the whole coat moulting in spring (Ryder, 1984; Zeuner, 1963). The modern hair sheep however have a double undercoat of kemps and interlaced underwool (Ryder, 1984; Fitzhugh and Bradford, 1983). They also have the characteristics of thin limbs, a short tail and the presence of horn in the males or in both sexes, from their early stage of domestication (Ryder, 1984; Williamson and Payne, 1978). Therefore, the hair coat of hair sheep cannot be interpreted as being derived through their adaptation to tropical environments as is sometimes suggested. Since the stimulus to breed wool sheep is low in most tropical environments, the hair coat of the sheep may have been preferred and adapted in many tropical regions where they must have been one of the first domesticated animals (Ryder, 1984; Zeuner, 1963).

The hair sheep are comparatively few in number, comprising only about 10% of the world's sheep population and are not as economically important as the wool sheep. However, under tropical conditions, the hair sheep showed a much better contribution in terms of adaptation, production, fertility and survivability at all ages. They were also found to be more resistant to internal parasites and had pre- and post weaning growth rates similar to the wool sheep (Fitzhugh and Bradford, 1983).

The characteristic of the hair coat was reported to be the main factor for the hair sheep's adaptability to the humid tropical climate (Hernandez Ledezma, 1987;

Gatenby, 1986; Turner, 1977; Burns, 1967; Zeuner, 1963). Based on the concept of 'productive adaptability', their adaptability to local conditions can be indicated by utilizing the maintained level of productivity of individuals (Horst, 1983).

Hair sheep breeds can be categorized as fat-tailed, fat-rumped or thin tailed. The fat-tailed and the fat-rumped hair sheep are typically found in the hot and dry sub-tropics while the thin-tailed are mainly found in the humid parts of Africa, India, America and Southeast Asia (Gatenby, 1986; Devendra and Coop, 1982).

The majority of sheep found in Southeast Asia are of the small hair type (Williamson and Payne, 1978). The fat-tailed hair sheep breed found in Indonesia was reported to have originated from India or West Asia. In Malaysia and southern Thailand the breeds with less wool but more hair are believed to have originated from the crossbreds between the woolled Chinese sheep brought south by the Thai and other people, and the indigenous hair sheep of the region (Williamson and Payne, 1978).

The Barbados Blackbelly and the Virgin Island or St. Croix that originated in the Caribbean Islands of Barbados and St. Croix respectively, were categorized as hair sheep breeds although each might have some wool breed ancestry (Gatenby, *et. al.*, 1997). The Pelibuey of South and Central America also falls under this category (Fitzhugh and Bradford, 1983).

2.1.1 Meat production from hair sheep

Meat becomes the main purpose for the production of hair sheep in the world, as hair sheep produce fibre of no or little value. Since hair sheep in the world are primarily kept by smallholders, products like skin, milk and manure are considered as important side-products to the farmers (Figueiredo and Souza, 1990; Fitzhugh, 1984).

Their utilization for weed control, sacrificial purpose during religious ceremonies and above all, savings for times of need have also been mentioned by the above authors.

The introduction of hair sheep from Africa into the Americas had proven to be a reliable source of meat protein for developing countries while the crossbreeding of hair sheep with wool sheep had resulted in increased meat production as well as higher reproductive rate. Various types of hair sheep breeds including the Pelibuey, were found to be well adapted and resistant to tropical environments and had been proven to reproduce well under the Central and South American climate (Reyna, *et. al.*, 1991).

Table 2.1 A comparison of the performance and performance potential of the hair sheep and the wool sheep under tropical and temperate environments respectively

Type of environment	Hair sheep	Wool sheep
Temperate		
Size	Smaller	Bigger
Growth	Slower	Faster
Fertility	Fertile throughout the year (with adequate nutrition)	Mostly showed marked seasonal differences in fertility
Mortality rate	Higher	Lower
Dressing percentage	Lower	Higher
Carcass weight	Lighter	Heavier
Tropical		
Growth	Pre- and post weaning growth rate similar to wool sheep	Similar to hair sheep
Adaptation	More adapted	Less adapted
Fertility	Higher	Lower
Survivability rate	Higher at all ages	Lower

(Source: Fitzhugh and Bradford, 1983)

Fitzhugh and Bradford (1983) while studying the performance of hair sheep, wool sheep and their crosses in the southern parts of the United States suggested that hair sheep were smaller and had lower growth rates, had a considerably longer breeding season and tended to be fertile throughout the year. Even at temperate latitudes, lambs (especially offspring of crosses) had better survivability and showed superior resistance to internal parasites, and were more prolific than most breeds in the United States, except for the Finnish Landrace. The lambs also had similar dressing percentages but a higher percentage of kidney fat when slaughtered at 40 to 45 kilogram. Table 2.1 shows a comparison of the performance and performance potential of the hair sheep and the wool sheep under tropical and temperate environments respectively.

2.1.2 Physiological traits

Fitzhugh and Bradford (1983) suggested that hair sheep, either those with little or nor wool are better adapted to the hot, humid tropical climate. St. Croix hair sheep which originated from warmer climates was demonstrated to have an increased heat tolerance to heat stress in the elevated ambient temperatures from July to September in the United States. They exhibited lower respiration rates and lower rectal temperatures when compared to Targhee sheep (Horton, *et. al.*, 1991).

Lower rectal temperatures and respiration rates were also reported by Wildeus, (1997) in the St. Croix and Barbados Blackbelly hair sheep in the United States.

2.1.3 Hair coat

Fleeces of the F_1 Blackbelly crosses were reported to comprise of a mixture of wool and hair and ranged in weight from about 1.4 to 2.3 kg (Goode, *et. al.*, 1983).

A crossbreeding experiment between the East African Blackhead Persian hair sheep with the German Merino sheep showed that the F_1 – crosses were born with a smooth, hairy birth coat through which fine wool started to appear from the age of three months onwards. Apparently, massive shedding processes took place particularly at the belly, neck and flanks, so that only some wool on the back remained (Haring and Mukhtar, 1971). They concluded that three quarters of the hair sheep crosses would have a tendency of less wool so that a coat with less or no wool could be achieved through backcrossing towards the hair sheep parent.

Gatenby, *et. al.*, (1997) ranked the wool score of 6 and 9 months old lambs sired by the woolly Sumatran (S_1) and rams of three hair sheep breeds, Java Fat-tail (E_1), Virgin Island or St. Croix (H_1) and Barbados Blackbelly (B_1) in the following descending order: B_1, H_1, E_1 and S_1. At the age of 3 and 6 months the F_1 lambs were not free of wool but at 9 months of age, lambs sired by the Barbados hair sheep had very much less wool in comparison to the other crossbreds. This finding suggested that selection or the variability of wool score within the crossbred groups could lead to a reduction in the crossbred wool.

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2.2 Growth

Growth in sheep was referred to as the increase in linear size, weight, accumulation of adipose tissue and nitrogen and water retention (Edey, 1983). However, differentiation of specialized cells to form new tissues and the development of organs and functions as the animals grow should also be considered. Growth, at least to the weaning stage, constitutes part of the process of reproduction of the mother and the young animals itself must then continue to grow to reach sexual maturity and reproduce. Growth of sheep is usually divided into 2 sections: pre-weaning growth, during which the maternal influence through milk intake is important and post-weaning growth during which the animal exhibits its own independent capability for growth while eventually achieving mature size.

Growth traits are known to have positive correlations, both genetic and phenotypic. The significance of season of birth for early growth performance may thus be responsible as a carryover effect, for its significant influence on growth traits up to yearling (Mavrogenis, *et. al.*, 1980; Dzakuma, *et. al.*, 1978; Osman and Bradford, 1965). In the Federal Republic of Germany, West African Dwarf hair sheep males and females were reported to have age at sexual maturity between 6 – 8 months and 12 – 16 months respectively while mature size was achieved between the age of 2 – 2½ years old (Banze-Ngoy, 1985).

The maturity weight for the Sri Lankan native hair sheep was on the average of 25 and 19 kg for the males and females respectively (Goonewardene, *et. al.*, 1984). Rastogi (2001) in his studies on the production performance of the Barbados Blackbelly hair sheep in Tobago, West Indies found that sex of the lambs was not a significant variation for growth. Effect of the type of birth on the other hand was significant for the growth traits of the lambs and total lamb weight at weaning. In this study he also found that lambs born as singles were heavier than those born as twins or more.

Merkel, *et. al.*, (1999) reported that from the comparative performances of five (5) sheep genotypes in Indonesia: Sumatran, Virgin Island St. Croix, St Croix x Sumatran, Barbados Blackbelly x Sumatran and Sei Putih hair sheep (25% St. Croix, 25% Barbados Blackbelly, 50% Sumatran), the relative growth rates were similar among the genotypes, as were feed conversion efficiencies, which ranged from 190 to 208 g gain/kg feed consumed. They concluded that the Sei Putih hair sheep had a relatively high growth potential and could contribute to increased sheep production in Indonesia.

Studies on the development of synthetic hair sheep by crossbreeding purebred Malaysian Long Tail with Cameroon hair sheep had resulted in the F1 crossbred lambs (Malaysian Long Tail x Cameroon) that had 25% higher dry matter intake and 40% higher body weight gains than the purebred lambs (Antongiovanni, *et. al.*, 1995). The F_1 crossbred lambs showed significantly improved performance after weaning when compared to the purebred lambs (Noraida and Mukherjee, 2004).

Comparative performance of several breeds of Caribbean hair sheep, Barbados Blackbelly (BB), West African Dwarf (WAD), Blackhead Persian (BP), Blenheim Grade (BG) (developed from crosses of various breeds) and Virgin Island White (VIW) sheep and their 2-, 3- and 4- breed combinations were studied by Rastogi, *et. al.*, (1993). They reported that the BB, WAD and BG lambs had similar growth rates and were superior to the BP and VIW breeds. The purebreds and the 2- breed cross lambs were found to have similar growth rates and were superior in average daily gain and weaning weight. Only the birth weight showed significant differences in general combining ability of breeds and reciprocal effects.

In another experiment conducted by Pineda, *et. al.*, (1998), for the fattening of Pelibuey and crossbreds (Rambouillet-Dorset x Pelibuey) in the Mexican tropics, the animals were fed with a ration of 6% Guinea grass and 94% of a mixture of 37.5% poultry litter, 37.5% corn, 14.5% molasses, 7% coconut oilmeal, 2% urea, 1% salt and 0.5% minerals. They found that feed conversion efficiency for the crossbreds and the males were better than the purebreds Pelibuey and the females respectively. After 64 days of fattening, the daily weight gain for the crossbreds were 238 g in comparison to 182 g for the purebreds while that for the males and females were 182 g and 102 g ($P<0.05$) respectively. Crossbreds and males significantly achieved desirable slaughter weight earlier than the purebreds and females. They concluded that F_1 crossbreeding of hair sheep with larger wool breeds could produce crossbreds with a better feed conversion efficiency thus helping to obtain a higher weight gain in a shorter period of time.

Studies on the crossbred West African Dwarf and Sahel (West African Long-legged) sheep showed that differences in type of breed and sex of lamb were not significant for body weight at all ages up to 32 weeks (Arthur and Ahunu, 1989). They analysed and found that different body features in the growing sheep seemed to be more prominent at different ages and this reflected the differences in growth rates of different parts of the body. They suggested that the size and the shape of the head at birth, were of great importance when body size was being considered while at older ages head size and shape might not be important. This was consistent with the fact that the head was big in proportion to the body at birth, but was small in proportion to the body at older ages.

2.2.1 Birth weight

A summary of the birth weights of some hair sheep breeds and their crosses with wool sheep and different hair sheep breeds is tabulated in Table 2.2.

Sex of lamb, type of birth, age of dam, year of birth and ram effects were reported to be important sources of variation for growth traits from birth to 3 months of age (Djemali, *et. al.*, 1994).

The Santa Ines breed of Brazil and the the West African Dwarf of Germany were reported to be the hair sheep breeds that have the average birth weight of below 2.0 kg. Their average birth weight of the Santa Ines was 1.90 and 1.60 kg for the males and females respectively and the overall birth weight was 1.84 kg (Figueiredo, *et. al.*, 1983), while the average birth weight of the West African Dwarf was 1.73 kg whereby

Table 2.2 Birth weights of the various hair sheep breeds and their crosses to wool sheep breeds by sex and the type of birth

Year	Country	Breed	Birth weight (kg)					Reference
			Male	Female	Single	Twins	Aver.	
1972	Venezuela	Crossbred sheep	-	-	-	-	2.70	Gonzalez, 1972
1973	Venezuela	Barbados Blackbelly	-	-	-	-	2.50	Bodisco, 1973
1983	Venezuela	Barbados Blackbelly	-	-	2.73	2.49	2.54	Martinez, 1983
1983	Barbados	Barbados Blackbelly	3.04	3.01	3.52	2.88	3.03	Bradford, et. al., 1983
1983	Barbados	Barbados Blackbelly	3.37	2.87	3.22	3.10	3.10	Patterson, 1983
1983	Guyana	Barbados Blackbelly	2.17	2.45	2.58	2.23	2.33	Nurse, et al, 1983
1983	Tobago	Barbados Blackbelly	-	-	-	-	3.10	Rastogi, et. al., 1983
1983	Mexico	Barbados Blackbelly	2.84	2.65	2.73	2.00	2.12	Zarazua and Padilla, 1983
1983	Mexico	Pelibuey	2.60	2.40	2.70	2.10	2.50	Gonzales-Reyna, et. al., 1983
1983	Mexico	Pelibuey	2.62	2.47	2.66	2.13	2.49	Zarazua and Padilla, 1983
1983	Venezuela	Pelibuey	-	-	3.12	2.57	2.78	Martinez, 1983
1983	Venezuela	Pelibuey	2.44	2.40	2.62	2.12	2.42	Stagnaro, 1983
1983	Colombia	Pelibuey	2.59	2.34	2.65	2.20	2.45	Pastrana, et. al., 1983
1983	Brazil	Santa Ines	1.90	1.60	-	-	1.84	Figueiredo, et. al., 1983
1983	Tobago	Pelibuey	-	-	-	-	2.90	Rastogi, et. al., 1983

Table 2.2 continued

1983	Florida	St. Croix	-	-	-	-	2.70	Foote, 1983
1983	Florida	Florida Native	-	-	-	-	2.80	Foote, 1983
1983	Utah	St. Croix	2.86	2.63	3.13	2.68	2.74	Foote, 1983
1983	Togo	Vogan (West African Dwarf x West African Long-Legged)	-	-			2.25	Amegee, (1983)
1983	Tobago	Blackhead Persian	-	-	-	-	3.00	Rastogi, et al., 1983
1983	Venezuela	Blackhead Persian	-	-	2.50	2.08	2.49 '	Martinez, 1983
1983	Venezuela	Criollo	-	-	2.87	2.44	2.76	Martinez, 1983
1983	Florida	SC x FN	-	-	-	-	2.80	Foote, 1983
1983	Guyana	BB x Creole	2.88	2.60	2.83	2.56	2.78	Nurse, et. al., 1983
1983	Missisippi	BB x Suffolk	3.37	3.36	3.99	3.20	3.36	Boyd, 1983
1983	Missisippi	(BB x Dorset Horn) x Suffolk	4.12	3.95	4.56	3.74	4.05	Boyd, 1983
1983	Utah	St. Croix x Rambouillet	4.54	3.17	4.45	3.98	4.16	Foote, 1983
1983	North Carolina	BB x Dorset Horn	-	-	-	-	3.90	Goode, et. al., 1983
1985	Germany	- West African Dwarf	-	-	2.03	1.43	1.73	Banze – Ngoy, 1985

Table 2.2 continued

1989	Virgin Island	Barbados Blackbelly	-	-	-	-	2.80	Wildeus, 1989
1991	Colombia	- African hair breed	-	-	-	-	2.32	Mejia, et. al., 1991
1992	N.E. Brazil	Santa Ines	-	-	-	-	2.80	Rajab, et. al., 1992
1993	Mexico	Barbados Blackbelly	-	-	-	-	2.51	Carillo and Segura, 1993
1993	Mexico	Pelibuey	-	-	-	-	2.59	Carillo and Segura, 1993
1993	Mexico	BB x Pelibuey	-	-	-	-	2.63	Carillo and Segura, 1993
1993	Mexico	Pelibuey x BB	-	-	-	-	2.43	Carillo and Segura, 1993
1993	Trinadad	Barbados Blackbelly (BB)	-	-	-	-	2.85 '	Rastogi, et. al., 1993
		West African (WA)	-	-	-	-	2.83	
		Blackhead Persian (BHP)	-	-	-	-	2.38	
		Blenheim Grade (BLG)	-	-	-	-	2.76	
		Virgin Island White (VIW)	-	-	-	-	2.61	
1993	Trinadad	BB x WA	-	-	-	-	2.77	Rastogi, et. al., 1993
		WA x BB	-	-	-	-	2.87	
		BB x BHP	-	-	-	-	2.77	
		BHP x BB	-	-	-	-	2.58	

Table 2.2 continued

1993	Trinadad	WA x BHP	-	-	-	-	2.63	Rastogi, et. al., 1993
		BHP x WA	-	-	-	-	2.76	
		VIW x BB	-	-	-	-	2.59	
		VIW x WA	-	-	-	-	2.69	
1994	Malaysia	Barbados Blackbelly)	-	-	-	-	2.05	Khusahry, et. al., 1994
		Virgin Island White (VIW)	-	-	-	-	2.57	
		Uda	-	-	-	-	3.29	
		Uda x Malin	-	-	-	-	1.92	
		Uda x Dorset Malin VIW	-	-	-	-	2.20	
		x Malin	-	-	-	-	1.97	
		VIW x Dorset Malin	-	-	-	-	1.99	
		BB x Malin	-	-	-	-	2.56	
		BB x Dorset Malin	-	-	-	-	2.14	
1994	Malaysia	Cameroon	-	-	-	-	2.65	Noraida, et. al., 1994
		Thai Long Tail	-	-	-	-	2.80	
		Cameroon x Thai Long Tail	-	-	-	-	2.91	
1996	Mexico	Pelibuey	-	-	-	-	2.45	Galina, et. al., 1996

Table 2.2 continued

1996	Mexico	Barbados Blackbelly	-	-	-	-	2.85	Galina, et. al., 1996
1997	Indonesia	BB x Sumatra	-	-	-	-	1.97	Gatenby, et. al., 1997
		Virgin Island White x Sumatra	-	-	-	-	1.95	
		Java fat-tail x Sumatra	-	-	-	-	1.82	
		Sumatra	-	-	-	-	1.71	
1997	Virgin Island	Barbados Blackbelly	-	-	-	-	2.90	Godfrey, et. al., 1997
1997	Virgin Island	St. Croix	-	-	-	-	3.20	Godfrey, et. al., 1997
1997	Virgin Island	Florida Native	-	-	-	-	2.50	Godfrey, et. al., 1997
2000	Indonesia	Sumatran	-	-	-	-	1.30	Doloksaribu, et. al., 2000
		Virgin Island x Sumatran	-	-	-	-	1.80	
		Barbados Blackbelly x Sumatran	-	-	-	-	2.00	
2001	Tobago, West Indies	Barbados Blackbelly	-	-	-	-	2.75	Rastogi, 2001

Table 2.2 continued

2003		Dorper x St. Croix	-	-	-	-	3.60	Burke, et. al., 2003
		Dorper x Romanov x St. Croix	-	-	-	-	3.00	
		Katahdin	-	-	-	-	3.60	
		St. Croix	-	-	-	-	3.00	
		¾ St. Croix x ¼ Romanov	-	-	-	-	3.10	
2004	Malaysia	Cameroon (C)	-	-	-	-	2.52	Noraida, et. al., 2004
		Thai Long Tail (TLT)	-	-	-	-	2.82	
		F_1 (C x TLT)	-	-	-	-	2.68	
		F_2 (F_1 x F_1)	-	-	-	-	2.48	
		F_3 (F_2 x F_2)	-	-	-	-	2.74	
		BC_1 (C male x TLT female)	-	-	-	-	2.83	
		BC_2 (TLT male x C female)	-	-	-	-	2.72	

the birth weights of the single and the twin born lambs were 2.03 kg and 1.43 kg respectively (Banze-Ngoy, 1985).

In a study conducted by Galina, *et. al.*, (1996), they reported that the Barbados Blackbelly, St. Croix and Pelibuey had comparatively higher birth weights than the Santa Ines in Brazil. In another study, St. Croix lambs were found to be lighter at birth than the Rambouillet's but St. Croix sired lambs had intermediate birth weight between the two parental breeds (Foote, 1983). In 2001, Rastogi reported that in Tobago West Indies, the Barbados Blackbelly hair sheep had the birth weight of 2.75 kg and the pre-weaning daily gain of 152 g.

The Vogan hair sheep (West African Dwarf x West African Long – Legged) that was developed in Togo had the birth weight of 2.0 – 2.5 kg and there were 62.86%, 34.42% and 2.92% occurrence of single, twin and triplet births respectively (Amegee, 1983).

Lallo, *et. al.*, (1994) reported that the birth weight of Barbados Blackbelly lambs raised intensively on sugarcane and agro-by-products ranged between 2.7 - 3.4 kg while African hair breed ewes fed on diets of chopped fresh sugarcane tops ad libitum with or without king grass (*Pennisetum purpureum* x *Pennisetum americanum*) had their lambs birth weight of 2.32 ± 0.52 kg (Mejia, *et. al.*, 1991).

In a study involving the performance of crossbred and indigenous sheep under village conditions in the cool highlands of central-northern Ethiopia, Hassen, *et. al.*, (2002) reported that crossbred lambs were heavier than indigenous lambs at birth and at all ages. However the Crossbred lambs were not significantly better than indigenous lambs in average daily gains. They added that the birth weight advantage was also lost with increasing age, indicating that the milk production of the ewes of the dam breed was inadequate to rear large size crossbred lambs (Hassen, *et. al.*, 2002)

Burke, *et. al.*, (2003) studied the effect of breed-type on performance and carcass traits of intensively managed hair sheep to evaluate the growth performance and carcass characteristics of intensively managed purebred and crossbred hair sheep and to determine the value of the Dorper breed as a terminal sire on St. Croix and St. Croix-cross dams. Animals used were Dorper x St. Croix (DS), Dorper x Romanov x St. Croix (DX), Katahdin (KA), St. Croix (SC) and ¾ St. Croix-¼ Romanov (SX) wether lambs. They found that from birth to weaning, daily gains (ADG) were greater (P<0.01) for DS and KA lambs than SC and SX lambs while from weaning to harvest ADG was greatest (P<0.01) for DS followed by DX, SC, SX and KA lambs. Carcass weights were heavier (P<0.01) for DS than all other breeds. DS, DX, KA and SX carcasses had greater (P<0.01) fat thickness measurements than SC carcasses. Results indicate that improvements in live animal performance, carcass muscularity, and quality can be achieved by using Dorper sires on purebred and crossbred St. Croix dams.

No significant difference was found between the birth weight of Barbados Blackbelly, Dorset and their crossbreds (Boyd, 1983) but lambs from the crosses between Barbados Blackbelly ewes and Dorset sires were reported to have significantly higher birth weights than the purebred Dorset (Goode, *et. al.*, 1983).

Rastogi, *et. al.*, (1993) studied the comparative performance of several breeds of Caribbean hair sheep, Barbados Blackbelly (BB), West African Dwarf (WAD), Blackhead Persian (BP), Blenheim Grade (BG) (developed from crosses of various breeds) and Virgin Island White (VIW) sheep and their 2-, 3- and 4- breed combinations. They reported that the BB, WAD and BG lambs had similar growth rates and were superior to the BP and VIW breeds. The purebreds and the 2- breed cross lambs were found to have similar growth rates and were superior in average daily gain and weaning weight. The growth performance of the lambs in this study was found to be markedly superior to that of the same pure breeds born at the same station during the month of October 1974 (Rastogi, *et. al.*, 1979).

In Malaysia, Khusahry, *et. al.*, (1994) studied the effects of the breed of sires on the preweaning growth performance of hair sheep crosses. They reported that the average birth weights of lambs from purebred Malin and Dorset Malin (DM) were 1.80 and 1.98 kg. Lambs from Malin, Dorset Horn x Malin (DM) and Uda ewes mated with Uda rams had the average birth weights of 1.92, 2.20 and 3.29 kg respectively while lambs from Malin, DM and Virgin Island White (VIW) mated with VIW rams had the respective average birth weights of 1.97, 1.99 and 2.57 kg. Lambs of Malin, DM and Barbados Blackbelly (BB) ewes sired by BB had birth weight averaged 2.56, 2.14 and 2.05 kg. respectively.

In another study, Noraida, *et. al.*, (1994) reported the birth weights of the Cameroon hair sheep, Thai Long Tail wool sheep and their F_1 crosses managed under the intensive management system as 2.65 ± 0.11, 2.80 ± 0.49 and 2.91 ± 0.38 kg respectively, showing that the weights of the crossbreds were intermediate of the birth weights of the two parental breeds. No significant difference was observed between the birth weights of the genotypes. In 2004, Noraida and her co-workers reported the least square means of the birth weights of the Cameroon (C) hair sheep and the Thai Long Tail (TLT) wool sheep were 2.52 ± 0.16 kg and 2.82 ± 0.04 kg respectively, while the birth weights of their F_1 (C x TLT), F_2 (F_1 x F_1), F_3 (F_2 x F_2), BC_1 (F_1 male x TLT female) and BC_2 crosses were 2.68 ± 0.04 kg, 2.48 ± 0.05 kg, 2.74 ± 0.08 kg, 2.83 ± 08 kg and 2.72 ± 0.07 kg respectively.

Comparative studies on the Sumatran sheep and three hair sheep crossbreds in Indonesia revealed that the Barbados Blackbelly and Virgin Island sired lambs were heavier at birth than the Java Fat-tail crossbreds and the Sumatra purebred lambs (Gatenby, *et. al.*, 1997). For Sumatran, Java fat-tail (Indonesian Fat-tailed) x Sumatran

(E1), Virgin Island (Virgin Island White) x Sumatran (H1) and Barbados Blackbelly x Sumatran (B1) ewes mated to the same breed type, the mean birth weights of the Sumatran, E1, H1 and B1 lambs were 1.45, 1.62, 2.03 and 2.10 kg respectively. The average birth weights of the crossbred lambs was 1.83 kg.

American hair sheep breeds were reported to have higher birth weights than the Djallonke sheep in West Africa, occasionally as high as the Dorset wool sheep. Crossbreds between hair sheep breeds of Barbados Blackbelly, St. Croix and Pelibuey, and wool breeds with high birth weights had showed lambs having birth weights comparable to those of the superior parental breeds (Halbeisen, 1998).

Crossing and inter se matings were carried out using the Barbados Blackbelly and St. Croix hair sheep to the Sumatran sheep. The result revealed that the birth weight and the weaning weight for the matings of Barbados Blackbelly rams to St. Croix ewes were higher than their reciprocal matings but the differences were not significant (Subandriyo, *et. al.*, 1998).

Crossbred of West African Dwarf and Sahel (West African Long-legged) sheep showed that differences in type of breed was not significant for body weight at all ages up to 32 weeks. Birth weight was also not significantly affected by the season of birth (Arthur and Ahunu, 1989).

2.2.1.1 Effect of sex on birth weight

Birth weight was found to have not affected by the sex of lambs (Sinha and Singh, 1997; Arthur and Ahunu, 1989) but findings from other authors showed that sex of the lambs did show significant effect on their weights at birth. Several authors reported the significant effects of sex on the birth weights of American hair sheep lambs (Gatenby, *et. al.*, 1997; Ulusan and Bekyurek, 1996; Bunge, *et. al.*, 1995; Ogan, 1994;

(E1), Virgin Island (Virgin Island White) x Sumatran (H1) and Barbados Blackbelly x Sumatran (B1) ewes mated to the same breed type, the mean birth weights of the Sumatran, E1, H1 and B1 lambs were 1.45, 1.62, 2.03 and 2.10 kg respectively. The average birth weights of the crossbred lambs was 1.83 kg.

American hair sheep breeds were reported to have higher birth weights than the Djallonke sheep in West Africa, occasionally as high as the Dorset wool sheep. Crossbreds between hair sheep breeds of Barbados Blackbelly, St. Croix and Pelibuey, and wool breeds with high birth weights had showed lambs having birth weights comparable to those of the superior parental breeds (Halbeisen, 1998).

Crossing and inter se matings were carried out using the Barbados Blackbelly and St. Croix hair sheep to the Sumatran sheep. The result revealed that the birth weight and the weaning weight for the matings of Barbados Blackbelly rams to St. Croix ewes were higher than their reciprocal matings but the differences were not significant (Subandriyo, *et. al.*, 1998).

Crossbred of West African Dwarf and Sahel (West African Long-legged) sheep showed that differences in type of breed was not significant for body weight at all ages up to 32 weeks. Birth weight was also not significantly affected by the season of birth (Arthur and Ahunu, 1989).

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Rastogi, *et. al.*, 1993; Carillo and Segura, 1993; Wildeus, 1989; Bradford, *et. al.*, 1983; Martinez, 1983; Patterson, 1983; Zarazua and Padilla, 1983).

Sex of lamb was one of the important sources of variation for growth traits from birth to 3 months of age. Male and single lambs were found to grow faster than female and multiple lambs (Djemali, *et. al.*, 1994). Sex variation was reported to be important as the lambs grew older (Hassen, *et. al.*, 2002)

At the Mococha Experimental Centre in Yucatan, Mexico, male lambs of the Pelibuey and Barbados Blackbelly hair sheep breeds were found to be heavier at birth and gained weight faster than female lambs. The lambs born from Pelibuey were heavier than that of the Barbados Blackbelly (Carillo and Segura, 1993).

Studies done by Noraida, *et. al.*, (1994) in Malaysia showed that under intensive type of management sex had significant ($P<0.05$) effect on the birth weights of the Cameroon hair sheep, Thai Long Tail wool sheep and their F1 (Cameroon males x Thai Long Tail females) crossbred lambs. The males were found to be significantly ($P<0.05$) heavier than the females at birth. During the period of this study the birth weights of the Cameroon, Thai Long Tail and the F_1 crossbred males were reported as 2.73 ± 0.04, 2.95 ± 0.55 and 2.98 ± 0.40 kg while that of the females were 2.58 ± 0.11, 2.73 ± 0.44 and 2.85 ± 0.36 kg respectively.

2.2.1.2 Effect of the type of birth on birth weight

Birth type had significant effect on lamb birth weight (Ogan, 1994; Rastogi, *et. al.*, 1993). Birth type and also the year of birth had significant effect on lamb weight (Rastogi, *et. al.*, 1993; Carillo and Segura, 1993).

Type of birth (single or twin) significantly affected birth weight in both Ramlic and Daglic breeds (Ulusan and Bekyurek, 1996). The percentage of single, twin and triplet births for the Vogan hair sheep (West African Dwarf x West African Long – Legged) in Togo were reported as 62.86, 34.42 and 2.92% respectively (Amegee, 1983). West African Dwarf hair sheep in the Federal Republic of Germany was reported to have the average birth weight of 1.80 – 2.26 kg for the single- born and between 1.35 – 1.50 for the twin lambs (Banze-Ngoy, 1985).

Significant (P<0.01) effect of the type of birth (single versus twins) was also reported by Noraida, *et. al.*, (1994) from their studies on the purebreds (Cameroon hair sheep and Thai Long Tail wool sheep) and the crossbreds (Cameroon males x Thai Long Tail females) of the two genotypes in Malaysia.

The type of birth was also reported by several authors to have an effect on the birth weight of the lambs. These include the birth weights of the Barbados Blackbelly hair sheep in Caribbean (Wildeus, 1989), in Pelibuey hair sheep in Mexico (Zarazua and Padilla, 1983), Djallonke hair sheep in Ghana (Tuah and Baah, 1985), in West African Djallonke sheep (London, 1993; Armbruster, *et. al.*, 1991; Filius, 1984), West African Dwarf hair sheep kept in ile- Ife, Nigeria (Odubote, 1992), American hair breeds and prolific wool breeds in Southern Illinois (Bunge, *et. al.*, 1995), hair sheep in Mexico, (Carillo and Segura, 1993), St. Croix and Uda hair sheep (Gatenby, *et. al.*, 1997), hair sheep in Venezuela (Martinez, 1983), lambs from the crosses between the Nigerian Dwarf sheep with Uda, Permer and Yankasa hair sheep (Taiwo, *et. al.*, 1982), in the hair sheep breeds in America and their crossbreds (Bradford, *et. al.*, 1983), the crossbreds of Djallonke with Sahelian (Kabuga and Akowuah, 1991), in the crossbreds between Sumatran sheep and Barbados Blackbelly (Yapi, 1993), in Barbados Blackbelly and crossbred sheep in Barbados (Patterson, 1983).

2.2.1.3 Effect of ewe body weight on birth weight

Birth weight increased with dam body weight in mid-pregnancy ($P<0.001$), and weaning weight and growth rate increased with dam body weight (Hall, *et. al.*, 1995). Survival of the lambs was reported to be primarily a function of birth weight. Lambs weighing 4.00 kg at birth from primiparous dams were found to have had survival rates of 76%, when compared to 88% for lambs from multiparous dams ($P<0.01$). No lamb with birth weight of <2.00 or ≥6.30 kg survived and 48% of death occurred within one day of birth.

2.2.2 Weaning weight and subsequent body weights

Two periods of growth had been described in sheep (Edey, 1983). One is pre-weaning growth, during which the maternal influence through milk intake is important and secondly the post-weaning growth, during which the animal exhibits its own independent capability to keep on growing until it reach its mature size. At least to the weaning stage, growth of the animals usually constitutes part of the process of reproduction of the mother, and the young animals itself must then continue to grow to reach sexual maturity and reproduce (Edey, 1983).

In Tobago, West Indies the Barbados Blackbelly hair sheep was reported to have the pre-weaning daily weight gain, weaning weight, body weight at 56 days and 6 months old as 152 g, 16.7 kg, 10.80 kg and 19.20 kg respectively (Rastogi, 2001).

In an on- station assessment of performance of the DS synthetic and parental sheep breeds, D'man and Sardi, between the year 1998 and 2000, Boujenane, *et. al.*, (2003) compared the performance of DS synthetic breed of sheep (50% D'man and 50% Sardi genes) and showed that the breeds differ for weight at breeding, litter size at birth and at 90 days, litter weight at birth ($P<0.01$), but were similar for fertility, litter weight at 90 days and gestation length (P<0.05). They found that the performance of DS ewes were in general intermediate to those of the parental breeds. DS ewes were lower than average of the parental breeds for weight at mating by 3%, litter size at 90 days by 3.5%, and litter weight at birth by 10.2%. Milk production during the 2-month lactation was identical for Sardi, D'man, and DS breeds (P<0.05). DS lambs were intermediate to those of D'man and Sardi lambs for weight at birth, 30 and 90 days, whereas pre-weaning growth was higher. Although the DS lambs were 9.4% lighter at birth but they were 0.6 and 2.3% heavier at 30 and 90 days than the average of the parental D'man and Sardi breeds. Carcass characteristics for DS lambs were close to those of the best parental breed. Lamb survival to 90 days, fattening growth and feed efficiency did not differ among breeds (P>0.05). They concluded that the DS synthetic breed could be considered as a purebred flock or maternal breed for market lamb production.

Mandal, *et. al.*, (2003) studied the growth traits of Muzaffarnagari sheep at the Central Institute for Research on Goats, Makhdoom, Mathura, India and obtained the following results. The average weight at 12 months of age was 28.0 ± 0.6 kg, the pre- and post-weaning average daily weight gain were 127.8 ± 3.30 g and 49.4 ± 1.60 g, and the associated growth efficiencies were 3.59 ± 0.08 g and 0.95 ± 0.03 g. There was a significant differences associated with the year of lambing in body weight, weight gain and efficiency in weight gain at different stages of growth. At almost all stages of growth the males were found to be heavier and had a higher weight gain than females. The difference tended to increase with age. Single born lambs were superior to those born in multiple births at all stages of growth.

In another study, Matika, *et. al.*, (2003) analysed and described the growth, carcass and reproductive traits of Sabi sheep in Zimbabwee from 1984 to 1994. They found that year of birth, sex, birth/rearing status of lamb, dam age, age of lamb and slaughter age were significant sources of variation for body weights and average daily gain, except for age (P>0.05) of lamb at 18 months of age. Significant (P<0.001) difference was obtained between the year of birth and sex for pre-weaning average daily gain, 12- and 18-month weight and for birth status and sex for lamb survival. They reported that the least square means for body weights (kg) and average daily gains (g per day) were 2.63 for birth weight (BW); 17.2 for weaning weight (WW) (recorded at 120 days of age); 23.5 for 12-month weight (12W); 35.7 for 18-month weight (18W); 124 for average daily gain between birth and weaning; 21.7 for total litter weaned; 14.6 for Kleiber ratio. The average weight of ewe at mating, in May/June were 38 kg, and 35.6 kg for post-partum in Oct/Nov and 26.2 kg at weaning in February.

According to Saatci, *et. al.*, (2003), live weight can be improved by supplementary feeding of lambs. They compared traditional rearing system based on pasture and hay supplementation with rearing systems based on supplementation of barley based concentrate on Tuj (Tushin) lambs. The lambs were slaughtered and carcasses were evaluated at the end of 150 days experimental period. The result showed that liveweights of group T (control managed as a traditional system with grazing and hay as the main feed sources), TC (lambs were separated from the main flock once a day and offered 500 g concentrate per animal) and C (lambs were separated from the main flock and fed 175 g per day per animal hay and 1 kg per day per animal concentrate) were 36.4, 38.2 and 41.3 kg respectively. They concluded that feeding animals with barley based concentrate instead of hay is profitable for breeders.

Under the intensive management system at the University of Malaya's (Kuala Lumpur, Malaysia) nucleus farm, the weaning weight at 90 days old and the weight at 270 days old for the Cameroon hair sheep bred in Malaysia were reported as being 12.19 ± 2.08 kg and 18.64 ± 2.67 kg. The F_1 crossbreds of the Cameroon males and the Thai Long Tail wool sheep females had the weaning weight and 270 weight of 14.85 ± 2.62 kg and 24.24 ± 3.21 kg, while that of the purebred Thai Long Tail were 14.19 ±

3.00 kg and 23.09 ± 4.40 kg respectively (Noraida, *et. al.*, 1996). The effect of genotype was found to be significant ($P<0.05$) at the age of 270 days only.

Khusahry, *et. al.*, (1994) reported the average weaning weights at 90 days of lambs from Malin, Dorset Horn x Malin (DM) and Uda ewes mated with Uda rams had the average as 11.97, 13.02 and 17.73 kg versus 10.92, 12.11 and 12.65 kg in lambs from Malin, DM and Virgin Island White (VIW) mated with VIW rams, 14.71, 14.09 and 11.69 for lambs of Malin, DM and Barbados Blackbelly (BB) ewes sired by BB. The 90 days weight of the lambs from purebred Malin and DM ewes averaged 9.68 and 11.38 kg respectively.

Gatenby, *et. al.*, (1997) reported the average weaning weight of the crossbred lambs from the crosses between Sumatran ewes and Java Fat-tail (Indonesian Fat-tailed) (E1), Virgin Island (Virgin Islands White) (H1) and Sumatran (S) rams or were inseminated with Barbados Blackbelly (B1) semen was 8.70 kg. The mean weaning weights for the lambs born to the Sumatran, E1, H1 and B1 were 8.5, 9.2, 11.7 and 12.1 kg respectively. Weaning weights of the males were higher than the females. The average weights at 6 and 9 months for the female lambs were 14.40 kg and 17.90 kg. The average increases in the weights of the E1, H1 and B1 crossbreds in comparison to the Sumatran breeds were 10-13, 14-15 and 32% respectively. All the breed groups had similar wool scores at the age of three months but the at older ages the scores were in the increasing order of Barbados Blackbelly, Virgin Island, Java Fat-Tail and Sumatran.

Weaning weights among the F_1 crossbreds, F_2 crossbreds, Barbados Blackbelly x Sumatran, St. Croix x Sumatran and St. Croix Sheep were found to be significantly different after the effects for season, sex, age of dam and the type of birth (single or multiple) were adjusted (Subandriyo, *et. al.*, 1998). However the inter se crossbreds did not differ significantly from the crossbreds between the Barbados Blackbelly x Sumatran and St. Croix x Sumatran sheep.

2.2.3 Average daily weight gain (ADG) for growth performance

West African Dwarf hair sheep in the Federal Republic of Germany was reported to have an average daily gain from birth to the age of 3 months of between 80 – 90 g and that from 3 – 18 months of between 45 – 60 g (Banze-Ngoy, 1985).

Studies on the Barbados Blackbelly hair sheep in Tobago, West Indies have found that the pre-weaning daily weight gain of the lambs was 152 g (Rastogi, 2001). While for tropical hair sheep lambs from Barbados, the average daily weight gain for Barbados x Blackhead Persian, fed on fresh whole chopped sugarcane plus soya bean (SBM) and poultry byproduct meal (PBM) was evaluated by Lallo and Garcia (1994). As a substitute for SBM in the four treatments PBM nitrogen replaced 0, 33, 67 and 100% of nitrogen from the SBM in the diet and the average daily gain ($P<0.05$) obtained was 142, 171, 148 and 161 g/lamb daily respectively. They concluded that lambs fed on the 100% PBM diet had higher daily gain ($P<0.05$) than those fed on the 100% SBM diet.

Crossbreeding hair sheep rams with larger wool breeds ewes would enable to obtain crossbreds and males with better feed conversion efficiency and thus could obtain a higher weight gain within a shorter time (Pineda, *et. al.*, 1998; Olazaran, *et. al.*, 1991; Torres, *et. al.*, 1978). The finding was concluded from their studies on Pelibuey hair sheep and Pelibuey x Ramboullet-Dorset in Mexico. The Pelibuey hair sheep were allowed to graze in the Mexican tropical climate have shown that they had low weight gains from 40-80 g per day (Torres, *et. al.*, 1978) while Pelibuey crossbreds could gained 110-110 g per day (Olazaran, *et. al.*, 1991). Daily weight gains after 64 days of finishing with 65 guinea grass and 94% a mixture of 37.5 poultry litter, 37.5% maize, 14.5% molasses, 7% coconut oilmeal, 2% urea, 1% salt and 0.5% minerals was found to be significantly ($P<0.05$) higher in the crossbreds of Pelibuey x Rambouillet-Dorset

(238 g) than that of the Pelibuey hair sheep (182 g), while between the sexes showed that the males gained significantly (P<0.05) higher than the females, at 182 g and 102 g respectively (Pineda, *et. al.*, 1998). Similar results were obtained after 34 days of finishing. The studies also showed that the crossbreds and the males had better feed conversion efficiency than the purebreds and the females.

Khusahry, *et. al.*, (1994) reported that the average daily weight gain (P<0.01) of lambs sired by hair sheep rams were in the descending order 136 g, 132 g, 100 g for Barbados Blackbelly x Malin, Barbados Blackbelly x (Dorset-Horn x Malin) lambs, Virgin Island White x Malin respectively, while for the Uda purebreds and Malin purebreds lambs, the daily weight gain averaged 160 g and 87 g respectively. Thus the daily weight gain was highest in the Uda purebreds hair sheep and lowest in Malin purebreds wool sheep.

In another study involving the F_1 (Cameroon males x Thai Long Tail females) crossbreds, the purebreds Cameroon hair sheep and Thai Long Tail wool sheep, the average daily gain from birth to 90 days (pre-weaning) was higher than that after weaning. Under the intensive management system the average daily gains of the crossbreds and the purebreds were 0.132 g, 0.016 g and 0.126 g before weaning and 0.059 g, 0.035 g and 0.049 g respectively for the F_1, Cameroon and Thai Long Tail sheep (Noraida, *et. al.*, 1994).

For the five sheep genotypes studied in Indonesia, (Merkel, *et. al.*, 1999) reported their average daily weight gain as 209, 196, 192 and 179 g/day for the Barbados Blackbelly x Sumatran, Virgin Island St. Croix, Sei Putih hair sheep (25% St. Croix, 25% Barbados Blackbelly, 50% Sumatran) and St. Croix x Sumatran respectively. Fed ad lib with the grass *Brachiaria brizantha* and supplemented with concentrate at 0.7% body weight, 18% crude protein and 2.8 Mcal. metabolizable energy/kg, the four genotypes showed significantly (P<0.05) higher average daily weight gain than that of the purebred Sumatran sheep (155 g/day). The relative growth rates were similar among the genotypes, as were feed conversion efficiencies, which ranged from 190 to 208 g gain/kg feed consumed. They concluded that the Sei Putih hair sheep has a relatively high growth potential and could contribute to the increased sheep production in Indonesia.

The average daily gain or pre-weaning growth weight of African hair breed bred in Colombia and fed on diets of chopped fresh sugarcane tops ad libitum with or without king grass (*Pennisetum purpureum* x *Pennisetum americanum*) forage, 10% molasses/50% urea block, poultry litter and rice polishings (9:1) and fresh *Gliricidia sepium* foliage 3 kg/100 kg live weight, daily weight gain was reported as 106 ± 0.43 g/day (Mejia, *et. al.*, 1991).

Sinha and Singh (1997) described that lambs maintained in feedlots had better average daily gain and higher weights than those grazed plus supplementary feeding in groups. They also reported that season of birth have an effect on the average daily gain (ADG) at 3-6 months (ADG2) and at 0-6 months (ADG3). The linear regression effect of age of ewe at lambing was significant for ADG2 and ADG3, while linear and quadratic regression effects of age of ewe at lambing were significant for all traits except ADG3. Ram lambs had higher ($P<0.05$) final average body weight and liveweight gain than ewes.

2.2.4 Effect of nutrition on body weights

Godfrey and Dodson (2003) reported that strategic nutritional supplementation of hair sheep ewes might provide a method for increasing the weight of lambs produced during the dry season in the tropics, but it did not seem to be beneficial during the wet season. The result was produced from their studies on the effect of supplemental nutrition around the time of lambing (beginning 14 days before the expected date of lambing) on pregnant St. Croix White and Barbados Blackbelly hair sheep ewes during the dry (June – September) and wet (October – January) season in the US Virgin Islands. A group of ewes were fed a pelleted supplement in addition to grazing guinea grass pasture (FEED) while another group of ewes were allowed to graze on pasture only (CONTROL). The 24-hr milk production of each ewe was measured on days 7, 21, 35, 49 and 63. They found that the FEED ewes had higher lamb birth weight ($P<0.04$) and weaning weight ($P<0.05$) than CONTROL ewes (3.2 ± 0.1 and 12.2 ± 0.5 vs 2.9 ± 0.1 and 10.9 ± 0.5 kg, respectively) during the dry season. In the wet season, lamb birth weight and weaning weight were similar ($P<0.10$) between FEED and CONTROL (3.2 ± 0.1 and 15.5 ± 0.7 vs 3.1 ± 0.1 and 15.3 ± 0.6 kg, respectively).

In addition to that, Ben Salem and Nefzaoui (2003) suggested the potential use of feed blocks as alternative supplements for sheep and goats especially for stall-fed and grazing small ruminants raised under harsh environments. These could also help in the utilization of numerous agro-industrial by-products and thus to overcome constraints due to nutritional factors. They added that hard blocks, a mixture of agro-industrial by-products, urea, binder and preserver, improve digestion of low quality forages, thereby may help to increase body weights of the animals during their growing period. Other than that they also pointed out that another potential role of feed blocks is their use as efficient carrier of tannin-neutralising reagents (eg. Polyethylene glycol) to valorise tanniniferous shrubs and trees. Feed blocks may also reduce the use of concentrate feeds, thus reduce feeding cost and increase farmer's income.

2.2.5 Lamb mortality

The effects of season, year or geographical region were reported to influence mortality rates especially of the post-weaning growth phase including adulthood, through differences in fodder availability and parasite influence. Litter type and parity of dam have been shown to influence birth weights and can also affect survivability. Parity can affect the post-natal survivability rate through its influence on the mother's milk production (Filius, 1984).

The birth weight limit for not-surviving lambs were specified as 1.00 kg (Filius, 1984) while extremely small lambs were less likely to survive than lambs of intermediate weights (London, 1993).

In his study with the West African sheep on the island of Tobago, West Indies, Rastogi (2003) found that lambs with below average birth weight had significantly higher mortality than others (28.1% vs. 13.5%). Earlier, Rastogi (2001) reported the lamb mortality of the Barbados Blackbelly hair sheep in Tobago, West Indies was 18.8%. He found that lamb mortality was significantly ($P<0.05$) 27.8% for those with below average birth weight and 8.8% for those with the above average birth weight.

Hair sheep lambs, especially their crossbreds were reported to have better survivability and showed superior resistance to internal parasites when compared to wool sheep lambs (Fitzhugh and Bradford, 1983). The higher mortality rate of wool breed lambs and their crosses compared to hair sheep lambs was attributed to the superior adaptability of the hair sheep over the wool sheep to the tropical environment (Bunge, *et. al.*, 1993).

The pre-weaning lamb mortality rate could be affected by the age of dam (Gatenby, *et. al.*, 1997; Gonzales-Reyna, *et. al.*, 1991; Stagnaro, 1983) and they attributed this to the indirect effects of multiple birth frequency of ewes and birth weights of lambs.

Pre-weaning mortality was reported to be greater in twins and triplets lambs when compared to single born lambs (Gatenby, *et. al.*, 1997; Galina, *et. al.*, 1996; Gonzales-Reyna, *et. al.*, 1996; Bradford, *et. al.*, 1983; Foote, 1983). Thus birth weights could influence the survivability of the newborn lambs.

Other than birth weight, mortality was reported to increase with the increase in the number of litter size. Single born lambs were found to have the highest survival, whereas those born and raised as triplets or greater had the lowest survival (Boujenane, 2002; Gama, *et. al.*, 1991; Hinch, *et. al.*, 1985).

Galina, *et. al.*, (1996) reported that, in Barbados Blackbelly and Pelibuey hair sheep in Mexico there were 15% mortality in 2528 parturition during the 7 years study period with most of the losses were attributed to still birth, malnutrition, diarrhea and pneumonia. They found that mortality increased to 23% when more than two lambs were nursed by one ewe and reduced to 8% when only one lamb was born.

In Indonesia, Gatenby, *et. al.*, (1997) compared the reproductive performance of Sumatran sheep and its crosses with the Java Fat-tail, Virgin Island, Sumatran and Barbados Blackbelly. Out of the 568 lambings they reported lamb mortality to weaning at three months was 22.5%.

According to Filius (1984) and Tuah and Baah (1985) under controlled environment system, with proper management on health and diseases the pre-weaning mortality and mortality rate up to the age of one year old of the Djallonke sheep in Ghana could be reduced to about 10% and 15% respectively. On the other hand, Armbruster, *et. al.*, (1991) reported pre-weaning mortality as high as 50% for Djallonke sheep bred under traditional management system in West Africa.

2.3 Body conformation traits (BCT)

Animal growth was defined as the sum of the growth of the component parts of the carcass, that is meat, bone and skin. As age advances, these parts not only differ in their rates of growth, but they also depend on the levels of nutrition. Growth was also defined as an increase in size, not only in cell size but also in cell number and in extra cellular fluid (Hafez, 1974).

According to Fowler (1968), body composition of an animal is the chemical composition such as protein, lipid, water etc. in the body of the animal. The body composition of an animal is important in the growth of the animal. For example, an animal with the higher composition of protein and lipid will have better growth performance. The understanding of the changing of an animal body composition also enables the assessment of nutrient requirement for the growth of the animal. The age and diet of the animal affect the body composition of an animal.

The body composition of an animal will be changed as the age of the animal increases. A new born sheep has 21% of protein and 77% of water in its body composition but when the sheep reached the age of one year old, the percentage of protein increased to 27% while the percentage of water decreased to 73% (Reid, 1972).

Sheep growth however refers to the increase in linear size, weight, accumulation of adipose tissue and nitrogen, and water retention as well as the differentiation of specialized cells to form new tissues and organs, and the development of organs and functions as the animals grow (Edey, 1983).

2.3.1 Measurements of growth

Growth is a complex biological process that is induced by differential development rates of body tissues. In practice external measurements of the body have been used to estimate the development of the skeleton and/or soft tissues of the body. (Atta and Khidir, 2004)

Body measurements have been widely used for estimating animals' liveweight, especially when there is no access to weighing equipment. The method is more common for cattle (El Khidir, 1980), to a lesser extent for sheep, pigs and poultry (Lawrence and Fowler, 1997). Weighing machines have also been used to record body weight of goats, deer and rabbit in Malaysia. Besides body weight, body length, heart girth and body depth are commonly measured in animals. Each of these traits partially reflect the body conformation of animals.

No differences between ewes and rams with regard to their body measurements in Djallonke in Ghana (Ngere, 1973). He measured several body measurements and reported that at age of 15 months, their weights were 17 kg and with the average wither heights and chest girth of 48 cm and 65 cm respectively. Differences in individual wither height were attributed to the length of their legs.

For adult Nigerian Djallonke ewes, Dettmers (1983) found that their average wither heights and chest girth were 58 cm and 65.5 cm respectively. In comparison, the adult rams have the wither height of 63 cm and the chest girth of 86.5 cm. He suggested that adults rams and ewes differ with regard to their chest girth but the difference was not shown in growing animals.

Halbeisen (1998) reported that at the age of 12 months, Cameroon had a weight of 22.8 kg, wither height of 55.2 cm and chest girth of 62.5 cm. Although smaller than the Thai Long Tail wool sheep, the Cameroon represents a more compact body type than the Thai Long Tail.

Hupp and Deller (1983) compared the body measurements of 6 to 12 months old St. Croix ewes with that of the Djallonke ewes. At the weight of 23.2 kg, they found that the St. Croix ewes had the average wither height of 59.9 cm and a chest girth of 66 cm, which was higher in comparison to the in Djallonke ewes at the same weight. They concluded that the American hair sheep breeds have better meat type qualities than the West African Djallonke ancestors.

According to Sandford, *et. al.*, (1982), body length is the distance between scapula and pin bones, while Sulieman, *et. al.*, (1990) described it as the distance between tip of scapula and ischium. Sulieman, *et. al.*, (1990) added that body length and height at wither were skeletal measurements that were less variable than body weight while considering knee and hock heights as early maturing dimensions.

In Apennine sheep, selection reduced the variability of body measurements and at the same time helped to establish a breed standard (Panella, *et. al.*, 1993). Sharples and Dumelow (1990) postulated that dimensions could be predicted from body weight in Mule sheep and the Scottish Blackface breeds. Relationship between body measurements and body weight have also been investigated in sheep (Aziz and Sharaby, 1993) while Valdez, *et. al.*, (1997) used body measurements to predict body weight in sheep.

2.3.2 Biometrical measurements of growth

Biometrical measurements have been used to evaluate the characteristics of the animals that may vary due to the influence of breed evolution, environment and nutrition. Useful information on the suitability of the animals for selection and the outcome resulting from genetic improvement programmes could be evaluated on morphological basis (Riva, *et. al.*, 2003).

Brody (1945) used a nonlinear equation to describe growth based on heart girth and body weight of cattle that changed with the cubed heart girth while Lawrence and Fowler (1977) found that the coefficient of determination of multiple regression of heart girth and any other linear measurement on body weight was slightly higher than that of the simple regression of heart girth on body weight. They concluded that live weight estimations based on two or more body measurements were not more accurate than the estimations based on heart girth alone. For animals growing over a wide weight range, the relationship between live weight and heart girth has been reported to be curvilinear.

In another study, Chaturvedi, *et. al.*, (2003) assessed the body weight gain, body conformational changes and to develop the equation to predict the body weight based on body measurements in lambs fed with high concentrate roughage ratio, (75:25) diets containing graded levels of sodium bicarbonate (NaHCO3). They found that growth of lambs improved by 35% by 15.0 g NaHCO3 inclusion per kg diet than non-supplemented diet and the incorporation does not affect the feed conversion efficiency. They concluded that the body height, length, heart girth and paunch girth together can be used in predicting the body weight of intensively fed lambs with 86% confidence.

Objective measurements have been used for breed characterization (Martini, *et. al.*, 1993; Pena Blanco, *et. al.*, 1990) and to describe changes in size and shape (Arthur and Ahunu, 1989). Body measurements have also been studied in relation to age, live weight (Searle, *et. al.*, 1989b), nutrition (Searle, *et. al.*, 1989a), birth date, age of dam and litter size (Shrestha, *et. al.*, 1982).

2.3.3 Body conformation in various breeds

Riva, *et. al.*, (2003) studied body measurements in Bergamasca sheep to investigate the evolution of the Bergamasca sheep breed in the last two decades. Their body measurements were compared with the breed standard (BMST) and with those from a previous study conducted in 1984 (BM84). Animals were grouped into 12-24 months and >24 months of age. Height at withers (HW), height at rump (HR), depth of body (DB), width at shoulders (WS), hearth girth (HG), anterior pelvic width (APW), middle pelvic width (MPW), body length (BL), distance from the front to the back margin (HOCK1) and from the lateral to the medial margin (HOCK2) of hocks were measured on 495 Bergamasca sheep (466 ewes and 29 rams). In general, reductions of all body dimensions were observed compared to BMST and the largest decreases were for BL, APW and MPW. Compared to BM84, sheep older than 24 months were wider, with a slight increase in DB, HG and WS. Variations among these body measurements suggest that the breed standard need to be updated. Ewes raised in a transhumance system were taller, longer and showed a wider hock. On the contrary, ewes raised in a sedentary system were wider at chest and rump. Body measurements varied with increasing age: the smallest were for 12-18 months of age whereas little variation was observed after 18 months of age. In general, with the exception of young sheep in a sedentary system the first and second factor analysis largest positive association between variables and factors for measures concerning the width and height and the third was associated with body development. In conclusion, since variation in body width was not associated with body weight, body shape could possibly be improved to establish a tall animal with characteristic meat animal traits.

In another study, Sudan desert sheep was characterized by long legs and narrow trunk in adaptation to the natural habitat of the Savannah in which they have to travel long distances to search for pastures and water (Macleroy, 1961). On the other hand Nilotic sheep in Southern Sudan are well adapted with short legs and small body size suitable for a bushy and forest habitat.

The growth performance, slaughter traits and several conformation characteristics in Dorper sheep (hair and wool types) were evaluated under extensive conditions in the north-western Karoo region of South Africa from 1993 to 2000 (Snyman and Olivier, 2002). They found no significant differences between hair and wool type lambs for body weight from 42 days till 12 month of age. There were no significant differences between hair and wool type lambs for pre- or post-weaning growth rate. Their analysis of conformation tends to suggest that the hair type lambs were blockier with shorter legs, compared to the leggier appearance of the wool type lambs. They gave an evident from the longer carcass length (108.5 vs. 107.2 cm) and hind leg length of wool type lambs compared to hair type lambs. They also found that wool type lambs had heavier carcasses (19.6 vs. 19.2 kg) and higher dressing percentage (49.9 vs. 49.0%), than the hair type lambs although fat measurements and carcass grades were similar. They concluded that the economically important reproduction and growth traits were similar between the hair and wool types of Dorper sheep. Differences that occurred in some conformation and carcass traits would not effect the economic realisation from the different types.

2.3.4 Effect of the type of lambing and month of lambing

There are very few published report on the effect of type and month of lambing on body weight and body conformation traits.

Tabbaa (2003) studied and evaluated some factors affecting different body and fat-tail dimensions of Awassi ewes in Jordan. Body weight and dimensions and fat-tail dimensions were recorded immediately after lambing. They found that the type of lambing affected both hip width and heart girth. Month of lambing had significant influence on hip width, shoulder and hip heights and heart girth. Tail length was slightly affected by month of lambing. Significant interaction between sex of lamb and type of lambing was found on hip width and shoulder height and hip height. The coefficient of determinations had small values suggesting that other factors unaccounted for in the statistical model were responsible for the variation in these dimensions.

Type of birth had no significant effects ($P<0.05$) on body measurements of Nilotic sheep (Atta and Khidir, 2004) and their finding supported the report by Ngere and Aboagye (1981) that differences in live weights of single and twin West African Dwarf ewe lambs from poor milking dams were similar.

2.4 Reproductive traits

Literatures on reproductive characteristics of hair sheep are seldom seen in journal publications. Perhaps these are published in Spanish or native African languages, which could not be traced or translated.

Many authors have reported that reproductive activity in sheep is seasonally regulated by photoperiod (Sánchez, *et. al.*, 1995; Cruz, *et. al.*, 1994; González-Reyna, *et. al.*, 1991; Williams, 1984; Schanbacher, 1980). In temperate latitudes, reproduction of sheep is very commonly affected by the season but the effect of seasonality on reproduction is very much less in tropical countries, where sheep breeding can be practiced throughout the year (Galina, *et. al.*, 1992; González-Reyna, *et. al.*, 1991; Valencia and Gonzalez, 1983).

In their four years studies on the reproductive performance of three tropical hair sheep breeds (Brazilian Somali , Morada Nova and Santa Ines in America, Rajab and his co- workers (1992) revealed that Morada Nova had the highest prolificacy (1.82) in comparison to Brazilian Somali (1.39) and Santa Ines (1.32). Environmental effects on prolificacy (number of lambs born per ewe lambing) due to annual rainfall and its distribution pattern could influence ewe reproduction and the growth of the lamb up to weaning.

As a result from their studies on the reproductive performance of Pelibuey and Blackbelly hair sheep under tropical management systems in Mexico, Galina, *et. al.*, (1996) had suggested that with good reproductive management, 1.5 lambings per year could be achieved.

Apart from increased meat production and increased reproductive rate from crossbreeding of hair sheep to wool sheep, productivity could be further increased by increasing the selection pressure for traits such as twinning rate and weight gain (Reyna, *et. al.*, 1991).

From his study on the selection of mating season for hair sheep in the tropics, Rodriguez-Rivera (1990) had concluded that in order to achieve the best reproductive performance, birth weight and growth and the lowest lamb mortality, hair sheep in the tropics should be mated in January or September.

2.4.1 Effect of ewe genotype on reproductive traits

Significant genotype effects on the age at lambing, lambing interval, litter size and mortality of Sumatran sheep and three hair sheep crossbreds were studied by Gatenby, *et. al.*, (1997). They found that the hair sheep crossbred were better than the Sumatran sheep in all the traits studied.

Studies on the lambs of the Pelibuey and Barbados Blackbelly hair sheep showed that lambs born from Pelibuey ewes were heavier and grow faster than those born from Barbados Blackbelly ewes (Carillo and Segura, 1993).

Rajab and his co-workers in 1992 studied the performance of three tropical hair sheep breeds namely Brazilian Somali , Morada Nova and Santa Ines and found that breed differences were significantly different (P<0.01) for all traits. Santa Ines hair sheep were found to be superior to the Brazilian Somali and Morada Nova in total lamb weight born and total lamb weight weaned per ewe lambing.

The ewe genotype and rearing significantly affected lambs' weight at birth and weaning in the Sumatran (S); Virgin Island x Sumatran (HC) and Barbados Blackbelly x Sumatran (BC) ewes (Doloksaribu, *et. al.*, 2000). They reported that crossbred lambs belonging to HC and BC ewes were significantly heavier (P<0.01) both at birth and weaning while the Sumatran lambs were the smallest. There were an increase in lambs mature size and growth rate when crossing the native Sumatra sheep with the two Caribbean hair sheep breeds (Virgin Island and Barbados Blackbelly), however the reproductive performance of the crosses were similar to those of the native Sumatran breed. Superiority of the crossbred ewes was maintained into the F2 ewes in producing the F3 lambs and was still excellent but there was a reduction in the weights of the lambs.

Snyman and Olivier (2000) found that the ewes of the hair type were heavier at mating than the wool type (57.4 vs 56.4 kg). They reported this from their studies on the reproductive performance in Dorper sheep (hair and wool types), evaluated under extensive conditions in the north-western Karoo region of South Africa. No differences were observed for percentage of ewes lambed, lambs born, lambs weaned, survival rate of lambs or kg lambs produced per ewe per year. They concluded that the economically important reproduction and growth traits were similar between the hair and wool types of Dorper sheep.

Mukasa-Mugerwa, *et. al.*, (2002) found that ewes which lambed in the wet season had a significantly higher (P<0.001) weaning rate than those that lambed in the dry season (0.76 vs 0.53 respectively). They discovered that for the Menz and Horro sheep lambing in the wet and dry seasons in the highlands of Ethiopia., Menz sheep had a significantly higher (P<0.001) weaning rate (lambs weaned per ewe mated) than the Horro ewes (0.73 vs 0.57), respectively.

In the comparative performance of several breeds of Caribbean hair sheep, Barbados Blackbelly (BB), West African Dwarf (WAD), Blackhead Persian (BP), Blenheim Grade (BG) (developed from crosses of various breeds) and Virgin Island White (VIW) sheep and their 2-, 3- and 4- breed combinations Rastogi, *et. al.*, (1993) observed that maternal ability of BB, WAD and BP were significant for average daily weight gain and weaning weight. The lambs of BB, WAD and BG lambs showed similar growth rates and were superior to the BP and VIW breeds. Lambs from BP or crossbred lambs from BP ewes exhibited the highest survival from birth to weaning. Among the breed types, BB ewes was ranked the highest for frequency of multiple births, number of lambs weaned, total weight of lamb(s) weaned per ewe lambing and prolificacy followed by WAD, BG and BP ewes. VIW lambs and ewes had the lowest performance than the other breeds. They also concluded from these studies that crossbreeding did not significantly improve the number of lambs weaned or the total weight of lamb(s) weaned.

2.4.2 Age at first oestrus and sexual maturity

Most of the female animals will show periodical or cyclic reproductive behaviour which is formally known as oestrus cycle. The oestrus cycle not only shows a maximum need towards sexual activities but also bring changes on the layers of the uterus, in preparation of receiving a fertilized ovum (Wodzicka-Tomaszewska *et. al.*, 1980).

In mammals, when the estrogen is stimulated, oestrus can be detected through a change in the animal's behaviour (Hafez, 1974). In sheep, the duration of oestrus is usually between 18-72 hours in comparison to 25-30 hours in goats. Oestrus cycle is controlled by the action of gonadotrophic hormones (LH, FSH and Prolactins) which are secreted by the pituitary gland and gonadotrophic hormone (progesterone and oestradial-17β) secreted by the ovary (Hafez, 1974).

The West African Dwarf hair sheep females in the Federal Republic of Germany was reported to have the age at sexual maturity between the age of 12 – 16 months old (Banze-Ngoy, 1985) and it was presumed that the late maturity was due to aseasonality in oestrus and temperate climate in which the sheep were subjected to. For the pelibuey hair sheep in Mexico, the females reached puberty between five and ten months old, and depended mainly on body weight and season of birth (Reyna, *et. al.*, 1991).

The pelibuey hair sheep in Mexico reached puberty between five and ten months old, and depended mainly on body weight and season of birth (Reyna, *et. al.*, 1991) while the West African Dwarf hair sheep females in the Federal Republic of Germany was reported to have an age at sexual maturity between 12 – 16 months old (Banze-Ngoy, 1985). It is presumed that the late maturity is due to aseasonality in oestrus and the temperate climate to which the sheep were subjected to (Banze, 1985).

Boujenane and Kansari (2002) studied the lamb production and its components from purebred and crossbred mating types of D'man x D'man (DxD), Lacaune x Lacoune (LxL), Lacaune x Timahdite (LxT), LxD, DxT, LxLT, LxLD and LxDT. They reported that prolificacy at birth and 70 days, and litter weight at 70 days were affected by the type of mating ($P<0.01$). Mating types based on D'man ewes were most prolific, those based on Timahdite ewes were least prolific, while those based on Lacaune and crossbred ewes were intermediate. There was no difference among mating types for number weaned and prolificacy, except litter size at 70 days declined drastically for Lacaune and became similar to LxT and DxT. Although D'man produced the heaviest litter at 70 days (23.4 kg), it was not significantly different from LxD (22.9 kg), LxDT (22.2 kg), LxLD (22.1 kg) and LxLT (22.5 kg).

A dam productivity index (DPI) of the Sumatran, Java Fat-Tail (Indonesian Fat-Tailed) x Sumatran (E1), Virgin Island (Virgin Island White) x Sumatran (H1) and Barbados Blackbelly x Sumatran (B1) ewes was reported Gatenby, *et. al.*, (1997). The average DPI for the Sumatran, E1, H1 and B1 calculated from the total weight of lamb weaned at the first two lambings divided by a measure of age was found to be 16.00, 18.10, 21.50 and 24.20. Productivity of the ewes, expressed in terms of weight of lamb weaned per unit body weight of ewe was 0.73, 0.74, 0.79 and 0.86 respectively. The DPI was found to be higher for ewes mated at the age of ten months than those mated at the age of 13 months.

2.4.3 Age at lambing, gestation length, lambing interval and post-partum oestrus

The matured weight for the Sri Lankan native hair sheep females was on the average of 19 kg and the age at first lambing was reported at approximately 16 months old. The lambing rate was between 63 – 86% (Goonewardene, *et. al.*, 1984).

Gatenby, *et. al.*, (1997) reported earlier that for Sumatran, Java Fat-Tail (Indonesian Fat-Tailed) x Sumatran, Virgin Island (Virgin Island White) x Sumatran and Barbados Blackbelly x Sumatran ewes mated to the same breed type, the average age at first and second lambing was 516 and 733 days respectively. Young ewes (age less than 2 years) were found to wean smaller lambs than older ewes (aged 2-6 years). There were no significant effects of the type of breed on the age at lambing, lambing interval, litter size or mortality.

In the humid lowland tropics of North Sumatra, Indonesia, data collected from the 230 lambings and 350 lambs from 132 young Sumatran (S); Virgin Island x Sumatran (HC) and Barbados Blackbelly x Sumatran (BC) ewes showed that the average age for the first and the second lambings were 465 and 694 days respectively, while the mean interval between the first and the second lambings was 231 days (Doloksaribu, *et. al.*, 2000).

Galina, *et. al.*, (1996) reported that Pelibuey and Blackbelly hair sheep ewes studied under tropical management systems in Mexico had the average age at first lambing at 465 days (15.25 months) and the average first lambing intervals for the years 1988 to 1994 were 265, 227, 238, 225, 252, 230 and 258 days, with an overall average of 242 days.

Banze-Ngoy (1985) reported that the gestation length of the West African Dwarf hair sheep was between 147 – 154.3 days. In the pelibuey hair sheep in Mexico, the gestation length was within the ranges reported for wool sheep breeds (148-154 days) while the first post-partum oestrus occurred fairly soon after parturition.

In the Pelibuey hair sheep in Mexico gestation length was within the ranges reported for wool sheep breeds (148-154 days) while the first post-partum oestrus occurred fairly soon after parturition. Nutrition seemed to influence the length of the post-partum interval (Reyna, *et. al.*, 1991). They assumed that nutrition seemed to have an influence on the length of the post-partum interval.

The length of the post-partum interval was reported to be influenced by the nutrition of the females during that period (Reyna, *et. al.*, 1991). However (Galina, *et. al.*, 1996) found that lambing interval was significantly affected by lambing season and the interval was longer for ewes lambing during autumn, winter and spring when compared to the ewes lambing in summer. The lambing interval of the Pelibuey and Blackbelly hair sheep ewes under tropical management systems in Mexico increased significantly ($P<0.05$) as the lactation length increased from 60 to 120 days. Lambing interval and fertility was also found to be significantly correlated with rainfall, but not with temperature and photoperiod (Galina, *et. al.*, 1996).

2.4.4 Effects of weight, age and parity of ewes on reproductive traits

Birth weight increased significantly ($P<0.001$) with dam body weight in mid pregnancy and the weaning weight and growth rate increased with dam body weight (Hall, *et. al.*, 1995).

Ewe's weight at parturition influence pre-weaning growth in sheep (Acharya, 1985; Chopra and Acharya, 1971; Dass and Acharya, 1970).

Ewe weight at second lambing was influenced ($P<0.01$) by genotype, with the average weights of 21.2 ± 0.50 kg, 26.80 ± 0.50 kg and 29.00 ± 0.50 kg for the

Sumatran, Virgin Island x Sumatran crosses and Barbados Blackbelly crosses respectively (Doloksaribu, *et. al.*, 2000).

Gatenby, *et. al.*, (1997) reported that the average body weights of the Sumatran, Java fat-tail (Indonesian Fat-tailed) x Sumatran, Virgin Island (Virgin Island White) x Sumatran and Barbados Blackbelly x Sumatran ewes at second lambing was 22.00, 24.40, 27.20 and 28.10 kg respectively.

Young ewes tend to produce smaller lambs at birth. These were reported by Dass and Acharya (1970) in their studies on the growth of Bikaneri sheep and by Wilson (1987) in sheep production in Central Mali.

Age of dam had significant effect on lamb weight (Sinha and Singh, 1997). Age of dam was also an important source of variation for growth traits from birth to 3 months of age, and all growth traits were optimal when the age of the dam was 5 years (Djemali, *et. al.*, 1994). Significant effect of the age of dam on lamb weight and on yearling body weight as well as a significant effect on lifetime body weight gain and fleece production was also reported by Ogan (1994).

Influence of the age of dam on birth weights of the lambs were reported by other authors (Yapi, 1993; London 1993; Odubote, 1992; Armbruster, *et. al.*, 1991, Kabuga and Akowuah, 1991; Tuah and Baah, 1985; Filius, 1984; Taiwo, *et. al.*, 1982). Other than the effect of breed groups, age of dam also affect the pre-weaning growth rates (Bunge, *et. al.*, 1995; Wildeus, 1989; Martinez, 1983; Patterson, 1983, Zarazua and Padilla, 1983).

Smith and Clarke (1972), a female adult Malin can give birth at the age between 12 to 18 months with many twins. Abdullah, *et. al.*, (1992) reported that in a group of Malin sheep in Malaysia, out of 452 births, only 11% of it is twins and the age of female adult Malin which give birth to its first lamb is between 22 and 30 months.

It is generally known that mothering ability, especially milk production, increases with parity, older ewes are larger in body and better milkers thus, influence of the superior maternal environment of such ewes is expected to be translated into better lamb performance up to weaning. It was therefore not surprising that post-weaning growth performance was not significantly influenced by parity. First parity ewes are still growing and thus must provide for their own growth in addition to the foetal demand. The effect of parity of dam on lambs is thus imparted as maternal influence whose direct influence is limited to the nursing period (Stobart, *et. al.*, 1986; Wright, *et. al.*, 1975; Dass and Acharya, 1970; Eltawil, *et. al.*, 1970).

2.4.5 Litter size

Litter size was reported to be affected by the breed of the ewe (P<0.001) but not by the age of the ewe and the season of birth (Gatenby, *et. al.*, 1997). Young ewes tended to produce smaller lambs at birth in Bikaneri sheep (Dass and Acharya, 1970).

The Vogan hair sheep (West African Dwarf x West African Long – Legged) in Togo had the average litter size of 1.4, and out of the 308 lambings, the percentage of single, twin and triplet births were 62.86, 34.42 and 2.92% respectively (Amegee, 1983).

Findings from the lambing data of Barbados Blackbelly (West Indian), West African, Blackhead Persian, Virgin Island White and crossbred ewes by Dumas, *et. al.*, (1988) showed that, their average litter size were 1.97 ± 0.04, 1.64 ± 0.04, 1.29 ± 0.04, 1.14 ± 0.10 and 1.63 ± 0.05 respectively while the percentage of survival to weaning were 79 ± 1.72, 85 ± 1.74, 88 ± 2.03, 89 ± 4.65 and 80 ± 2.22% respectively. Breed differences for litter size at weaning were not significant for the singles or the twins.

2.5 Estimates of genetic and phenotypic parameters

2.5.1 Genetic and phenotypic parameters

Estimates of genetic parameters such as heritability of traits and genetic correlations between traits are essential, as these estimates are necessary before the commencement of a selection programme and for predicting genetic gain from a selection programme. The genetic and phenotypic parameters are useful information to develop genetic evaluation methods for management within-flock breeding programmes.

2.5.2 Estimates of heritability for birth weights and subsequent body weights

The post-weaning heritability estimates of Dorper lambs at Ol'magogo were generally higher than those for pre-weaning suggesting a lower direct genetic influence early in life (Inyangala, *et. al.*, 2004).

The heritabilities of all body weights, weight gains and efficiency of weight gains at different stages of growth were moderate (0.18 – 0.20) except for birth weight which had low heritability (0.07 ± 0.01). The phenotypic and genetic correlations among the different body weights were positive and high, except for birth weight. The genetic correlation of the pre- and post-weaning average daily weight gains with body weights were also high and positive. Positive estimates of heritabilities have been commonly found in the literature although there are differences in magnitudes between these estimates. For example, the heritability and repeatability of birth weight were 0.14 and 0.48 respectively for Ramlic lambs and 0.18 and 0.02 for Daglic lambs (Ulusan and Bekyurek, 1996). Heritability estimates obtained from paternal half-sib correlations using least square analysis were 0.16 for birth weight (Ogan, 1994).

Heritabilities of birth weight, weaning weight and average daily gain of Pelibuey hair sheep were reported as 0.16 ± 0.04, 0.12 ± 0.03 and 0.11 ± 0.03 versus 0.04 ± 0.07, 0.17 ± 0.09 and 0.15 ± 0.08 for Barbados Blackbelly hair sheep (Carillo and Segura, 1993).

In Tunisia, Djemali, *et. al.* (1994) reported that in Barbarine lambs the heritability estimates for weights at birth, 10, 30, 70 and 90 days were 0.26 ± 0.04, 0.14 ± 0.03, 0.19 ± 0.03, 0.27 ± 0.04 and 0.32 ± 0.04 respectively while heritabilities for average daily gains from 10-30, 30-70 and 30-90 days were 0.15 ± 0.03, 0.24 ± 0.04 and 0.31 ± 0.05, respectively.

Estimates of heritability of the Santa Ines hair sheep lambs from Northeast Brazil was found to be 0.29 using the non-linear sire models and was 0.14 using the linear model. Heritability estimates obtained from paternal half-sib correlations using least square analysis were 0.16 for birth weight, 0.08 for 60 day body weight, 0.18 for 120 day body weight, 0.17 for 180 day body weight, 0.28 for yearling body weight, and 0.58 for yearling greasy fleece weight (Ogan, 1994).

Mandal, *et. al.*, (2003) studied the genetic analysis of growth traits in Muzaffarnagari sheep in India and found that heritabilities of all body weights, weight gains and efficiency of weight gains at different stages of growth were moderate (0.18 – 0.20) except for birth weight which was of low heritability (0.068 ± 0.01).

Heritability estimates for Barbarine lambs in Tunisia were 0.26 ± 0.04, 0.14 ± 0.03, 0.19 ± 0.03, 0.27 ± 0.04 and 0.32 ± 0.04 for weights at birth, 10, 30, 70 and 90 days respectively while heritabilities for average daily gains from 10-30, 30-70 and 30-90 days were 0.15 ± 0.03, 0.24 ± 0.04 and 0.31 ± 0.05, respectively (Djemali, *et. al.*, (1994).

The heritability and repeatability of birth weight were 0.14 and 0.48 respectively for Ramlic lambs and 0.18 and 0.02 for Daglic lambs (Ulusan and

Bekyurek, (1996). Heritability estimates for litter size were approximately 0.08 and repeatability estimates were 0.14 and 0.11 for single-trait and multi-trait models respectively (Analla, *et. al.*, 1997).

Heritability estimates calculated from sire and dam data, were 0.01 for weaning weight at 60 days (0.00 for western flocks and 0.07 for eastern flocks), 0.10 for weaning weight at 120 days, 0.33 for postweaning gain for lambs weaned at 60 days and 0.20 for lambs weaned at 120 days, 0.41 for fleece weight and 0.58 for fiber diameter. Additive maternal and maternal permanent environmental effects as a proportion of phenotypic variance were 0.10 and 0.09 respectively for 60 day weaning weight and 0.05 and 0.08 for 120 day weaning weight (Notter and Hough, 1997).

The low heritability estimates found for lactation length confirmed that this trait is mainly affected by environmental conditions (El Saied, *et. al.*, 1999).

Reports on the estimates of heritabilities for different traits in growth and other traits are very few in the literature available in the English language. The few estimates that are presented in this section involve populations at different ages and in varying environments. These differences resulted in varying estimates of body weight at different ages.

2.5.3 Genetic and phenotypic correlations

Important genetic correlations were found between some traits while some estimates of genetic correlations did not seem to have a biological explanation. Estimates of genetic correlations among traits could be a basis for deriving selection indexes for reproductive traits. This finding was reported by Rosati, *et. al.*, (2002) in their studies on the genetic parameters for six basic and seven composite traits of five breeds (Dorset (D), Finnshheep (F), Ramboullet (R), Suffolk (S) and Targhee (T) and two composite lines (C1 (1/2F +1/4R+1/4D) and C2 (1/2F+1/4S+1/4T)).

The genetic correlations were 0.18 between litter size and birth weight, 0.48 between litter size and weaning weight, and 0.36 between litter size and weight at 90 days. The environmental correlations between litter size and weight traits were close to zero. Because the genetic correlations between litter size and weight traits were all positive, no deterioration of breeding values of weight traits could be expected when selecting for litter size (Analla, *et. al.*, 1997).

Hansen and Shrestha (2002) studied the consistency of genetic parameters of productivity for ewes lambing in February, June and October under an 8-month breeding management and they estimated the genetic correlations among lamb weights at birth, 21 and 91 days were 0.74 – 0.96 while the corresponding phenotypic and environmental correlations were 0.65 – 0.93 and 0.58 – 0.93 respectively.

Positive genetic and phenotypic correlations have been observed for growth traits (Mavrogenis, *et. al.*, 1980; Stobart, *et. al.*, 1986). The genetic and phenotypic correlations among growth traits of Barbarine lambs in Tunisia were reported to be all positive, ranging from 0.43 to 0.96 and 0.10 to 0.92 respectively (Djemali, *et. al.*, 1994).

In a flock of Sabi sheep reared in South Africa, Matika, *et. al.*, (2003) reported the genetic correlations between birth weight, weaning weight (140 days), 12 month and 18 months body weights were 0.75 – 0.85 and the phenotypic correlations were estimated to be between 0.34 – 0.80.

Inyangala, *et. al.*, (2004) reported that the genetic and phenotypic correlations estimated between weights of Dorper lambs collected over a 10 year period (1978 to 1987) at Ol'Magogo were mainly positive, being 0.15 to 0.99 and 0.02 to 0.98, respectively. They found that the genetic and phenotypic correlations between adjacent weights and rates of growth, and among growth rates themselves were generally high.

Mandal, *et. al.*, (2003) reported that for Muzaffarnagari sheep in Mathura, India, the phenotypic and genetic correlations among the different body weights were positive and high, except for birth weight. The genetic correlation of the pre- and post-weaning average daily weight gains with body weights were also high and positive. However, the linear regression effect of age of ewe at lambing was found to be significant for birth weight (Sinha and Singh, 1997).