DEVELOPMENT OF THE TESTES, EPIDIDYMIDES, AND SEXUAL BEHAVIOR OF FALL-BORN CROSSBRED RAM LAMBS

By

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Bachelor of Science

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Fargo, North Dakota

1975

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1982

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SEXUAL BEHAVIOR OF FALL-BORN CROSSBRED

RAM LAMBS

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ACKNOWLEDGMENTS

Sincere appreciation and thanks are extended to Dr. J. V. Whiteman for the opportunities and guidance he has given throughout the course of this study and my graduate program.

Special appreciation is extended to Drs. R. L. Hintz, R. P. Wettemann and M. Gould for their help and advice while serving on my M.S. committee.

I am grateful to Dr. R. R. Frahm for his counsel during my graduate career.

I wish to thank Roger Spencer and Guy Robson as project herdsman for their help throughout the study.

I also want to recognize Debbie Stritzke and Jackson Dzakuma for their assistance in data collection as well as other graduate students for their advice.

I wish to thank Drs. T. R. Thedford and R. J. Morton for their advice and assistance in herd health.

I am grateful to Susan Reinsch for expertly typing this manuscript.

But most of all, I simply want to say thank you to Marian, Kirstin and Kristofor for making my life what it is.

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CHAPTER I

INTRODUCTION

Animal agricultural efficiency is influenced by the rate of reproduction. The number of lambs marketed per ewe in the breeding flock is the principal factor used to determine net return to a sheep enterprise; therefore, understanding the reproductive traits is essential. The subject of this thesis is reproductive development in fall-born ram lambs.

Selection criteria must be developed to improve reproduction efficiency in rams and ewes. Initially, traits related to reproduction must be characterized and the method of measurement determined. The identification of more fertile individuals can then be accomplished.

Dzakuma (1980) reviewed techniques for identifying more productive ewe lambs and found that lambing performance of ewes at 12 months of age is an excellent indicator of subsequent performance. Recently, additional emphasis has been put on the ram in an attempt to genetically rank young developing males for subsequent reproductive efficiency.

No standard procedure is currently available for evaluating young developing ram lambs. One of the problems is that male reproductive development does not express itself at a specific time. The ability to produce spermatozoa is somewhat more precise and has been used to define the beginning of the reproductive life of rams (Rice et al., 1953). Live evaluation of the onset of spermatozoa production in the testes is difficult due to variation in early development of the endocrine system and the subsequent development of the entire reproductive tract. Live evaluation is also complicated by considerable variation for age and weight of the ram at the onset of spermatogenesis.

The objectives of this study were: 1) to estimate the growth patterns of the testes and epididymides from two months through ten months of age in the fall-born ram lamb, 2) to estimate sperm cell numbers in ram lambs between three to eight months of age, and 3) to evaluate libido characteristics of ram lambs at seven to eight months of age and at ten to eleven months of age.

CHAPTER II

REVIEW OF LITERATURE

This literature review will cover reproductive development of ram lambs. It will be divided into: 1) Testicular development and spermatogenesis; 2) Factors influencing reproductive development, such as season, genotype, nutrition, and temperature; and 3) Ram lamb sexual behavior. This review will involve ram lamb development from one or two months of age until complete sexual maturity.

Testicular Development and Spermatogenesis of the Ram Lamb

Certain anatomical developments and changes must take place in the male reproductive organs before spermatozoa are produced. Such developments take place gradually and are under the control of testosterone (Dyrmundsson, 1973) and will be discussed in the order of 1) testes and 2) spermatogenesis.

1. Testes: Testes'descent is obvious by 16 weeks of age in Merino rams (Pertorious and Marincowitz, 1968); however, little growth has taken place. This period of latency is followed by a period of rapid testicular growth. Courot (1962) studied 56 Ile-de-France ram lambs and rapid testes'growth commenced at an average of 90 days of age and 20 kgs of weight. Similarly, 84 Clunn Forest ram lambs initiated rapid testicular growth at an average of 84 days of age and 20.9 kgs of body weight

(Colyer, 1971). Skinner (1971) evaluated 38 Dorper rams and they exhibited increased testicular growth rate at an average age of 84 days and 19.5 kgs body weight. These experiments demonstrate that testicular growth rate occurs slower until approximately 100 days of age and under 20 kgs body weight, providing the body growth rate of the lamb is not extremely fast.

Skinner et al. (1968) found that 54 Suffolk ram lambs initiated rapid testes' growth at an average of 42 days of age. Body growth rate of these ram lambs was faster than that for the rams in the previous studies; thereby, suggesting increased body growth can trigger testicular growth at younger ages. The growth rate varied widely in these rams. Twenty kgs body weight was required to show a marked increase in testes' growth in 110 Merino ram lambs of widely varied growth rates (Watson et al., 1956). The age and body weight at which the initiation of increased testicular growth rate occurs can be identified. Several factors (discussed on pages 12-19) will influence actual mature testicular size and growth rate.

For the purpose of estimating testicular size at various ages and body weights estimates were obtained from studies involving many breeds raised in several regions of the world. Unfortunately, testes' size is reported in three forms: 1) testicular weight, 2) testicular diameter and 3) seminiferous tubule diameter. The Tables I and II summarize testicular size at around 62, 85, 108, 139 and 172 days of age and approximately 15, 24 and 35 kgs of body weight.

No distinct pattern exists in Table I for testicular size at various ages. Slow developing breeds, such as the Merino, tend to have smaller testes. The larger-framed breeds, such as the Suffolk and

TABLE I

LITERATURE ESTIMATES[a] FOR TESTICULAR DEVELOPMENT AND BODY WEIGHT AT SEVERAL AGES FOR RAM LAMBS AVERAGED ACROSS SEVERAL BREEDS AND ENVIRONMENTS

Age	Body Weight (kgs)	Testicular Weight (gms)	Testicular Diameter (cms)	Seminiferous Tubule Diameter (microns)
62	17.8	7.49	2.25	56.57
85	23.6	23.28	2.52	81.03
108	25.6	46.37	3.72	111.77
139	29.0	61.90	5.20	117.79
172	31.4	98.06	4.49	171.62

[a]Phillips and Andrews, 1936; Carmen and Green, 1952; Courot, 1962; Skinner and Rowson, 1968; Skinner et al., 1968; Barr, 1969; Skinner, 1971; Dyrmundsson and Lees, 1972b; Aire, 1973; Schanbacher et al., 1974; Carr and Land, 1975; Land and Carr, 1975; Land and Sales, 1976; Ghannom et al., 1978b; Ricordeau et al., 1979.

TABLE II

LITERATURE ESTIMATES[a] FOR TESTICULAR DEVELOPMENT AT SEVERAL BODY WEIGHTS FOR RAM LAMBS AVERAGED ACROSS SEVERAL BREEDS AND ENVIRONMENTS

Body Weight (kgs)	Testicular Weight (gms)	Testicular Diameter (cm)
15.59	7.16	1.78
24.42	27.37	3.02
34.71	107.75	5.40

[a]Carmen and Green, 1952; Courot, 1962; Skinner and Rowson, 1968; Barr, 1969; Renfro and Dutt, 1970; Skinner, 1970; Dyrmundsson and Lees, 1972b; Carr and Land, 1975; Land and Sales, 1976; Ghannom et al., 1978b; Ricordeau et al., 1979.

Targhee crosses, tend to have a larger testes at various ages; however, the smallest breed (Dwarf Nigeria) also have a larger testes than the breeds of moderate body size. The Awassi breed has the most variation; however, most of the breeds were not studied more than once. The European breeds were similar to the American breeds, but the Middle East breeds tended to develop slower, both in body growth and testes' growth.

Table I involves testicular size at various ages. No obvious pattern is present, probably due to the extreme variation in breed type and environments. A large portion of the testes appears to have developed by 172 days of age with the greatest testicular growth rate between 62 and 139 days of age.

The variation in testicular growth is not as great at similar body weights as the variation is at similar ages. This suggests that body weight is a better indicator of testicular growth than age.

Table II involves testicular size at various body weights. Testes were only slightly heavier for rams at 24 kgs compared to 15 kgs. The testes of rams at 35 kgs were about four times heavier than the testes of the 24 kg rams.

Tables I and II suggests that ram lambs vary considerably in body size and growth rate at any particular age. By holding body weight constant, much of the variation due to breed and environment is removed and a more defined pattern of testicular growth is evident. Body weights of 20 to 30 kgs appear to be needed for adequate testicular growth in the ram lamb.

2. <u>Spermatogenesis</u>: Only supporting cells (located along the basement membrane) and gonocytes (located in the central part of the sex cords) are present in the testes of the fetus. The supporting cells

become sertoli cells and the gonocytes become spermatogonia. Gonocytes give rise to type A spermatogonia. Several mitotic divisions follow and conclude with the production of primary spermatocytes.

Primary spermatocytes undergo progressive nuclear changes and divide to form diploid secondary spermatocytes. Finally, haploid cells are produced called spermatids. Spermatids undergo a series of morphological changes in the formation of spermatozoa. The interval between the appearance of the stem spermatogonium and the release of spermatozoa that are produced is about 49 days. An additional 11 to 14 days is required for the spermatozoa to travel through the epididymis (Ortavant, 1958).

Sapsford (1962) summarized early testicular development of rams by classifying lambs into three phases. Phase I concerned the fetal lamb and Phase II included the period from late fetal life to approximately 21 kgs postnatal life. The gonocytes underwent considerable differentiation during phase II. The central portion of the sex cord contained mature gonocytes and pro-spermatogonia. The indifferent cells (future sertoli cells) increased in volume and underwent cytoplasmic differentiation. Phase III began around 21 kgs with initiation of spermatogenesis and appearance of the lumen in the sex cords. The indifferent cells transform to sertoli cells and become wedged in between germ cells. Phase III ends with the production of the first spermatozoa.

The appearance of spermatozoa is a common criterion for estimating reproductive development of the male. Considerable variation exists for the age at which spermatozoa are first present. Factors such as nutrition, season and genotype probably vary considerably between experiments. The median age for the appearance of spermatozoa is between 140 to 170 days of age. The average age for the appearance of spermatozoa is 153 days (Table III). No trend is evident that would suggest certain breeds produce spermatozoa at a younger age than other breeds. An important point is that ram lambs were first able to produce spermatozoa at 112 days of age. This suggests that even under optimum conditions, ram lambs probably need to be over 100 days of age to produce spermatozoa.

The range in weight at the appearance of spermatozoa is not as great as that for age. The average body weight at the first appearance of spermatozoa was 28.56 kgs (393 ram lambs omitting the Dwarf Nigerian) (Table IV). With the exception of the Dwarf Nigerian, rams probably must weigh at least 20 kgs before spermatozoa are produced. No conclusions can be made concerning how breeds or environments influence the age at the onset of spermatozoa production. Breeds must be studied under common environments to determine if genotypes are involved.

Combining Tables III and IV suggests a range in body weight and age is probably present for the production of spermatozoa within each breed and environment. Very fast growing ram lambs will probably be younger when spermatozoa are produced, while slow growing ram lambs would first produce spermatozoa at an older age. Rams with stunted body growth may eventually produce spermatozoa at body weights below 20 kgs due to the increase in age.

Factors Influencing Reproductive Development of Ram Lambs

Genotype, season, temperature and nutrition account for considerable variation in the reproductive development of ram lambs. Interactions between these factors do exist (Land, 1978). Most studies in the

TABLE III

LITERATURE SUMMARY OF AGE AT FIRST APPEARANCE OF FOUR GERM-CELL TYPES IN THE RAM LAMB

Breed	Number	Location[c]	Spermatocytes Primary	Spermatocytes Secondary	Spermatids	Spermatozoa	Ref[c]
Merino	10	k				200	6
Hampshire	12	a	56	70	168	168	3
Southdown	7	a	63	140	154	154	3
Several[a]	14	a	63	126		147	1
Ile-de-France	56	b	105	117	120	140	8
Askanian	21	c				168	13
Awassi	20	d				140	22
Pedi	12	e	112			168	25
Africander	12	e	112		168	196	25
Dorper	38	e	84		112	112	27
Karakul	50	e				150	42
Tabasco X Dorset	2	f				173	45
Tabasco X Dorset	7	f				132	45
Several[b]	—	f				138.9	47
Native	43	g		93	105	165	50
Merino Crosses	23	h	80		110	160	16
Awassi	42	i			171	234	46
Targhee Crosses	69	a	61			121	33
Dwarf Nigerian	10	j	84		98	126	30
Merino X Corriedale	29	k				273	41
Clunn Forest	76	l				141.5	29
Dorset	14	l				122.2	29
Merino	110	k				126	5
Suffolk	54	m	70		105	112	20
Suffolk	18	m				126	19
Welsh Mountain X Suffolk	6	m				117	19
Unknown	30	c				150	43

[a]Southdown and Shropshire
[b]Dorset, Tabasco, Suffolk, Tabasco X Dorset.
[c]Appendix Table XIX lists locations and references.

TABLE IV

LITERATURE SUMMARY OF WEIGHT IN KILOGRAMS AT FIRST APPEARANCE OF FOUR GERM-CELL TYPES IN THE RAM LAMB

Breed	Number	Location[b]	Spermatocytes Primary	Spermatocytes Secondary	Spermatids	Spermatozoa	Ref[b]
Hampshire	12	a	15.8	19.28	42.64		3
Southdown	7	a	9.98		21.32		3
Ile-de-France	56	b			35.0		8
Awassi	20	d				29.0	22
Pedi	12	e	14.5				25
Africander	12	e				33.2	25
Dorper	38	e				21.3	27
Tobasco X Dorset	7	f				29.7	45
Tobasco X Dorset	2	f				23.0	45
Several[a]	--	f				26.6	47
Awassi	42	i			22.8	33.7	46
Dwarf Nigerian	10	j	9.2		11.55	12.04	30
Clunn Forest	90	l				32.6	29
Merino	110	k				28.0	5
Clunn Forest	32	l				20.9	26
Suffolk	18	m				36.8	19
Welsh Mountain X Suffolk	6	m				29.9	19
Welsh Mountain X Suffolk	6	m				20.3	19

[a]Dorset, Tabasco, Suffolk, Tabasco X Dorset.
[b]Appendix Table XIX lists locations and references.

literature only deal with one or two factors in order to avoid confounding; therefore, each topic will be reviewed separately.

1. Seasonal Variation: Lincoln and Short (1980) conducted extensive studies on the reproductive physiology of both Soay ewes and rams. Soay sheep have a defined breeding pattern and were selected by Lincoln and Short to document the physiological changes throughout the year. Only limited data are available on seasonal effects on developing lambs; however, seasonal variation is often assumed in many studies because of the lack of evidence to the contrary.

Skinner and Rowson (1968) used 12 Suffolk X Welsh Mountain ram lambs to study seasonal effects on sexual development. Six were born in February/March (spring) and six were born in July/August (summer). Spring-born ram lambs produced electro-ejaculates as early as 42 days of age. Summer-born ram lambs did not ejaculate until 63 days of age. Spermatozoa first appeared in the ejaculates at 119 days for spring-born lambs, and 138 days for summer-born lambs. The ram lambs were slaughtered at 168 days of age, and at that time spring-born ram lambs had heavier body weights, larger testes, greater seminiferous tubule diameter and larger epididymides. Other accessory glands were heavier in the summer-born lambs.

Dyrmundsson and Lees (1972b) studied 36 Clun Forest ram lambs born during March, April and May, 1970, 41 ram lambs born January and February, 1971 and 35 ram lambs born March and April, 1971. In the 1970-born ram lambs, no strong relationship existed between date of birth and testicular weight up to one year of age. March-born lambs weighed more at a set age, followed by May-born and then April-born. In 1971, the early-born ram lambs produced spermatozoa at 145.3 days of age, 33.7 kg body weight and 74.55 grams of testis. The late-born ram lambs produced spermatozoa at 141.5 days of age, 31.1 kg body weight and 87.95 grams of testis. Body weight and testicular weight were significantly different between the groups in the fall; hence, late-born ram lambs obtained a heavier mean testicular weight despite similar age and weight.

Courot et al. (1975) studied Ile-de-France lambs born in September and February and raised indoors under natural daylight. Accelerated testicular growth occurred slightly earlier in September-born than in February-born lambs. By 200 days of age the September-born lambs had a statistically significant decrease in testicular weight while February lambs continued to increase. The LH concentration in the lamb's pituitaries increased from birth to 80 days of age with no dependency on season. After 80 days of age, the level of LH decreased rapidly in the February-born lambs, while autumn-born lambs decreased at 155 days of age. Maturation of the feed-back mechanisms (hormone regulatory system) appears to change to adult type sensitivity around 80 days of age. This may account for the seasonal change in testicular growth. The precocious testicular growth of autumn-born ram lambs could be explained by more gonadotropin secretion in lambs born under favorable neuroendocrine systems.

Land et al. (1979) studied 38 Finn-Dorset ram lambs born in December 1976, to January 1977, and 37 lambs born in July and August 1977. Both groups were raised indoors under natural daylight. Twenty winter-born and 17 summer-born ram lambs were hemicastrated at 12 weeks of age and studied to 24 weeks of age. The effects of hemicastration were independent of season, thus the sensitivity to testosterone negative feedback on gonadotropin secretion under decreasing day length was similar to that under increasing day length. The testes of the summer-born ram lambs grew faster than testes of the winter-born ram lambs. This suggests that seasonal variation in ram lamb testicular growth may not arise from variation in sensitivity to negative feedback, but rather to variation in the basic activity of the hypothalamus/hypophysis.

Seasonal variation in testicular growth rate does exist in ram lambs; however, the mechanisms and results are not well understood. The developing ram lamb appears to be insensitive to daylight changes the first three months of life. Crim and Geschwind (1972) documented a negative feed-back system at 30 days of age when testosterone propionate was injected into Targhee castrated ram lambs. Lincoln and Short (1980) reported that changes in the sensitivity to steroid negative feedback existed in mature sheep during decreasing and increasing daylight. The age at which negative feedback first occurs in ram lambs has not been determined.

In summary, seasonal variation in testicular growth rate during development may be explained by larger surges of gonadotropin hormone in lambs born in the normal breeding season causing precocious testicular development. Although the seasonally-influenced negative feedback system is present in the ram lamb, total function of the system is not evident. Maturation of the feedback system during non-breeding seasons appears to slow testicular growth prematurely during development (Courot et al., 1975) with growth returning the next breeding cycle. Spring-born ram lambs should reach a larger portion of mature testicular size the first nine months of life than fall-born ram lambs. Individual reproductive development will be influenced by time of birth and length of time to maturation of the negative feedback system (Land, 1978).

2. Genotype: Breeds of sheep vary in regards to reproduction. Land and Sales (1976) determined the testicular growth pattern of Finnish Landrace (Finn), Tasmarian Merino (Merino) and their crossbreds. The Finn sheep are rated for high fertility and early maturity whereas, Merino sheep are late maturing and have lower fertility. They found that testicular growth was more rapid in the Finn and Finn crossbreds than the Merino. Testicular diameter was greater for the Finn throughout the first year of life, while testicular diameter of the crossbreds and Merinos were 88 percent and 47 percent, respectively, of those for Finns. The measurements of ram libido and testicular diameter were greater for the more fertile breed (Finnish Landrace). Using the previously mentioned breed groups, Wheeler and Land (1977), as well as Islam and Land (1977), have demonstrated that a close relationship exists between time of ewe ovulation and ovarian activity and ram testes and sperm activity. These relationships have not been demonstrated in more closely-related breeds.

Variation in testicular size within lines of sheep is only starting to be studied. Land and Lee (1976) obtained a realized heritability of testicular diameter of .4 involving high and low selected lines of Finn X Dorset ram lambs. Land (1977) observed an increase in the number of eggs shed and lowering of days to first estrus in the ewe lambs sired by Finn X Dorset rams selected for increased testicular size.

Islam (1979) theorized that selection of males from multiple births, females based on ovulation rate, and males for testicular size would have a large effect on genetic gain for prolificacy. Over .02 lambs per year could be gained compared to .004 lambs per year by only selecting for litter size. Genetic correlations in the rate of genetic gain equations were assumed because the magnitude of these are not known.

A genetic difference appears present for differences in testicular size. These differences in developing ram lambs can be expressed through different testicular growth rates or variation in actual mature testicular size.

3. Nutrition: Growth rate, as influenced by nutrition, has a strong influence on reproductive development. Watson et al. (1956) observed 110 Merino ram lambs from one to 64 weeks of age. The body weight of the rams varied widely at any one age due to different nutritional and other conditions related to by changing seasons and weather. A closer association was observed between testicular development and body weight than with age. The testes in these Merino ram lambs increased greatly in size at a body weight of 23 to 27 kg. The lumen appeared in the seminiferous tubules at this time. Their conclusion was that early attainment of sexual capacity can only be expected when there is a high rate of growth which is dependent on a good plane of nutrition. Symington (1961) studied Merino, Persian, and Native ram lambs in Rhodesia and found similar results. Well grown ram lambs ejaculated from 169 to 250 days of age with Native ram lambs weighing 21 kgs. and Merinos weighing 36 kgs. Onset of sexual maturity in poor doing rams was only achieved once they reached a weight similar to that at which the well grown rams first ejaculated.

Pretorius and Marincowitz (1968) evaluated penial and testicular development of 39 Merino ram lambs provided with 110, 140, and 170 percent of the energy requirements for maintenance. The low level nutrition significantly retarded reproductive development. Rams on both the high and medium feeding levels ejaculated sperm at a significantly earlier age and heavier body weight.

Ragab et al. (1968) studied the benefits of increased nutrition on 15 Rahmani purebred and 18 Fleisch Merino X Rahmani crossbred ram lambs. Half the lambs were fed under a conventional feeding system. The other half received creep feed from three to four weeks of age and twice the concentration as the conventional fed lambs. The creep fed lambs expressed reproductive behavior 119 days earlier than the non-creep fed rams.

Solomonou (1971) evaluated 75, 85, 100 and 120% of dietary requirements and obtained conception rates of 94.5, 98.2 100.0 and 98.2 percent, respectively, for ewes exposed to these rams. Ghannam et al. (1978a) provided 100 and 125 percent of the protein requirements in a study involving 39 Awassi ram lambs. The additional protein was not high enough to exert an effect on sexual development. Dyrmundsson (1973) concluded that deficiencies of Vitamin A, zinc, and phosphorus will also delay puberty.

Reproductive development has been noted to occur at a younger age and heavier body weight in rams fed a medium to high plane of nutrition versus a low plane of nutrition (Courot, 1962; Skinner and Rowson, 1968; Leatham, 1970; Rattray, 1977).

In summary, no clear division exists between somatic growth and subsequent development of reproductive capacity. Nutritional levels will influence the rate of reproductive development either indirectly through body growth or directly on the reproductive system.

4. <u>Temperature</u>: Information and studies are lacking on temperature effects on reproductive development of ram lambs. The same detrimental effects of increased ambient temperature would be expected as in

the mature ram. The following is a summary of several reports of increased temperature on the ram reproductive system.

Summer sterility or lowered fertility is a problem during the hot summer due to lower spermatogenic activity (McKenzie and Berliner, 1937; Gunn et al., 1942; Bogart and Mayer, 1946; Moule, 1948; Cupps et al., 1960). Rams subjected to 38°C for more than 24 hours show semen quality deterioration (Djanuar, 1965; Fowler and Dun, 1966; Simpson, 1966). Higher temperatures for shorter time periods will have the same effect (Moule and Waites, 1963; Rathore, 1969, 1970a, 1970b; Lindsey, 1969; Braden and Mattner, 1970; Coser et al., 1979).

Development of Sexual Behavior of the Ram Lamb

Libido is one criterion used to measure sexual development in ram lambs. Several researchers have used confined estrus ewes (libido test) to measure growing sexual behavior in the ram lamb.

Dyrmundsson and Lees (1972a) reported 62 Clun Forest ram lambs first achieved intromission and ejaculated at an average of six months of age (142 to 223 days of age) and body weight of 35 kg (24 to 49 kg). Testicular growth rate increased prior to the first copulation by several weeks.

Bryant (1975) found no difference in group or single reared ram lambs when placed with restrained estrus ewes. The average age to first mount was 170 days and to first service was 176 days. Average live weight for first mount was 45.25 kg and for first service was 46.3 kg.

Land and Sales (1976) found a 20-minute libido test adequate to rank the maturity pattern of Finnish Landrace, Merino and their crosses.

The Finnish Landrace obtain a higher degree of mating dexterity at about six months of age, while the Merinos were about 18 months of age.

Ram lambs do not demonstrate adult mating dexterity and capacity during libido tests (Lightfoot and Smith, 1968; Croker and Lindsay, 1972; Winfield and Kilgour, 1977). Croker and Lindsay (1970) reported older rams could detect 90 percent of the estrus ewes while ram lambs only detected 78 percent. Shreffler and Hohenboken (1974) found no effect on mating behavior due to the dominant or subordinate roles of other ram lambs. Hulet et al. (1962) found the opposite was true for adult rams. Ivan (1972) indicates that 40 percent of the ram lambs expressing poor libido the first breeding season would have good libido the second season.

Homosexual activity can be very high in ram groups (Banks, 1964; Hulet et al., 1964). This can account for some rams with poor mating activity during the first libido test. Roux and Barnard (1974) report that isolation will also adversely affect sexual behavioral development.

Tables V and VI summarize reports of ejaculate capabilities and conception rates of ewes exposed to ram lambs. Most ram lambs are capable of servicing ewes readily after seven months of age. Eastern European countries and Russia are the principle users of ram lambs. In these countries, a large portion of the ewes are serviced by artificial insemination. Table V indicates that ram lambs have adequate ejaculations around 203 days of age.

No current libido test exists that can properly evaluate reproductive potential. Considerable variation exists in libido test procedures. Table VII lists the variation in test length and number of ewes used during tests of 27 reports in the literature. Only three reports used

TABLE V

LITERATURE SUMMARY OF AGE AND BODY WEIGHT AT VARIOUS EJACULATE CLASSIFICATIONS FOR RAM LAMBS[a]

Breed	NumR	Loc	Ejac	Age	Wt.	Ref
QQ	--	h	Viable	210		21
QQ	--	h	Normal	240	49.7	21
F	20	d	Excellent	180		22
I	20	e	Good	128.5	27.26	12
DD	47	s	1st Ejaculate	319	28.23	31
O	43	g	Fertile	165		50
EE	--	c	Normal	120	30	15
D	4	b	1st Ejaculate	182.5		37
FF	4	b	1st Ejaculate	175.0		37
U	39	e	1st Ejaculate	200.9		17
GG	3	t	1st Ejaculate	250	35.9	7
HH	4	t	1st Ejaculate	224	21.8	7
O	3	t	1st Ejaculate	169	20.9	7
II	--	c	Normal	210		28
E	--	c	Normal	210		34
E	--	c	50% Normal	180		10
E	--	c	Normal	210		10
EE	--	c	Normal	210		15
D		b	Normal	210		39
D	--	b	Normal	280		39

[a]Appendix Table XIX lists abbreviations.

TABLE VI

LITERATURE SUMMARY OF CONCEPTION RATES OF RAMS UNDER ONE YEAR OF AGE VERSUS AGED RAMS[a]

Breed	Loc	NumR	NumE	Rage	Conc	Ref
E	c			210-225	54.6	14
E	c			Aged	56.1	14
W	c	5		210-240	normal	23
W	c	5		255-285	normal	23
W	c	10		Aged	normal	23
U	n	16	700	300	67.5-83.7	11
U	c	66	48	240	72.7-90.1	44
X,Y	c	8		210-240	normal	35
X,Y	c			Aged	normal	35
Z	p	21	425	180-210	90.6	48
Z	p			Aged	89.7	48
Y,AA	q	10	475	Ram lamb	92.0	32
Y,AA	q	7	651	Aged	93.9	32
BB	a	135	31,473	Ram lamb	89.1	4
BB	a	974		Aged	90.9	4
CC	a	21		240-360	81.0	2
CC	a	39		Aged	93.0	2

[a]Appendix Table XIX lists abbreviations.

TABLE VII

SUMMARY OF LIBIDO TEST PROCEDURES OF 26 REPORTS*
IN THE LITERATURE INVOLVING EWE NUMBERS
AND TEST LENGTH

Test Ewe Numbers	Number of Reports[1]	Length of Test	Number of Reports[2]
1	6	<10 min.	1
2	4	10 min.	2
3	2	15 min.	1
4	1	20 min.	7
5	3	30 min.	2
6-9	1	1-3 hrs.	11
10-20	2	24 hrs.	0
>20	5	>1 day	5
Unknown	3		

[1]One report used one ewe group of 5 and one group of 42.

[2]Two reports used time periods of 20 minutes and 3 hours.

*(Ortavant, 1958; Hulet et al., 1962; Bermant et al., 1969; Croker and Lindsay, 1970; Land, 1970; Mattner et al., 1971; Tomkins and Bryant, 1972; Roux and Barnard, 1974; Bryant, 1975; Bryant and Tomkins, 1975; Cahill et al., 1975; Signorett, 1975; Singh et al., 1975; Jennings, 1976; Land and Sales, 1976; Jennings, 1977; Kilgour and Herdegen, 1977; Winfield and Kilgour, 1977; Galal et al., 1978; Winfield and Cahill, 1978; Winfield and Makin, 1978; Winfield et al., 1978; Dhillion et al., 1979; Kilgour, 1979; Kilgour and Whale, 1980; Zenchak and Anderson, 1980).

ewes that were cycling naturally, the rest were artificially induced into estrus. Two cases of restraining the ewes were reported. Four cases of switching ewes during the test were found. Pen size depended on the number of ewes in the test and length of test. All 27 reports included the number of matings resulting in ejaculation, while only 22 reported mounting behavior. Twelve reports included time between sexual activities. Only seven reports included courting behavior of any type.

No preference can be given for any particular test since no test has been able to predict ram fertility under large-scale commercial production. Mattner et al. (1971), Winfield and Kilgour (1977), and Kilgour and Whale (1980) reported measures of services and mounts were moderately correlated with flock mating activity and fertility when libido tests were continued for one hour. Many researchers cannot correlate libido tests with flock mating activity and fertility (Hulet et al., 1962; Bryant and Tomkins, 1975; Cahill et al., 1975; Kelly et al., 1975; Singh et al., 1975; Walkley and Barber, 1976; Winfield and Cahill, 1978; Dhillion et al., 1979). Kilgour (1979) found no difference in fertility; however, high libido rams produced a shorter lambing season. Zenchak and Anderson (1980) concluded that low response rams during libido tests are mainly due to environmental factors.

Several general conclusions can be made in regards to libido tests. Libido tests can be used to identify rams that will not breed (Hulet et al., 1964; Mattner et al., 1973; Roux and Barnard, 1974; Walkley and Barber, 1976a). Rams tend to favor certain ewes during libido tests despite other ewes that display more intense heat (Rouger, 1969; Westhuysen, 1971). Introduction of a new ewe will revive sexual behavior in rams (Pepelko and Clegg, 1965; Beamer et al., 1969; Thiery and

Signoret, 1978). The level of sexual activity tends to be repeated from year to year (Mattner and Braden, 1975; Wilkins and Kilgour, 1977).

In spite of the inability of current libido tests to predict fertility, studies of large numbers of rams indicate highly fertile sheep have increased expressions of sexual behavior. The most promising future for libido tests is the indications that high libido rams sire more fertile ewe lambs (Wilkins and Kilgour, 1978) and ram lambs (Mattner et al., 1971). A simple five-minute libido test may be all that is needed (Dyrmundsson and Lees, 1972a; Land and Sales, 1976).

CHAPTER III

MATERIALS AND METHODS

Live Animal Procedures

Two types of crossbred ram lambs born during the fall of 1979 were selected from the sheep project at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma, to study the development of ram lambs. The first group of lambs (black-faced) were the progeny of Hampshire, Suffolk, Hampshire X Suffolk, and Suffolk X Hampshire rams mated to crossbred ewes consisting of various levels of Rambouillet, Dorset, and Finnish Landrace (Finn) breeding. The second group of lambs (white-faced) were F_2 Finn X Dorsets from a broad sampling of Finn and Dorset germplasm. There were 44 black-faced and 26 white-faced lambs. The highest percentage of Finn breeding in any of the black-faced lambs was 12½%.

The white-faced lambs were born during September and October. The black-faced lambs were born during October and November. Both groups were creep fed a ration composed of 35% chopped alfalfa, 10% soybean meal, 5% molasses, and 50% grain sorghum until they reached 27 to 33 kg. The soybean meal was replaced with alfalfa hay at that time. The white-faced lambs were pasture reared and weaned at approximately 90 days of age, while the black-faced lambs were drylot reared and weaned at approximately 70 days of age. Following weaning, the two ram lamb types were managed separately; therefore, each group is discussed separately.

Protocol for the Black-Faced Lambs Following Weaning

Initially, the first ten lambs to reach 34 kg were placed in a finishing pen. These ten lambs (Group 4) were later used to test sexual behavior. Three groups of 12 black-faced lambs about 32 kg were each placed in a finishing pen. Two of these 36 lambs were later removed due to poor health and the other 34 were slaughtered and used to study testicular development. All four groups were on the pre-weaning ration. At seven months of age the ration for Group 4 was changed to 80% alfalfa and 20% grain sorghum. Body weight was taken at least every two weeks.

Testicular and epididymidal observations were made on all 44 lambs and are described under procedures and these data were analyzed as one set for all 44 lambs.

Testicular and epididymidal sperm numbers were determined on the lambs that were slaughtered and are described under procedures. When a pen of 12 lambs averaged 45 kg live weight, the lambs were sorted into upper, average and lower one-third weight groups and one lamb from each group was randomly chosen for slaughter. The same procedure was used at average pen weights of approximately 54, 64, and 73 kg. This procedure gave each lamb an equal chance of being slaughtered at any weight and it prevented the average pen weight from changing substantially each time lambs were slaughtered. Group 4 was used to study the development of sexual behavior in black-faced ram lambs as described under procedures.

Protocol for the White-Faced Lambs Following Weaning

As each lamb reached approximately 37 kg, the ration was changed to

80% alfalfa and 20% grain sorghum, and the lambs were placed in a growing pen. They were weighed at least once every two weeks.

Testicular and epididymidal observations were made on all 26 white-faced lambs and are described under procedures. Testicular and epididymal sperm were not determined for these lambs. Sexual development was studied as described in the procedures for the libido test. Only the ten heaviest lambs during April were used for evaluation of sexual behavior.

Procedures

Testicular and Epididymidal Observations

Two independent scrotal circumference measurements were made. The ram was placed on his rump and the holder supported the ram with his knees. The holder then grasped the upper portion of the scrotum with one hand and pushed both testes semi-firmly against the lower scrotum. The same person always took both measurements and the holder remained the same. Both testes were palpated between scrotal circumference measurements to prevent bias. The measurements were taken with a fiberglass tape measure in centimeters.

A series of scores were developed to indicate the stage of testes' descent and scrotal development. A numerical system from one to five was used, with one indicating slight to no development. Full testicular descent (score = 5) indicated no palpatable resistance to manual descent of the testes. The scrotum scored a 5 when no palpatable fat, fluid or tissue was present within the scrotum and had no tendency to remain pulled tight against the body wall.

All measurements and body weights were taken at two-week intervals starting before the lambs were weaned (approximately 70 days of age). The scrota were sheared at 110 ± 4 days of age.

Determination of Sperm Numbers

Both testes were removed during slaughter at the Oklahoma State University meat lab and weighed. If both testes were approximately the same weight, the left testis was discarded and the right testis kept for analysis. If one testis was smaller than the other by visual appearance, the ram was not used in the study.

The epididymis and connective tissue were removed. The testis was weighed and a ten-gram sample of the mid-section of the parenchyma was removed. The ten-gram sample was homogenized in a blender for 90 seconds in 100 ml of STM composed of 0.9% NaCl containing 0.05% Triton X-100 and 100 ppm methiolate (Amann and Lanbiase, 1969). The homogenate was strained through three layers of cheese cloth into a 200 ml flask. A 50 ml sample was saved and stored at $4^{o}C$ until sperm numbers were quantified.

The connective tissue was removed from the epididymis. The epididymis was cut into the caput-corpus and cauda. The parts were divided where the cauda narrowed at the attachment of the corpus. Each section was weighed, minced with scissors and homogenized in 100 ml of STM for 90 seconds. The homogenate was handled the same as for the testis.

The following day the homogenates were stirred with a magnetic stirrer and sampled. The sample was diluted in STM until 25 to 100 germ cells were present per five squares on the hemocytometer. A sample was taken with a Pasteur pipet for microscopic evaluation of sperm numbers.

Two counts were made from a 0.1 mm hemocytometer under a phase contrast microscope. For each count, five diagonal squares were counted. If the concentration of sperm cells was too small to obtain at least 25 germ cells per five squares, then all 25 cells were counted. The sampling procedure was repeated by a different person and two additional counts were taken.

Computation of sperm numbers was done using the formulas in Table VIII. Total sperm cells in 25 squares were found by multiplying the mean of the four individual readings by five. The multiplicative factor of 10,000 results from using a 0.1 mm hemocytometer. The hemocytometer is 1 mm X 1 mm X 0.1 so to convert to cc, multiply 10 X 10 X 100 = 10,000 per ml of cc of sample. The dilution total is the sum of the sample volume and the volume of STM diluent. The values in the equation were multiplied by two to place the sperm numbers on a testes per ram basis.

Libido Tests

Two libido tests were conducted involving the ten black-faced lambs and ten heaviest white-faced lambs. The tests were conducted on April 17 and July 11 of 1980 when the rams were six to seven months old and again when they were nine to ten months old.

Two pens were used to test two rams at one time, in order to save time. Each pen was constructed so no visible contact could be made with sheep not involved with the test. A five foot, solid wall was required. Straw bales stacked three high supported by wire fence were used. One holding pen for rams, two holding pens for ewe groups, and three transfer pens were required.

The test area was located where no other sheep could be heard and there were no other activities. Gates permitted easy access to the pens

TABLE VIII

COMPUTATION OF SPERM NUMBERS IN THE TESTES AND EPIDIDYMIDES

Epididymidal Sperm Numbers Equal

$$\left(\begin{array}{l}\text{Total Sperm}\\ \text{in 25 squares}\end{array}\right)\left(10000\right)\left(\begin{array}{l}\text{Tissue Weight}\\ \text{+ STM Volume}\end{array}\right)\left(\begin{array}{c}\text{dilution}\\ \text{Total}\end{array}\right)\left(2\right)$$

Testicular Sperm Numbers Equal

$$\left(\begin{array}{c}\text{Total Sperm Cells}\\ \text{in 25 squares}\end{array}\right)\left(10000\right)\left(\begin{array}{l}\text{Tissue Weight}\\ \text{+ STM Volume}\end{array}\right)\left(\begin{array}{c}\text{dilution}\\ \text{Total}\end{array}\right)\left(\begin{array}{l}\text{Total Testis Wt.}\\ \text{Total Sample Wt.}\end{array}\right)\left(2\right)$$

and permitted rotation of the ewes without mixing the groups. All gates in the test area were solid. The test pens were approximately 10 m by 10 m.

Seventeen days before the test day, 24 non-pregnant ewes were selected. Each ewe received 10 mg progesterone intramuscularly for 14 days. The last progesterone injection was given three days before the test. Each ewe received .25 mg of estradiol benzoate intramuscular two days and one day before the libido test. All injections were given in the morning. Hormone injections were diluted in corn oil so that a two cc injection provided the proper dosage. The ewes were used for both tests so they were treated 8 to 12 days following the test with prostaglandin to terminate possible pregnancies.

Ewes were maintained under good nutritional levels and handled daily to prevent nervousness around humans. Fourteen days before the test day, the rams and test ewes were allowed to graze and feed together. This allowed the ewes and rams to become familiar with each other and helped prevent shy rams from over-reacting on test day.

Rams were handled and fed under the same conditions as the ewes and had access to the libido testing area. Rams and ewes were confined to the testing area for several nights before the test.

The rams and ewes were separated when the 1st estrogen injections were given. The ewes were removed from the testing area and housed separately and the rams had access to the testing area until the test.

All holding pens were supplied with hay and rams were allowed their morning feed. The ewes were brought to the testing area in the morning and placed in a holding pen. Two rams were placed in one of the testing areas to determine if the ewes were estrus. The rams were equipped with a pad placed over the belly to prevent intromission. One to four ewes were placed in the pen. Each ewe was classified as estrus, not in estrus, or questionable. No questionable ewes were used for the test.

Ewes not in estrus would refuse to stand for the ram and avoided the ram. Estrus ewes would crowd the ram, nudge the ram's flanks, wiggle their tail, stand as the ram approached, and flex their back. Questionable ewes would stand for the ram's approach; however, the ewe exhibited no other signs and the ram refused to mount. The selected ewes were randomized into groups of test ewes. The April test had one non-estrus ewe with five estrus ewes. The July groups had eight ewes per group with five estrus ewes per group.

The ram groups alternated pens so that one breed group would not always be in the same pen. The observer for each pen observed the same pen throughout the test. The July test was conducted at night due to summer heat.

Each ram was exposed to one group of test ewes for 20 minutes. The score sheet was divided into 20-second intervals. The following activities were recorded for each time period: 1) sniffing the vulva, 2) courting behavior, 3) nonsuccessful mating, and 4) successful mating. There was no restriction on the number of entries during any one 20-second time period.

Courting behavior was defined as the ram's approach to a ewe, including kicking, nudging, or licking. Nonsuccessful mating was anytime a ram had both front legs off the ground, in contact with the ewe, and failed to ejaculate. A successful mating was when a ram achieved intromission and ejaculated. Ejaculation was defined as a sudden thrust towards the ewe followed by several seconds of latency.

Statistical Analyses

Three data sets were analyzed: 1) individual ram body weights and scrotal circumferences obtained on each ram once or twice a month for several months, 2) the testicular weight, epididymidal weight and spermatozoa counts obtained at slaughter of individual rams over a period of several months, 3) sexual behavior data collected during two different 20-minute libido tests.

Several multiple regression models (first to the seventh order) were tested within each ram lamb type to obtain the highest order equation with statistical significance ($P<.05$) for the first two data sets. The residual mean square was used as the error term to test for significant sources of variation within each model. The data were analyzed with the assistance of the Statistical Analysis System (Helwig and Council, 1979).

In the first data set, body weight was analyzed by fitting the following multiple regression model to each lamb:

$$\text{Body weight} = B_0 + B_1 \text{ age} + B_2 \text{ age}^2 + \text{random error.}$$

From each individual growth curve, body weight was predicted at set ages. Group means were calculated for selected ages.

Scrotal circumference was analyzed by fitting two multiple regression models to each lamb:

$$\text{Scrotal circumference} = B_0 + B_1 \text{ age} + B_2 \text{ age}^2 + B_3 \text{ age}^3 + \text{random error}$$

$$\text{Scrotal circumference} = B_0 + B_1 \text{ body weight} + B_2 \text{ body weight}^2 + \text{random error.}$$

From each individual curve, scrotal circumference was predicted at set ages and body weights. Group means were calculated for selected ages and body weights.

Ram lamb type (black-faced vs white-faced) was added to all three of the above models to test the effects of type. An analysis of covariance was done to obtain the effects of birth weight on body weight at various ages. The following model was used:

$$Y = B_0 + B_1 \text{ age} + B_2 \text{ age}^2 + B_3 \text{ birth weight} + \text{random error}$$

The second data set was testicular weight, epididymidal weight and spermatozoa counts obtained at slaughter of the 34 ram lambs. A prediction equation was developed to predict each variable at set ages and scrotal circumferences. The following equation was used:

$$Y = B_0 + B_1 \text{ scrotal circumference} + B_2 \text{ scrotal circumference}^2 + B_3 \text{ age} + B_4 \text{ age}^2 + B_5 \text{ scrotal circumference X age} + \text{random error.}$$

The third set of data involving ram lamb sexual behavior was analyzed within ram lamb type by group means and standard errors of the means.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter is divided into five sections: 1) live animal performance, 2) testicular development, 3) sexual behavior, 4) testicular and epididymidal sperm numbers, and 5) scrotal development and testicular descent. The first three sections involve the black-faced and white-faced lambs. The last two sections only involve the black-faced ram lambs.

A comparison was made of the two types of sheep (sections one, two, and three) even though management was confounded with ram lamb type due to different requirements of the black-faced and white-faced ram lambs.

Live Performance

Growth performance of the ram lambs is presented in Table IX. The means were obtained by establishing a growth curve for each ram and his weight was estimated at each reported age in the table. Then the means of the estimated weights were obtained for both the black-faced and white-faced ram lambs. The means were calculated every 20 days from 80 to 160 days of age and every 40 days after 160 days of age. Figure 1 illustrates the growth curve of the two ram lamb types and the differences in body size at the same ages.

The black-faced ram lambs ranged from 26.9 kgs to 42.9 kgs at 80 days of age with a standard deviation of 4.14 kgs. As they got older, variation in body weight gradually increased until 200 days of age when

TABLE IX

MEAN BODY WEIGHT ESTIMATED[a] AT SEVERAL AGES OF BLACK-FACED AND WHITE-FACED RAM LAMBS

Age (days)	Number Black-Faced Lambs	Mean Estimated Body Weight (kgs) ± SE.	Number White-Faced Lambs	Mean Estimated Body Weight (kgs) ± SE.
80	44	33.72 ± .62	12	23.20 ± .95
100	44	39.73 ± .62	21	28.22 ± .91
120	38	45.27 ± .71	21	32.24 ± .84
140	35	51.00 ± .82	21	35.96 ± .79
160	30	56.11 ± .96	21	39.39 ± .76
200	17	64.71 ± 1.41	21	45.35 ± .71
240	10	67.49 ± 1.75	21	50.12 ± .70
280	10	71.29 ± 1.57	20	53.60 ± .71

[a]Weights were estimated for each ram by individual regression analysis using the model body weight = $B_0 + B_1$ Age + B_2 Age^2 + random error.

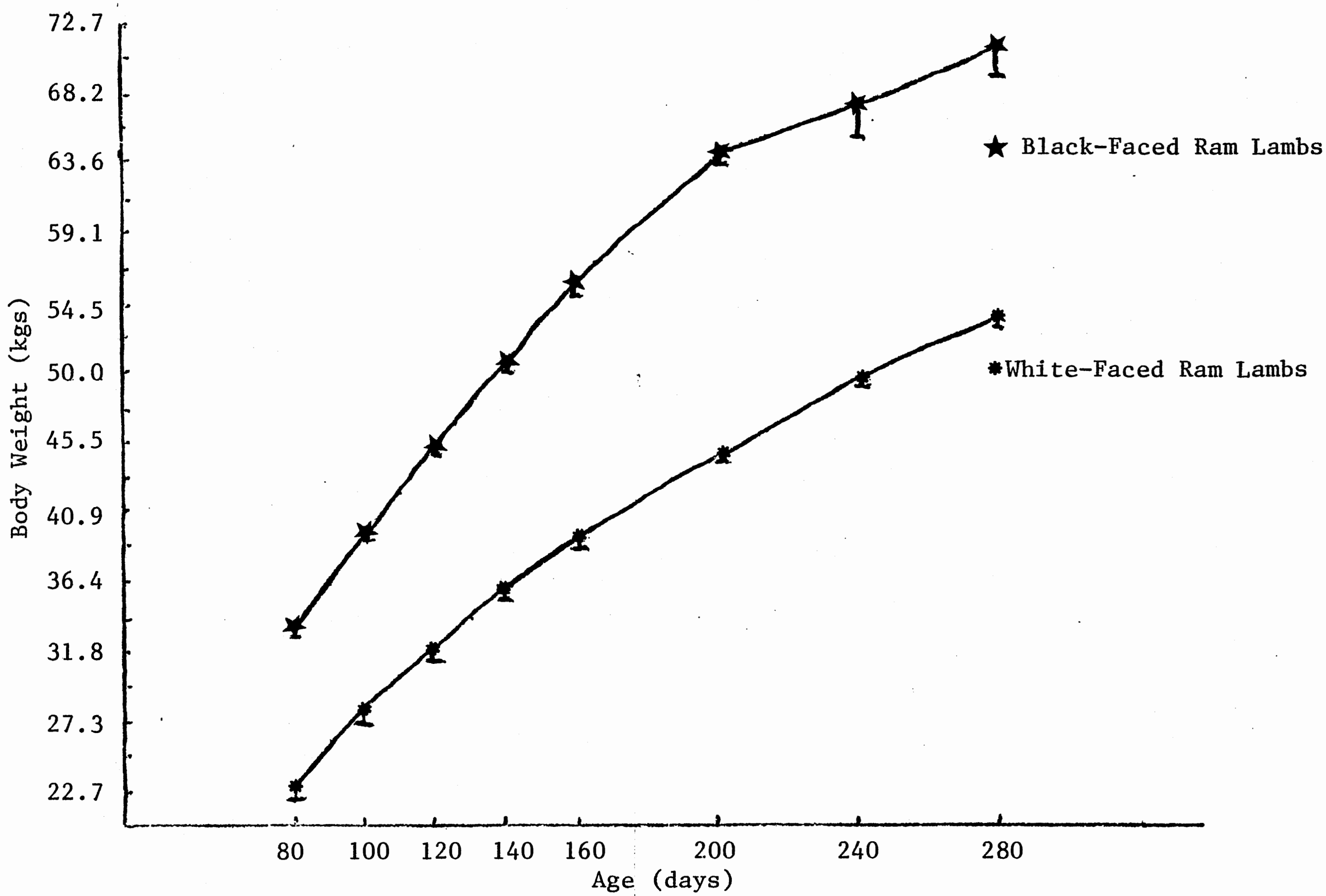


Figure 1. Mean Body Weight of Black-Faced and White-Faced Ram Lambs From 80 to 280 Days of Age (The Standard Errors of the Means are Listed in Table IX)

the standard deviation was 5.82 kgs. There were fewer lambs at 200 days of age. Perhaps some of the rams had already reached their lean growth potential causing them to slow down in growth rate and increase the range in body weights.

Average daily gain remained fairly constant until the lambs reached 63.6 kgs after which rate of gain decreased gradually until 240 days of age (Figure 1). Growth rate in these black-faced ram lambs was typical of the flock as reported by Stritzke (1980) and Sents (1981). Early average daily gain was .30 kgs per day from 80 to 100 days of age when calculated from Table IX. By 200 days of age the black-faced ram lambs were only gaining .21 kgs per day.

The white-faced ram lambs ranged from 18.5 kgs to 30.4 kgs at 80 days of age with a standard deviation of 3.28 kgs. Variation among the lambs was greatest at 100 days of age with a standard deviation of 4.16 kgs. The lambs were weaned at about 90 days which may account for the increased variation in weights if there was individual stress at weaning. At 280 days of age the overall group was more uniform with a standard deviation of 3.18 kgs; however, rams varied from 49.4 to 63.0 kgs.

Early maturity patterns of the Dorset as well as the poor growth rate of the Finn were evident in the white-faced lambs. Daily gain was .16 kgs from 36.4 to 45.5 kgs as compared to .3 kgs per day for the black-faced rams. White-faced lambs gradually decreased in average daily gain from 80 days of age until the end of the study (Figure 1). In contrast, the black-faced ram lambs maintained their growth rate until 140 days of age. Most market lambs maintain a rapid daily gain until at least 120 lbs. (Shelton and Carpentor, 1972; Sents, 1981).

Management practices may have contributed to the reduced growth rate of the white-faced ram lambs compared to the black-faced. General observations indicate that these white-faced lambs do not consume creep feed very readily. The lambs have a strong tendency to remain with the ewes even though the milking ability of the ewes does not seem to be sufficient for sustained lamb growth.

There was a large difference in body size and a difference in growth rate between the two types of sheep (Figure 1). The difference existed from birth. The black-faced lambs average 4.5 kgs at birth while the white-faced lambs only averaged 2.6 kgs.

Birth weight was used as a co-variant in the following analysis of co-variance model to determine if birth weight differences were responsible for the difference in growth pattern.

$$\text{Body weight} = B_0 + B_1 \text{ age} + B_2 \text{ age}^2 + B_3 \text{ birth weight} + \text{random error}$$

Even with the effects of birth weight removed, the weight was still greater ($P<.001$) for the black-faced ram lambs.

Despite management differences the breed combinations of Finnish Landrace and Dorset apparently do not have the genetic potential for sustained body growth and large body size as compared to breed combinations which contain Suffolk or Hampshire breeding.

Even though United States standards for lamb growth are not met by these white-faced lambs, this group of lambs was similar in body weight at 100 days of age to most of the sheep used in reproductive research in other parts of the world including Europe. The approximate 100 day weight was 24.9 kgs for reported studies (Table I) and 28.2 kgs in the present study.

Testicular Development

Means of the scrotal circumference growth of the ram lambs for every 20 days from 80 to 160 days of age and every 40 days after 160 days of age were obtained the same way as they were for live performance (Table X). Throughout this discussion, development of the testes was measured by changes in the scrotal circumference.

The scrotal circumference of the black-faced ram lambs showed the greatest variation of 160 days of age with a range of 25.4 cm to 36.16 cm with a standard deviation of 2.65 cm (Table X). Testicular size changed the fastest in these ram lambs between 80 and 100 days of age, growing at .19 cm per day (Figure 2). Testicular growth rate was fast until 140 days of age at which time the rate of scrotal circumference change slowed to .07 cm per day until 160 days of age. Very little change in scrotal circumference occurred after 160 days of age in the black-faced ram lamb.

Very little work has been done on the reproductive development of the large-framed Suffolk or Hampshire-sired ram lambs. Skinner et al. (1968) reported the onset of testicular growth as early as 42 days of age in Suffolk ram lambs. This is about one-half the age that is reported for smaller-framed breeds. Rapid testicular growth was well established by 80 days in the present study of black-faced lambs.

The white-faced ram lambs had the greatest variation in scrotal circumference at 100 days of age with a range of 16.91 cm to 25.19 cm with a standard deviation of 1.99 cm (Table X). Testicular size increased the most (Figure 2) between 100 and 120 days of age and gradually declined in growth rate until 240 days of age when testicular growth slowed.

TABLE X

MEAN SCROTAL CIRCUMFERENCE ESTIMATED[a] AT SEVERAL AGES OF BLACK-FACED AND WHITE-FACED RAM LAMBS

Age (days)	Number Black-Faced Lambs	Mean Estimated Scrotal Circumference (cm) ± SE.	Number White-Faced Lambs	Mean Estimated Scrotal Circumference (cm) ± SE.
80	42	19.38 ± 0.321	7	19.56 ± 0.291
100	44	23.17 ± 0.349	20	21.55 ± 0.445
120	37	26.32 ± 0.365	21	23.71 ± 0.331
140	35	29.13 ± 0.417	21	25.48 ± 0.290
160	30	30.51 ± 0.484	21	26.85 ± 0.280
200	17	31.58 ± 0.523	21	28.60 ± 0.285
240	10	31.70 ± 0.530	21	29.36 ± 0.303
280	10	31.77 ± 0.493	20	29.46 ± 0.346

[a]Scrotal circumferences were estimated for each ram by individual regression analysis using the model scrotal circumference = $B_0 + B_1$ age $+ B_2$ age^2 $+ B_3$ age^3 + random error.

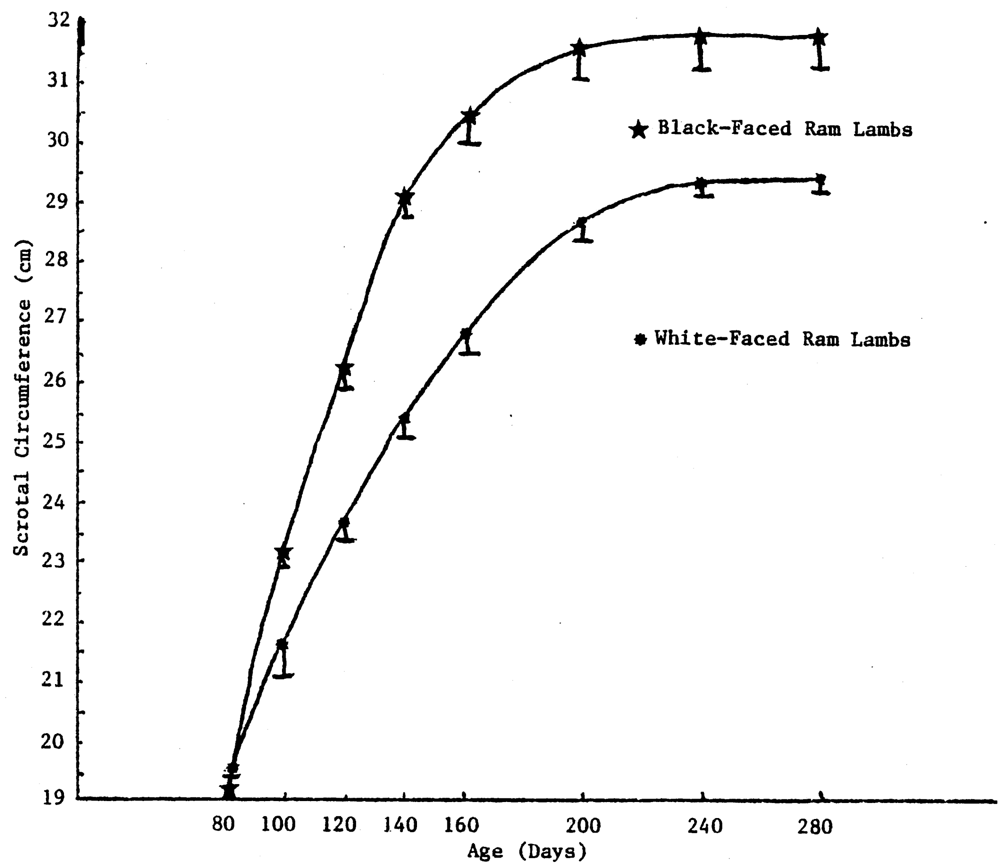


Figure 2. Mean Scrotal Circumference of Black-Faced and White-Faced Ram Lambs From 80 to 280 Days of Age (The Standard Errors of the Means are Listed in Table X)

The testicular development of the white-faced rams was similar to estimates in the literature. Rapid testicular growth appears to be first established by 80 to 90 days of age (Courot, 1962; Colyer, 1971; Skinner, 1971). The white-faced ram lambs had initiated rapid testicular growth by 80 days of age. Data were not available for comparisons with Finn and Dorset crossbreds.

Carr and Land (1975) reported that Finn ram lambs had a scrotal circumference of approximately 12 cm at 83 days of age. Land and Sales (1976) reported that similar Finn rams had a scrotal circumference of approximately 17.2 cm at 84 days of age. The white-faced ram lambs in the present study had larger scrotal circumferences (19.6 cm) at 80 days of age.

Figure 2 illustrates scrotal circumferences at various ages for the two ram lamb types. The testicular growth curve for the black-faced ram lambs was different ($P<.001$) than that for the white-faced ram lambs. At 80 days of age, there were no significant differences in scrotal circumference between the two types. The black-faced ram lambs averaged .16 cm of scrotal circumference growth from 80 to 140 days of age versus .05 cm for the white-faced lambs. Because of the increased testicular growth rate, the black-faced ram lambs had greater scrotal circumferences by 100 days of age and maintained larger testicular size throughout the study. The differences between the two groups is confounded by the difference in the growth rate of the two types of ram lambs.

Table XI presents scrotal circumference at several different body weights for the two ram lamb types. In these data, age (Table X) and body weight (Table XI) were of similar value in accounting for variation in growth rate of the testes. R-square values were calculated for both

TABLE XI

MEAN SCROTAL CIRCUMFERENCE ESTIMATED[a] AT SEVERAL BODY WEIGHTS OF BLACK-FACED AND WHITE-FACED RAM LAMBS

Body Weight (kgs)	Number Black-Faced Lambs	Mean Estimated Scrotal Circumference (cm) ± SE.	Number White-Faced Lambs	Mean Estimated Scrotal Circumference (cm) ± SE.
27.3	24	16.50 ± 0.276	19	21.53 ± 0.345
36.4	44	21.26 ± 0.311	21	25.81 ± 0.335
45.5	39	26.56 ± 0.357	21	28.48 ± 0.356
54.5	31	29.59 ± 0.372	20	29.45 ± 0.366
63.6	23	31.45 ± 0.432	--	---
72.7	13	31.80 ± 0.522	--	---

[a]Scrotal circumferences were determined for each ram by individual regression analysis using the model scrotal circumference = $B_0 + B_1$ body weight + B_2 body weight^2 + random error.

age and body weight using the multiple regression models listed in the footnote of each table. The R-square values for age were .82 and .71 for the black-faced and white-faced respectively. For body weight, the R-square values were .84 and .72 for the black-faced and white-faced, respectively. This suggests that either age or body weight would predict reproductive development with equal accuracy.

In the black-faced rams (Table XI), the greatest increase in circumference was from 36.4 kgs to 40.9 kgs (.13 cm per kg). This was also the time the rams had the greatest average daily gain. The decrease in testicular growth rate slightly preceded the reduced growth rate in the black-faced ram lambs.

The white-faced ram lambs never attained as heavy body weights as the black-faced. Testicular size increased the most between 27.3 kgs and 36.4 kgs for the white-faced lambs which roughly coincides with 120 to 140 days of age. Carr and Land (1975) and Land and Sales (1976) reported that pure Finn weights and scrotal circumferences of 20.5 kgs with 12 cm scrotal circumference and 22.3 kgs with 17.2 cm scrotal circumference, respectively. The present white-faced were heavier (23.2 kgs) and had a larger scrotal circumference (19.6 cm) than either of the previous studies.

In comparing the two types of ram lambs in Table XI the testicular growth curve adjusted for body weights was different ($P<.001$). The faster growing, larger-framed black-faced ram lambs also had faster growing, larger testes as reflected by scrotal circumference.

From 36.4 kgs to 45.5 kgs, the black-faced ram lamb testicular growth was .12 cm per each added kilogram of body weight. The white-faced testicular growth was only .06 cm per each added kilogram of body weight. Not only were the black-faced ram lambs growing faster, but for each kilogram of body weight added their scrotal circumference increased at twice the rate of the white-faced lambs. From 45.5 kgs to 54.5 kgs, the black-faced scrotal circumference increased three times as fast for each added kilogram of body weight than the white-faced ram lambs. Both types had similar scrotal circumference at 54.5 kgs of body weight. White-faced ram lambs started testicular growth at a lighter weight than did the black-faced; however, once the black-faced started increasing testicular growth rate, the testes grew faster so both types were similar 15 54.5 kgs (Table XI).

These results are similar to other reported differences in ram development (Land, 1973; Land and Sales, 1977). Both reports attribute the differences to genotype but there were extreme differences in actual body growth as well as testicular growth between the breeds tested. In comparing testicular development between breeds, body weight or growth confounds the result.

Sexual Behavior

Table XII presents several indicators of the degree of interest ram lambs had for estrous ewes plus the number of actual matings for each ram type during two different libido tests. Table XIII is the age, body weight and scrotal circumference during each test for each breed type. Sexual behavior is a more difficult area to study than physical traits like body weight and scrotal circumference.

The black-faced ram lambs averaged 184 days of age (Table XII) during the April libido test. During the 20-minute test they averaged 1.6 successful matings per ram (Table XIII). Two rams failed to mate,

TABLE XII

MEAN SEXUAL ACTIVITY[a] OF BLACK-FACED AND WHITE-FACED RAM LAMBS DURING EXPOSURE TO EWES INDUCED INTO ESTRUS IN APRIL AND JULY

Ram Type	Month	Vulva Sniffing	Courtship Activity	Unsuccessful Matings	Successful Matings
Black-Faced	April	23.4 ± 2.52	17.3 ± 2.87	5.8 ± .87	1.6 ± .48
Black-Faced	July	24.3 ± 2.44	15.1 ± 2.93	5.4 ± .97	2.6 ± 1.09
White-Faced	April	24.2 ± 2.70	25.7 ± 3.11	7.4 ± .97	4.0 ± .76
White-Faced	July	22.9 ± 1.99	16.1 ± 1.86	6.6 ± 1.39	2.3 ± .50

[a]Mean SE. of the number of attempts at each activity during a 20-minute libido test.

TABLE XIII

MEAN AND STANDARD ERROR FOR AGE, BODY WEIGHT AND SCROTAL CIRCUMFERENCE OF BLACK-FACED AND WHITE-FACED RAM LAMBS PRIOR TO EXPOSURE TO EWES INDUCED INTO ESTRUS IN APRIL AND JULY

Ram Type	Month	Age (days)	Body Weight (kgs)	Scrotal Circumference (cm)
Black-Faced	April	184.1 ± 1.9	57.2 ± 1.38	29.40 ± .58
Black-Faced	July	261.1 ± 1.9	69.1 ± 1.73	32.24 ± .54
White-Faced	April	211.6 ± 3.19	48.0 ± .97	28.46 ± .99
White-Faced	July	295.6 ± 3.19	56.0 ± 1.26	29.14 ± .54

while one ram achieved five successful matings. The rams showed interest through vulva sniffing, courtship activity and unsuccessful matings but the overall behavior was not very aggressive.

In July at about 261 days of age the same rams demonstrated a slight increase in reproductive performance. The rams averaged 2.6 successful matings per ram; however, the level of general desire and activity was almost the same as the April test.

The white-faced ram lambs were 211 days of age at the time of the April test (Table XII). During the 20-minute libido test the lambs averaged four successful matings per ram (Table XIII). All the rams completed at least one successful mating with the most active ram completing nine successful matings in 20 minutes. The rams actively sniffed vulvas, displayed courting behavior and attempted almost twice as many unsuccessful matings as successful matings. White-faced ram lambs appear to be able to breed ewes at 47.7 kgs body weight, 211 days of age and 28.5 cm scrotal circumference (Table XIII).

During the July libido tests (Table XII) the white-faced rams showed a decrease in sexual activity. The rams were older, had gained weight and the scrotal circumference had increased slightly. June and July are thought to be the poorest breeding months for Finn and Dorset sheep and the rams could have had reduced sexual activity due to season.

Sexual activity was similar for the two breed types (Table XII). The white-faced ram lambs tended to be more active during April. The increased activity of the white-faced ram lambs during April could be attributed to their greater age or to earlier development of a mature reproductive system.

Summer heat, seasonality and time of day are probably the main reasons for the different performance in July. Table VI indicated that rams of similar age and development should be capable of reproductive behavior similar to mature rams. Most reports are for spring-born ram lambs that are eight to nine months old during the fall, which is the normal breeding season for sheep. The fall-born ram lambs reached eight to nine months of age during the poor breeding period of June and July. The fall-born ram lamb may be reproductively active three to four months of age later than the spring-born ram lamb due to the different seasons.

Testicular and Epididymidal Sperm Numbers

Testicular and epididymidal sperm numbers were estimated on 34 of the black-faced ram lambs. One-fourth of the lambs were killed at each of the average pen weights of 45.5, 54.5, 63.6 and 72.7 kgs. Lambs were killed between 100 and 225 days of age, at which time the right testis and epididymis was removed and spermatozoa were quantified.

The purpose of the spermatozoa counts was to determine testicular development for the ram lambs at either certain body weights, ages, scrotal circumferences or a combination thereof. To find the best multiple regression equation, the spermatozoa counts and actual testicular and epididymal weights were each predicted by first using body weight, then age, and then scrotal circumference of the ram lambs at the time they were slaughtered. The R-square values for each model used in estimating the dependent variables involving spermatozoa counts and testicular and epididymal weight are listed in Table XIV. None of the first three models adequately estimated the dependent variables. The two best models were then combined to give model four in Table XIV which is:

TABLE XIV

R-SQUARE (COEFFICIENT OF DETERMINATION) VALUES FOR FOUR REGRESSION ANALYSIS MODELS USED TO ESTIMATE TISSUE MASS AND SPERM NUMBERS IN BLACK-FACED RAM LAMBS

Dependent Variable	Model One[a] R^2	Model Two[b] R^2	Model Three[c] R^2	Model Four[d] R^2
Testis Weight	.14	.17	.85	.87
Capita-Corpora Weight	.43	.49	.60	.76
Cauda Weight	.44	.60	.40	.72
Total Testis Sperm	.31	.49	.72	.80
Total Capita-Corpora Sperm	.28	.43	.59	.75
Total Cauda Sperm	.37	.55	.48	.73
Sperm/Gram Testis	.33	.58	.46	.65
Sperm/Gram Capita-Corpora	.28	.48	.45	.65
Sperm/Gram Cauda	.42	.66	.44	.73

[a]$Y = B_0 + B_1$ Body Weight $+ B_2$ Body Weight^2 + Random Error.
[b]$Y = B_0 + B_1$ Age $+ B_2$ Age^2 + Random Error.
[c]$Y = B_0 + B_1$ Scrotal Circumference $+ B_2$ Scrotal Circumference^2 + Random Error.
[d]$Y = B_0 + B_1$ Scrotal Circumference $+ B_2$ Scrotal Circumference^2 $+ B_3$ Age $+ B_4$ Age^2 $+ B_5$ Age X Scrotum Circumference + Random Error.

$$Y = B_0 + B_1 \text{ Scrotal Circumference} + B_2 \text{ Scrotal Circumference}^2 + B_3 \text{ Age} + B_4 \text{ Age}^2 + B_5 \text{ Scrotal Circumference X Age} + \text{Random Error}$$

To get a good estimate of the growth for testicular weight, epididymal weight and spermatozoa numbers, both age and scrotal circumference were required in the model. The linear effects of age and scrotal circumference were included. As the rams progressively got older and as scrotal circumference increased, testicular and epididymal weight and spermatozoa numbers increased. The dependent variables eventually leveled off or declined so the quadratic terms were included in the model to account for this change. The interaction term (Scrotal Circumference X Age) was included because the differences in testicular and epididymal weight and spermatozoa number caused by the variation in scrotal circumference was possibly dependent upon the age when the ram was measured.

Using the above model, the spermatozoa number and testicular and epididymal weights are estimated for the ages and scrotal circumferences and are reported on the black-faced ram lambs in Table XV. The estimates for the testes are in Table XV and for the epididymis in Tables XVI and XVII.

Testicular weight, total testes spermatozoa and spermatozoa/gram of testis are presented in Table XV for several ages and scrotal circumference measurements of the black-faced lambs. The negative values were obtained due to the analysis procedure and were assumed to equal 0. A curve was estimated from the data involving 34 ram testis. Spermatozoa would be estimated to appear between 100 to 120 days in the testes.

Spermatozoa numbers were estimated to be zero at 100 days of age. The only ram lambs killed at that age did have some spermatozoa present.

TABLE XV

ESTIMATED[a] TESTICULAR SPERMATOZOA AND TESTICULAR WEIGHT OF BLACK-FACED RAM LAMBS

Age[b] (days)	Scrotum Circumference[b] (cm)	Testicular Weight (gms)	Total Testicular Spermatozoa (billions)	Spermatozoa/ Gram of Testis (millions)
100	23.17	87.42	-0-[c]	-0-[c]
120	26.32	108.03	8.362	83.152
140	29.13	138.43	21.652	150.756
160	30.51	156.22	30.704	190.337
200	31.58	173.77	39.475	223.873
240	31.70	186.96	39.069	211.302

[a]Testicular weight, total testicular spermatozoa and spermatozoa/gram of testis were determined by regression analysis using age and scrotal circumference as independent variables (Appendix Table XIV).
[b]From Table X.
[c]The predicted values were negative.

TABLE XVI

ESTIMATED[a] CAPITA-CORPORA EPIDIDYMIDAL WEIGHT AND SPERMATOZOA OF BLACK-FACED RAM LAMBS

Age[b] (days)	Scrotal Circumference[b] (cm)	Capita-Corpora Weight (gms)	Total Capita-Corpora Spermatozoa (billions)	Spermatozoa/ Gram of Capita-Corpora (millions)
100	23.17	8.01	-0-[c]	-0-[c]
120	26.32	8.27	1.175	100.013
140	29.13	9.83	8.375	798.891
160	30.51	11.50	13.851	1,171.380
200	31.58	13.69	17.300	1,288.957
240	31.70	14.06	8.893	541.807

[a]Capita-corpora weight, total capita-corpora spermatozoa and spermatozoa/gram of capita-corpora were determined by regression analysis using age and scrotal circumference as independent variables (Appendix Table XIV).

[b]From Table X.

[c]Predicted values were negative.

TABLE XVII

ESTIMATED[a] CAUDA EPIDIDYMIDAL WEIGHT AND SPERMATOZOA OF BLACK-FACED RAM LAMBS

Age[b] (days)	Scrotal Circumference[b] (cm)	Cauda Weight (gms)	Total Cauda Spermatozoa (billions)	Spermatozoa/ Gram of Cauda (millions)
100	23.17	6.58	.149	-0-[c]
120	26.32	7.19	5.205	392.694
140	29.13	8.61	17.454	1,897.866
160	30.51	10.18	30.225	2,922.808
200	31.58	12.09	43.845	3,685.708
240	31.70	11.57	35.952	2,622.435

[a]Cauda weight, total cauda spermatozoa and spermatozoa/gram of cauda were determined by regression analysis using age and scrotal circumference as independent variables (Appendix Table XIV).

[b]From Table X.

[c]Predicted values were negative.

The number of spermatozoa increased rapidly until 140 days of age, then slowed slightly until 200 days of age. Spermatozoa numbers declined following 200 days of age.

Testicular weight was heavier than almost all reports in the literature for testicular weight at these ages (Carman and Green, 1952; Courot, 1962; Skinner et al., 1968; Skinner, 1970; Dyrmundsson and Lees, 1972b, Aire, 1973; Sergeeu and Zabolotskii, 1976; Ghannon et al., 1978b). Skinner and Rowson (1968), Barr (1969) and Schanbacher et al. (1974) report lighter but similar testicular weights. The increased testicular size could be due to the larger frame of the black-faced ram lambs or possibly due to a higher level of heterosis.

Spermatozoa were present in all 34 black-faced ram lambs. Literature estimates (Table III) of age at the appearance of first spermatozoa agree with these results. Despite larger testicular weight than most reported studies, these ram lambs did not appear to start spermatogenesis any earlier than smaller-framed lambs.

Capita-corpora epididymidal weight, total capita-corpora spermatozoa and spermatozoa/gram of capita-corpora are presented in Table XVI for several ages and scrotal circumference measurements. This table was developed using the same procedures as Table XV. Capita-corpora development had begun by 100 days of age, however no spermatozoa were estimated to be present at that age. The most rapid increase in spermatozoa occurred between 120 to 140 days of age. A drastic decline occurred after 200 days of age.

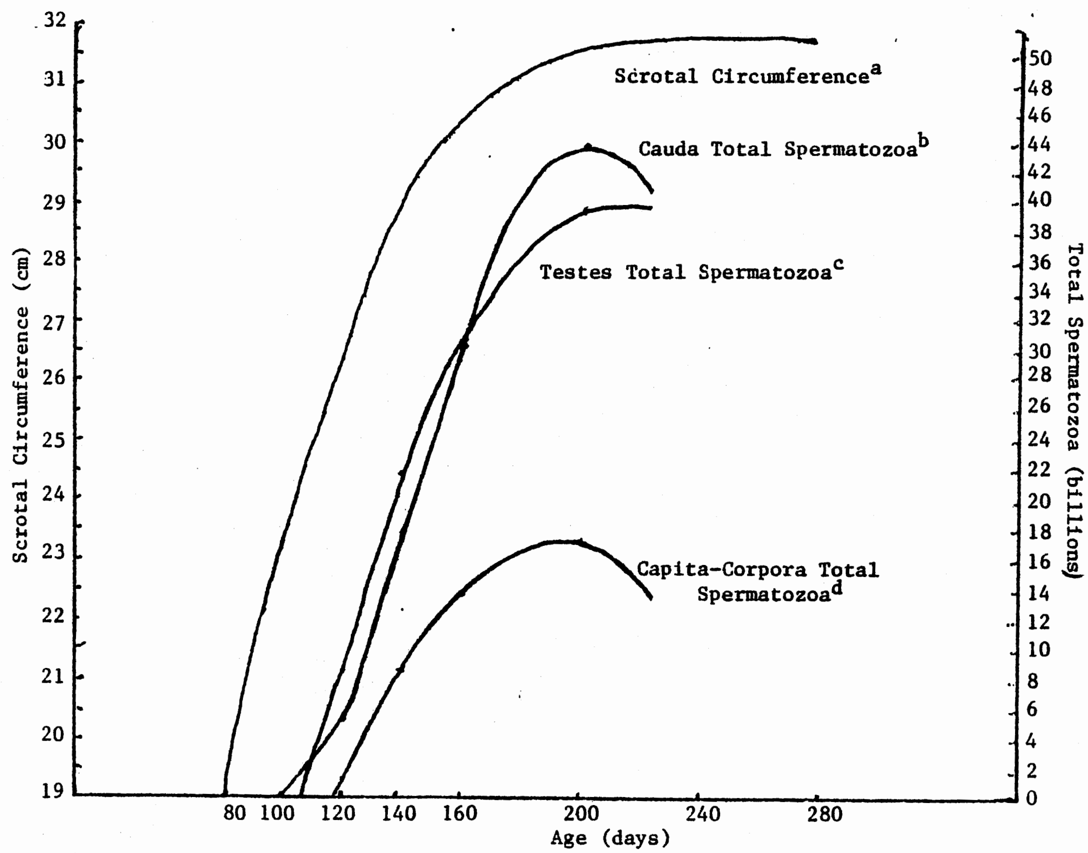
Cauda epididymidal weight, total cauda spermatozoa and spermatozoa/ gram of cauda are presented in Table XVII for several ages and scrotal circumference measurements. This table was also developed the same as

Table XV. At 100 days of age cauda spermatozoa would be estimated around zero. The cauda increased in spermatozoa the greatest from 140 to 160 days of age which is somewhat later than the testes or capita-corpora. Combining Tables XVI and XVII, total epididymidal weight was greater than literature estimates (Barr, 1969; Dyrmundsson and Lees, 1972; Ghannam, 1978b).

Figure 3 depicts testicular, capita-corpora epididymidal and cauda epididymal spermatozoa with scrotal circumference as the lambs got older. As scrotal circumference growth rate decreased, spermatozoa production declined in these ram lambs. Three possible explanations might account for this: 1) The older ram lambs were exposed to the effects of warmer weather; 2) These ram lambs were maturing during May and June which are poor breeding periods; 3) The last factor could be chance sampling.

The decrease in spermatozoa occurred approximately the same time scrotal circumference growth slowed. Some factors are causing the development of the testes to slow down. As previously indicated, this study can not determine the exact cause of the changes seen in Figure 3. The fact that these rams were 200 days old in May; however, would suggest some possible seasonal influences. The combination of heat and increasing day length are probably the main factors limiting further testicular growth and spermatozoa development.

Partial correlation coefficients (Table XVIII) between testicular and epididymidal characteristics were determined. The purpose of these data is only to compare the stage of development between the testes, epididymides and spermatozoa number. The selection method used in this study does not allow the use of these correlation estimates beyond comparison within this group of rams. The data were adjusted for age to



[a]From Figure 2
[b]From Table XVII
[c]From Table XV
[d]From Table XVI

Figure 3. Estimated Total Spermatozoa Number in the Testes, Capita-Corpora Epididymis, and Cauda Epididymis at Several Scrotal Circumferences and Ages for Black-Faced Ram Lambs

TABLE XVIII

PARTIAL CORRELATION COEFFICIENTS BETWEEN TESTICULAR AND EPIDIDYMIDAL CHARACTERISTICS ADJUSTED FOR AGE IN BLACK-FACED RAM LAMBS

	CCWT	TWT	TCS	TCCS	TTS	SGC	SGCC	SGT	SC	BW[e]
CWT[c]	.67[b]	.51[b]	.77[b]	.63[b]	.49[b]	.44[a]	.43[a]	.26	.37[a]	.05
CCWT[d]		.67[b]	.62[b]	.67[b]	.67[b]	.45[b]	.40[a]	.41[a]	.63[b]	.14
Testis Weight (TWT)			.65[b]	.71[b]	.86[b]	.56[b]	.56[b]	.44[a]	.91[b]	.01
Total Cauda Sperm (TCS)				.86[b]	.65[b]	.87[b]	.73[b]	.37[a]	.48[b]	-.08
Total Capita-Corpora Sperm (TCCS)					.80[b]	.83[b]	.92[b]	.54[b]	.64[b]	-.13
Total Testis Sperm (TTS)						.69[b]	.75[b]	.82[b]	.77[b]	-.09
Sperm/Gram Cauda (SGC)							.86[b]	.55[b]	.41[a]	-.15
Sperm/Gram Capita-Corpora (SGCC)								.64[b]	.51[b]	-.22
Sperm/Gram Testis (SGT)									.40[a]	-.15
Scrotal Circumference (SC)										.07

[a]P<.05
[b]P<.01
[c]Cauda weight
[d]Capita-Corpora weight
[e]Body weight

prevent forced positive correlations simply due to increased age. Removing the effects of age from the correlation coefficients probably also removed some of the effects of body weight since the two variables were highly related. This would help explain the low correlations of testicular and epididymidal traits to body weight in Table XVIII.

In Table XVIII, testicular weight, capita-corpora epididymidal weight and cauda epididymidal weight are all moderately correlated with each other (r = .51-.77). Scrotal circumference is also highly correlated (r = .91) with testicular weight and slightly to moderately correlated to epididymidal weight. Testicular weight and capita-corpora epididymidal weight are moderately to highly correlated with total sperm numbers (r = .62-.86), while they are only moderately correlated with sperm/gram of tissue (r = .40-.56). Cauda epididymidal weight is moderately correlated with epididymidal sperm but lowly correlated with testicular sperm.

Estimates in the literature for correlations between testicular weight, capita-corpora epididymidal weight and cauda epididymidal vary from .79-.94 (Colyer, 1971; Dyrmundsson and Lees, 1972b; Knight, 1977; Abdou et al., 1978). Estimates of correlations of testicular weight with scrotal circumference are .74 (Lino, 1972), .90 (Dyrmundsson and Lees, 1972b) and .92 (Knight, 1977).

Literature correlations are all highly positive for various measurements of sperm production with testicular and epididymidal weight. Semen quantity is positively correlated with testes' mass (Boyd and Vandemark, 1957; Willett and Ohms, 1957; Ortavant, 1958; Almquist and Amann, 1961; Amann and Almquist, 1962, Swierstra, 1966; Hahn et al., 1969b; Lino, 1972; Knight, 1977; Abdou et al., 1978). The one exception seems to be corpus weight which appears only slightly correlated with spermatozoa/ gram of testis tissue (Lino, 1972).

All the partial correlation coefficients for the black-faced ram lambs agree with the ranges of these correlation estimates in the literature.

Scrotal Development and Testicular Descent of the Black-Faced Ram Lambs

The testes, epididymides and scrotum were palpated and scored for subjective evaluation of reproductive development. Through the course of the study only two measures could be attained with any reliability. Full testicular descent was attained at 97.7 days of age with a standard deviation of 15.0 days. Full testes'descent was defined as no palpatable resistance to manual descent of the testes. Functional scrotal development was attained at 109.9 days with a standard deviation of 10.8 days. A functional scrotum was defined as a scrotum with no palpatable fat or fluid within the scrotum and had no tendency to remain pulled tight against the body wall. Both traits coincide with the previously mentioned time periods of increased activity in the reproductive system at around 100 days of age.

CHAPTER V

SUMMARY AND CONCLUSIONS

Three kinds of data were collected from 44 black-faced and 21 white-faced ram lambs from the fall of 1979 through the summer of 1980. Growth performance and scrotal circumference were obtained on all lambs at two- to four-week intervals from 70 to 290 days of age or until slaughter. Thirty-four of the black-faced ram lambs were divided into three finishing pens. The first 12 to average 32 kgs went to a pen, then the second 12 followed by the remaining lambs. At average pen weights of 45.5, 54.5, 63.6 and 72.7 kgs a stratified sample of three lambs was obtained for slaughter. Testicular weight, epididymidal weight and spermatozoa number were obtained on each ram at slaughter. The remaining ten black-faced plus ten white-faced were tested for sexual behavior during April and July. All the data except the libido data were analyzed by regression analyses.

Mean body weight for the black-faced ram lambs was 33.72, 39.73, 45.27, 51.00, 56.11, 64.71, 67.49, and 71.29 kgs at 80, 100, 120, 140, 160, 200, 240, and 280 days of age, respectively. The mean body weight of the white-faced rams for the same ages was 23.20, 28.22, 32.24, 35.96, 39.39, 45.35, 50.12 and 53.60 kgs. The growth rate was greater ($P<.001$) for the black-faced ram lambs. Growth rate was greater from 80 to 140 days of age than from 140 to 280 days of age for both groups.

Mean scrotal circumference for the black-faced ram lambs was 19.38, 23.17, 26.32, 29.13, 30.51, 31.58, 31.70, and 31.77 centimeters at 80, 100, 120, 140, 160, 200, 240, and 280 days of age, respectively. The mean scrotal circumference of the white-faced rams for the same ages was 19.56, 21.55, 23.71, 25.48, 26.85, 28.60, 29.36, and 29.46 centimeters. Scrotal circumference was almost the same at 80 days of age for both ram types, but greater for the black-faced after 80 days. The change in scrotal circumference per day of age was greater ($P<.001$) for the black-faced rams. The black-faced ram lambs averaged .16 cm/day of scrotal circumference from 80 to 140 days of age versus .10 cm for the white-faced and .05 cm versus .04 cm, respectively, from 140 to 160 days of age.

Mean scrotal circumference for the black-faced ram lambs at 27.3, 36.4, 45.5, 54.5, 63.6, and 72.7 kgs body weight was 16.50, 21.26, 26.56, 29.59, 31.47, and 31.80 centimeters, respectively. The scrotal circumference of the white-faced lambs was 21.53, 25.81, 28.48, and 29.45 centimeters, at 27.3, 36.4, 45.5, and 54.5 kgs, respectively. The change in scrotal circumference per kilogram of body weight was greater ($P<.001$) for the black-faced lambs. The white-faced rams had larger scrotal circumferences at 27.3 kgs than the black-faced (21.53 vs 16.50), but by 54.5 kgs the black-faced were slightly larger (29.59 vs 29.45). The white-faced lambs never attained body weights of 63.6 kgs.

Testicular weight, caput-corpus epididymidal weight, cauda epididymidal weight and spermatozoa number for each part were determined and then estimated for the black-faced rams at various ages and scrotal circumferences. All estimated tissue weights and spermatozoa counts increased rapidly until 200 days of age, then tissue weights leveled off and spermatozoa counts declined rapidly. A seasonal effect was possibly due to early summer heat or the effect of increasing daylight. Partial correlation coefficients were calculated and scrotal circumference was moderately to highly associated with tissue weight and spermatozoa number.

The sexual behavior was tested for ten rams of each group in April and July. The white-faced ram lambs tended to be more active during April but no other differences were obvious between or among the two groups. The black-faced ram lambs averaged 1.6 and 2.6 completed matings during a 20-minute libido test in April and July, respectively. The white-faced averaged 4.0 and 2.3 completed matings in April and July, respectively.

Scrotal development and testes' descent were palpated and scored by subjective evaluation of reproductive development. Full testes' descent was attained at 97.7 days of age and the scrotum was functional at 109.9 days of age.

The reproductive development of these ram lambs was comparable to other ram lambs reported in the literature. The white-faced rams did not express testicular development as rapidly as expected from reports in the popular press. The ability of rams with a large percentage of Finnish Landrace breeding to achieve quick reproductive development appears to be limited by body growth. The black-faced rams grew faster and increased testicular size at a more rapid rate than most reports in the literature; however, they did not decrease the age for initial production of spermatozoa. Further research is needed on the reproductive development of large-framed sheep.

Subjective scores indicated the same time period of increased changes in the testes as did the measurements of scrotal circumference.

The outward appearance of a ram lamb will change during reproductive development. Subjective appraisal of maturity does give a rough estimate of the physiological changes taking place during reproductive development. The libido tests indicated that ram lambs can achieve successful matings by seven months of age. The inability to quantify the environmental effects during a libido test limit the use of the data obtained.

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APPENDIXES

TABLE XIX

SYMBOLS AND ABBREVIATIONS USED

<u>Abbreviations in Column Headings</u>

NumR	- Number of ram lambs
Loc	- Locality in world
Prim	- Primary spermatocytes
Sec	- Secondary spermatocytes
Sper	- Spermatids
Sperm	- Spermatozoa
Ref	- Reference
NumE	- Number of ewes
Rage	- Ram age
Conc	- Conception rate (percent)
Ejac	- Ejaculate classification
Wt	- Body Weight in kilograms
Aage	- Actual age
TW	- Testis Weight in grams
TD	- Testis diameter in cms.
TuD	- Testis tubule diameter in microns

<u>Abbreviations Used to Describe the Breeds</u>

A	- Hampshire
B	- Southdown
C	- Shropshire
D	- Ile-de-France
E	- Askanian
F	- Awassi
G	- Pedi
H	- Namaqua Africander
I	- Dorper
J	- Karakul
K	- Tabasco
L	- Dorset
M	- Tabasco X Dorset
N	- Suffolk
O	- Native
P	- Merino Crosses
Q	- Targhee Crosses
R	- Dwarf Nigerian
S	- Merino X Corriedale
T	- Clunn Forest
U	- Merino
V	- Welsh Mountain X Suffolk
W	- Kirgiz Finewool
X	- Lincoln X Finewool
Y	- Romney Marsh
Z	- Polish Merino

TABLE XIX (Continued)

AA - Coopworth
BB - Western Crosses
CC - Rambouillet
DD - Ausimi
EE - Romanou
FF - Prealpes
GG - German Merino
HH - Persian Blackhead
II - Orkhor
JJ - Rahmani
KK - German Merino X Rahmani
LL - Finnish Landrace
MM - Finnish Landrace X Merino
NN - Cheviot
OO - Border Leicester
PP - Blackfire Highlander
QQ - Unknown

Abbreviations Used to Describe Locality

a - United States
b - France
c - U.S.S.R.
d - Lebanon
e - South Africa
f - Mexico
g - Iran
h - Bulgaria
i - Iraq
j - Nigeria
k - Australia
l - Wales
m - England
n - Hungry
o - Rumania
p - Poland
q - New Zealand
r - Bulgaria
s - Egypt
t - Rhodesia

Codes for References for Tables

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2 - Terrill, 1938
3 - Carmen and Green, 1952
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TABLE XIX (Continued)

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7 - Symington, 1961
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9 - Sapsford, 1962
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11 - Gaal, 1964
12 - Louw and Joubert, 1964
13 - Shulimou, 1964a
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15 - Dukin, 1966
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17 - Pretorius and Marincowitz, 1968
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22 - Barr, 1969
23 - Chamukha and Abdyldaeu, 1969
24 - Renfro and Dutt, 1970
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39 - Alberio and Colas, 1976
40 - Land and Sales, 1976
41 - Lee et al., 1976
42 - Rossouw and Grobbelaar, 1976
43 - Sergeeu and Zabolotskii, 1976
44 - Ionescu et al., 1977
45 - Valencia et al., 1977
46 - Ghannom et al., 1978
47 - Ortiz, 1978
48 - Nawara, 1978
49 - Ricordeau et al., 1979
50 - Schahid and Smidt, 1980

TABLE XX

INTERCEPTS, SLOPES, AND STANDARD DEVIATIONS OF THE MODEL[a] USED TO ESTIMATE TISSUE MASS AND SPERM NUMBERS IN BLACK-FACED RAM LAMBS

Dependent Variable	B_0	B_1	B_2	B_3	B_4	B_5	S_{yx}
Testis Weight	389.461	-31.505	.901	.194	.004	-.049	15.623
Capita-Corpora Weight	47.655	-2.872	.038	-.080	-.000	.008	1.722
Cauda Weight	28.785	-1.720	.008	-.029	-.001	.010	1.715
Total Testis Sperm	19.011	-6.267	.147	.379	-.002	.095	7.597
Total Capita-Corpora Sperm	1 225	-1.391	-.059	-.389	-.003	.048	5.503
Total Cauda Sperm	206.115	-16.121	.115	-.241	-.005	.081	13.339
Sperm/Gram Testis	-.932	.034	-.000	.005	-.000	.000	.044
Sperm/Gram Capita-Corpora	-13.225	.813	-.019	-.010	-.000	-.003	.425
Sperm/Gram Cauda	-16.069	.553	-.017	.058	-.001	.005	.943

[a]$Y = B_0 + B_1$ Scrotal Circumference $+ B_2$ Scrotal Circumference$^2 + B_3$ Age $+ B_4$ Age$^2 + B_5$ Age X Scrotal Circumference + Random Error.

TABLE XXI

ACTUAL AGE, SCROTAL CIRCUMFERENCE, TESTICULAR WEIGHT AND TOTAL SPERM, CAUDA WEIGHT AND TOTAL SPERM, AND CAPITA-CORPORA WEIGHT AND TOTAL SPERM FOR BLACK-FACED RAM LAMBS AT TIME OF SLAUGHTER

		Scrotal	Testicular		Cauda		Capita-Corpora	
Ram	Age (days)	Circumference (cm)	Weight (gm)	Total Sperm (billions)	Weight (gm)	Total Sperm (billions)	Weight (gm)	Total Sperm (billions)
A110	170	29.30	168.2	44.68	10.59	51.44	11.11	19.78
A117	113	29.65	158.3	20.11	6.35	4.53	8.30	3.89
A112	150	31.40	152.9	32.44	7.81	18.57	10.54	11.58
A201	194	33.30	206.9	46.94	13.03	55.60	16.12	20.45
A207	159	31.00	161.4	38.53	11.19	39.11	12.17	20.11
A211	195	30.30	147.1	25.28	12.41	27.09	13.16	12.26
A223	153	33.50	215.6	51.88	10.21	36.28	14.39	28.31
A302	176	31.70	178.1	39.67	13.21	31.80	14.88	17.53
A322	179	30.90	185.7	30.64	12.03	44.35	12.40	11.64
A343	113	25.50	100.6	9.98	6.49	.28	9.91	.10
A344	172	33.10	174.0	34.69	11.91	40.83	18.23	20.13
A407	225	31.10	166.2	40.22	12.21	37.50	15.21	8.77
A509	204	36.75	285.7	66.94	18.31	101.22	20.84	42.12
A531	115	33.35	232.3	31.01	6.72	.28	9.81	.38
A539	116	26.15	101.8	12.66	7.62	1.08	6.85	1.53
A543	176	34.20	226.0	51.27	9.90	44.72	13.01	22.77
A548	160	27.80	115.2	19.29	8.49	16.97	9.91	3.39
A601	209	31.45	166.8	38.53	11.09	27.21	15.13	5.86
A602	191	29.85	107.9	13.68	8.32	16.44	7.61	4.61
A603	117	29.95	154.5	14.28	6.15	.96	8.30	1.40
A610	199	31.50	188.8	39.46	15.59	74.76	13.30	23.44
A629	142	28.15	122.0	13.02	8.96	14.76	9.19	5.65
A636	224	31.25	169.0	39.97	11.20	55.39	13.42	23.34
A647	186	32.85	181.3	40.63	9.41	36.53	12.37	20.36
A707	202	30.30	173.9	35.39	10.99	32.99	12.81	9.77
A714	182	31.40	179.8	41.04	12.36	52.91	13.09	17.35
A715	100	27.80	135.3	.96	5.50	.05	7.60	.03
A726	160	31.90	168.6	37.97	14.19	40.77	12.47	18.93
A739	151	30.85	173.1	43.19	9.50	39.52	12.61	22.52
B333	224	32.85	186.2	46.60	10.94	23.88	12.64	13.48
B411	211	31.70	204.2	46.80	13.33	50.41	15.50	20.80
B548	123	27.65	127.3	14.18	7.81	2.55	9.03	.81
B647	135	27.95	121.0	1.32	6.11	.01	7.45	.02

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