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The trend in morphological growth of goat testis and its relationship to semen quality

(Arah aliran dalam pembesaran morfologi testis kambing dan korelasinya dengan mutu semen)

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Key words: morphological growth, testis, semen

Abstrak

Satu kajian telah dijalankan untuk menentukan pembesaran testis dan korelasinya dengan berat badan, umur, libido dan kualiti sperma. Enam ekor kambing dari kumpulan baka Katjang tulen (K), kacukan-kacukan Anglo Nubian x Katjang (AK), Saanen x Katjang (SK), AK x K (AKK) dan SK x K (SKK) telah dipelihara dari lahir hingga berumur 2 tahun. Tiap-tiap 28 hari, kambing tersebut ditimbang dan ukuran panjang, lebar dan lilitan testis telah dicatat. Selepas disapeh pada umur 112 hari, mani diperoleh dengan menggunakan faraj tiruan (artificial vagina) untuk dianalisis. Kajian menunjukkan bahawa pada umur satu tahun kumpulan baka AK dan SK mempunyai testis yang lebih besar berbanding dengan kumpulan baka lain. Ukuran testis (panjang, lebar dan lilitan) mempunyai korelasi yang ketara dengan berat badan dan umur dari semua kumpulan baka. Oleh kerana lilitan testis berkorelasi dengan kesuburan, kajian ini menunjukkan bahawa kacukan AK dan SK yang mempunyai lilitan testis yang terpanjang, menghasilkan mani yang banyak, mempunyai libido yang menggalakkan, adalah lebih subur daripada baka SKK dan AKK. Seterusnya lilitan testis bersama variat yang lain seperti pergerakan sperma dan morfologi boleh digunakan sebagai kaedah untuk memilih baka baka tertentu untuk pembiakbakaan.

Abstract

A study was conducted to determine the growth of testes and its relationship with body weight, age, libido and semen quality. Six male kids of each breed group comprising purebred Katjang (K), Anglo Nubian x Katjang (AK), Saanen x Katjang (SK), AK x K (AKK) and SK x K (SKK) were reared from birth to 2 years of age. At every 28 days, body weight and scrotal measurements (length, width and circumference) were measured. After weaning at 112 days of age, semen was collected using an artificial vagina for evaluation. The study showed that at one year old, Anglo Nubian x Katjang (AK) and Saanen x Katjang (SK) had the largest testes compared with the other breed groups. The scrotal measurements (length, width and circumference) were significantly correlated with body weight and age in all breed groups. As scrotal circumference is strongly related to fertility, the study showed that the first crosses of Anglo Nubian x Katjang (AK) and Saanen x Katjang (SK) bucks which had large scrotal circumference, produced large quantities of semen, possessed satisfactory libido, were more fertile than back crosses of SKK and AKK. Scrotal circumference together with other variables such as sperm motility and morphology could also be used as a tool for selection of bucks for breeding.

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Introduction

It has been shown that the same gonadotropic hormones (Follicular Stimulating Hormone-FSH) and (Luteinizing Hormone-LH) control the development of follicles and ovulation in the females, as well as spermatogenesis and testosterone production in the male (Cole 1969, Land 1974). It is believed that a relationship does exist between fertility of males and females (Land and Sales 1977). This relationship can be determined either by repeated measures of LH in males of various ages or by measuring the end product of gonadotropic stimulation in males. This is done by sperm production, or by recording the growth of the testes of young males. As testicular development is positively correlated with the ovarian activity of genetically related females (Bindon 1974), testicular weight can be an important criterion of the amount of parenchyma for the production of sperm and in the evaluation of fertility. Since testicular weight cannot be measured directly in the live breeding male, the indirect method of measuring scrotal circumference and testicular circumference can be employed. Scrotal circumference has been found to be significantly correlated with testicular weight, epididymal spermatozoa reserves and extra-gonadal spermatozoa reserves (Amann 1970, Lino 1972). The diameter of intact testes is also positively related to the ovulation rate in the females and it has been suggested that a high ovulation rate in the females is related to high testes growth rate in the male (Land 1973). Furthermore, males with longer testes tend to sire daughters that reach puberty at an earlier age and ovulate more ova during each oestrus period (Thompson 1979). Thus, it might be possible to increase genetic selection accuracy for increased fertility in the males and females based on the reproductive characteristics of the males. Scrotal measurements maybe used as a selection criterion for identifying bucks for breeding. Therefore, a study was conducted to measure testes growth and determine the relationship between testes measurements and age, body weight, libido and semen quality in the various breed groups of goat in Malaysia.

Material and methods

Six male kids of each breed group comprising purebred Katjang (KK), first cross of Anglo Nubian x Katjang (AK), first cross of Saanen x Katjang (SK), backcross of AK to Katjang dam (AKK) and backcross of SK to Katjang dam (SKK), that survived to 2 years of age, were used to study the body growth, testicle growth and the relationship between testicle measurements and body weight, age and semen quality.

The kids were weighed at birth and subsequently at every 28 days until 2 years of age. Testicular length, width and circumference were measured using a flexible cloth measuring tape. Length was measured from the base to the top of the testes; width was measured from the left to the right side of the scrotum at the widest point; and circumference was measured as the perimeter of the scrotum at the widest point after pushing the testes firmly into the scrotum.

After weaning at 112 days of age the kids were trained to mount a teaser so as to enable the semen to be collected by artificial vagina. Semen collection and evaluation was done fortnightly. Every 2 weeks the animals were tested for libido by recording the time taken to mount a teaser from a distance of 3 m.

The animals were grazed on Guinea grass *(Panicum maximum)* pastures from 0900 to 1500 h. They were given formulated concentrate ration containing 12% CP and 70% TDN at the rate of 0.25 kg/animal per day. Salt lick and water were provided ad libitum in the shed. The animals were in good health and had normal testicles.

Statistical techniques applied in the data analysis encompassed correlation and regression analyses, summary method and plotting procedure (Luginbuhl et al. 1985).

Results and discussion

The results *(Table 1)* showed that the AK crossbred bucks had the greatest body weight at weaning (11.43 kg) and at one year old (20.43 kg) when compared to KK and SK bucks (weaning weight: 7.42 and 8.28 kg; one year old weight: 13.83 and 17.74 kg, respectively). At one year old the KK bucks attained only 67.49% of the weight of AK. It was also observed that at this age the animals were still growing though at a slower rate contrary to some belief that the local goats mature at one year old. It was later observed that the superiority of the crossbreds was maintained and illustrated even at two years old.

It was noted that breed group AK had the biggest testicles at one year old. The SK breed group that possessed the smallest testicle length and width at weaning among the breed groups, had testicles as big as those of the AK and bigger than those of the KK group of the same age. Statistically there was no significant difference (p <0.05) between the testicle measurements (length and width) of AK and SK. The scrotal circumference of AK and SK breed groups at one year old (20.83 and 20.70 cm, respectively) was similar to that of Black Bengal goat of India (Borgohain et al. 1983). Although the testicle size of AKK was greater than that of SKK at one year old, there was no significant difference (p >0.05) between the two breed groups.

From weaning to year old, the greatest increments observed was 114% in body weight, 127.5% in testicle length, 139.9% in width and 141.8% in testicle circumference for the SK breed group. The significant increase in body weight and testicular measurements between weaning and 12 months of age in these animals was possibly due to the effects of luteinizing hormone (LH) and prolactin, which have been reported in sheep to be secreted and reach peak levels around 3 months of age, triggering the rapid testicular growth. The least increment in body weight was in SKK, the least increments in testicle length and scrotal circumference were in AK and the least increment in testicle width was in KK.

The trend of growth in body weight and testicular measurements varied between breed groups as illustrated in *Figure 1–4.*

Table 1. Mean body weight and testicular measurements of five breed groups of goat

Breed	Weaning				One-year old			
	Body weight (kg)	Ratio of body weight to			Body weight (kg)	Ratio of weight to		
		Length	Width	Circumf.		Length	Width	Circumf.
KK	7.42 ± 1.00b	1.34	2.06	0.75	13.83 ± 1.38b	1.51	2.47	0.84
AK	11.43 ± 0.86a	1.65	2.61	0.90	20.43 ± 0.89a	1.82	2.79	0.98
SK	8.28 ± 1.53ab	1.75	2.71	0.97	17.74 ± 2.62b	1.65	2.42	0.86
AKK	7.40 ± 0.53b	1.44	2.20	0.88	15.67 ± 1.18b	1.45	2.31	0.80
SKK	8.63 ± 0.91ab	1.64	2.78	0.97	14.50 ± 0.76b	1.43	2.21	0.78
Overall mean	8.65 ± 0.52	1.56	2.47	0.89	16.61 ± 0.81	1.57	2.44	0.85

ab = Means (± standard error of mean) with same subscript in column are statistically not different (p >0.05)
KK = Katjang x Katjang
AK = Anglo Nubian x Katjang
SK = Saanen x Katjang
AKK = (Anglo Nubian x Katjang) x Katjang
SKK = (Saanen x Katjang) x Katjang

There were significant (p <0.01) and positive correlations between body weight and age with testicular measurements in all the breed groups *(Table 2)*. Evidently, age had a pronounced effect on testes growth. As the animals grew older the testicular size increased. The testicular size as demonstrated by scrotal circumference *(Figure 5)* also increased correspondingly with increase in body weight until about 17 kg in KK and 26 kg in AK and SK. After that, further increase in body weight produced minimal increase in testicular size. The larger-sized breed groups had greater scrotal circumference. The ratios of body weight to scrotal length, width and circumference were 1.82, 2.79, and 0.98, respectively in AK while the corresponding values in SK were 1.65, 2.42 and 0.86. The increase in length and width could be due to the increase in mass of testes or tissue formation. Similar significant correlations of scrotal circumference with body weight were also observed in bulls (Willett and Ohms 1957; Elmore et al. 1976; Coulter and Foote 1977), rams (Braun et al. 1980; Otts and Memon 1980), buffaloes (Bongso et al. 1984) and in bucks (Bongso et al. 1982). Besides age, breed, year and season have also been reported to cause variation in testicular measurements of sheep (Islam and Land 1977).

The size of testes greatly affected the number of mounts per successful ejaculation in KK and SKK breed groups *(Table 3)*. It has been observed earlier that with greater tropical blood (KK-containing Katjang blood in toto and AK-containing Jamnapari and Nubian blood in greater amount), the libido (time to mount) was better (Abdul Wahid and Jaafar 1989). It has also been shown (Land 1970) that breed and seasonal differences in libido greatly influenced female fertility. In sheep, the semen quality of rams was significantly correlated with twinning rate (Hulet 1977). In the goats, Smith (1980) showed that the rate of male sexual development varied with breed, birth weight and nutrition.

In breed groups AK, AKK and SKK, the testes measurements were significantly (p <0.05) correlated with volume *(Table 4)*, that is, with the increase in size there was a corresponding increase in volume of semen. Similar results were obtained by Amann (1970) who showed that sperm production was related to testicular development as illustrated by a positive correlation between testicular weight, gonadal and extragonadal sperm reserves and sperm production. Borgohain et al. (1983) also found that scrotal circumference was significantly correlated with semen volume. This was associated with greater mass and cellular space in the testes giving better survivability and hence better motility. In AK, only width and circumference were highly correlated (p <0.01) with motility, whereas volume of semen was negatively correlated with testes size.

With regard to sperm count, results in the different breed groups varied. The testes measurements were significantly correlated in some breed groups and not significant in others. Sperm count was highly correlated with circumference in KK, AK and SK, with width in KK and AK and with length in KK and SK. The percentage of dead sperm was negatively correlated with length, width and circumference in breed group SK, whereas in SKK the correlations of these variables were positive and significant (p <0.05).

Since scrotal circumference is strongly related to fertility (Bongso et al. 1982), the results of this study indicate that testicle measurements together with other parameters such as sperm motility and morphology could be used to evaluate potential bucks of the different breed groups. In bulls, it has been shown that scrotal circumference which is significantly correlated with testes weight (Willett and Ohms 1957), is highly repeatable. It is also an easily obtainable indicator of testes size. Scoring systems for breeding soundness using such parameters have been developed for cattle (Simon 1976) and to a certain extent for sheep (Braun et al. 1980).

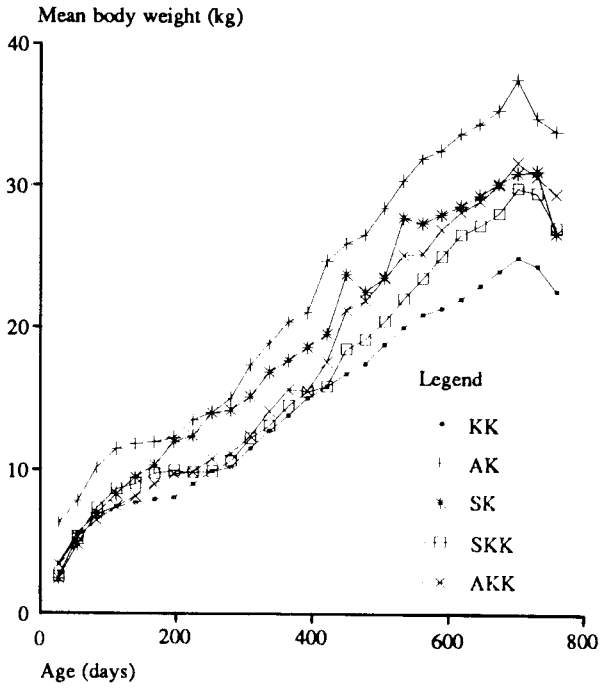

Figure 1. The trend in body growth in five breedgroups of goat

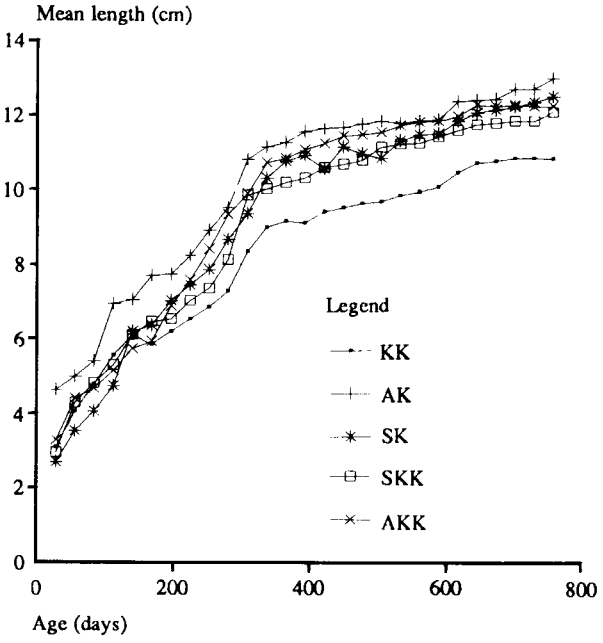

Figure 2. The relationship between testicular length and age of goat

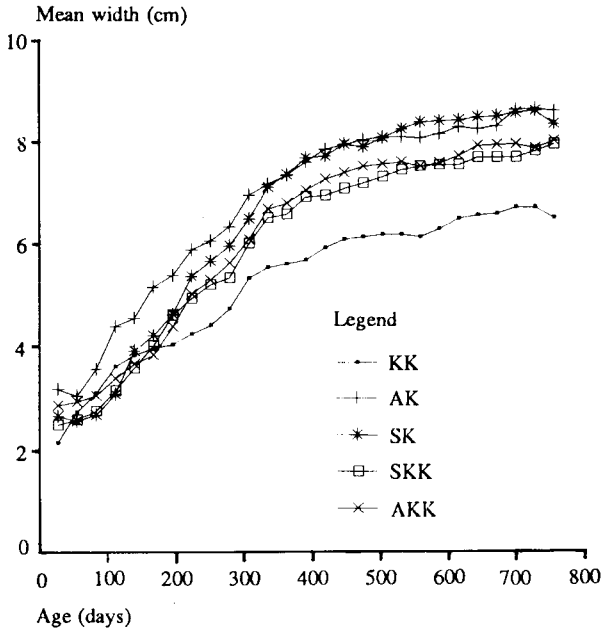

Figure 3. The relationship between testicular width and age of goat

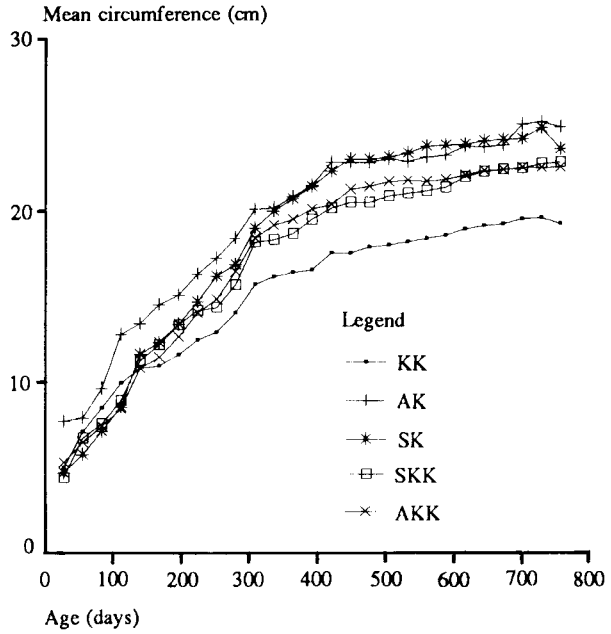

Figure 4. The relationship between testicular circumference and age of goat

Table 2. Correlation between testicular measurements and age and weight

		Testicular measurements		
	Breed	Length	Width	Circumference
Body weight	KK	0.91**	0.91**	0.90**
	AK	0.88**	0.88**	0.88**
	SK	0.91**	0.88**	0.88**
	AKK	0.86**	0.89**	0.88**
	SKK	0.89**	0.89**	0.87**
Age	KK	0.86**	0.83**	0.84**
	AK	0.87**	0.89**	0.89**
	SK	0.81**	0.82**	0.84**
	AKK	0.90**	0.91**	0.90**
	SKK	0.92**	0.92**	0.92**

* Significant at $p < 0.05$
** Significant at $p < 0.01$
KK = Katjang x Katjang
AK = Anglo Nubian x Katjang
SK = Saanen x Katjang
AKK = (Anglo Nubian x Katjang) x Katjang
SKK = (Saanen x Katjang) x Katjang

Table 3. Correlation coefficients between testicular measurements and libido

Testicular measurements	Breed	Time to mount	Time to ejaculate	No. of mounts
Length	KK	0.28**	0.15	–0.24*
	AK	0.31**	0.29**	0.09
	SK	0.18	0.14	–0.03
	AKK	0.32**	0.34**	0.19
	SKK	0.36**	0.23	–0.51**
Width	KK	0.27**	0.11	–0.21*
	AK	0.32**	0.11	–0.14
	SK	0.20	0.17	–0.05
	AKK	0.16	0.18	0.04
	SKK	0.20	0.07	–0.51**
Circumference	KK	0.27**	0.10	–0.21*
	AK	0.33**	0.09	–0.17
	SK	0.25*	0.21	–0.07
	AKK	0.18	0.18	0.04
	SKK	0.25	0.14	–0.48**

* Significant at $p < 0.05$
** Significant at $p < 0.01$
KK = Katjang x Katjang
AK = Anglo Nubian x Katjang
SK = Saanen x Katjang
AKK = (Anglo Nubian x Katjang) x Katjang
SKK = (Saanen x Katjang) x Katjang

Conclusion

At one year of age, Anglo Nubian x Katjang (AK) and Saanen x Katjang (SK) goats had the largest testes compared with the other breeds studied. The testicle measurements (length, width and circumference) were significantly correlated with body weight and age in all breed groups. As scrotal circumference is strongly related to fertility, the study confirms that the first crosses of Anglo Nubian x Katjang (AK) and Saanen x Katjang (SK), bucks which have large scrotal circumference, produce large quantities of semen, have satisfactory libido,

Table 4. Correlation between testicular measurements, and quantity and quality of semen

Testicular measurements	Breed	Volume	Motility	%Dead	Count
Length	KK	-0.24*	0.10	0.02	0.43**
	AK	0.42**	0.17	0.12	0.05
	SK	0.09	0.13	-0.08	0.34**
	AKK	0.36**	0.06	0.11	0.27*
	SKK	0.40**	-0.20	0.30*	0.28
Width	KK	-0.10	0.10	0.05	0.41**
	AK	0.51**	0.30**	0.02	0.26**
	SK	0.14	0.12	-0.04	0.22
	AKK	0.49**	-0.005	0.02	0.04
	SKK	0.44**	0.03	0.32*	0.33*
Circumference	KK	-0.09	0.08	0.12	0.43**
	AK	0.50**	0.27**	0.03	0.28**
	SK	0.18	0.19	-0.08	0.29**
	AKK	0.54**	0.03	0.06	0.17
	SKK	0.38**	0.05	0.25	0.36*

* Significant at $p < 0.05$
** Significant at $p < 0.01$
KK = Katjang x Katjang
AK = Anglo Nubian x Katjang
SK = Saanen x Katjang
AKK = (Anglo Nubian x Katjang) x Katjang
SKK = (Saanen x Katjang) x Katjang

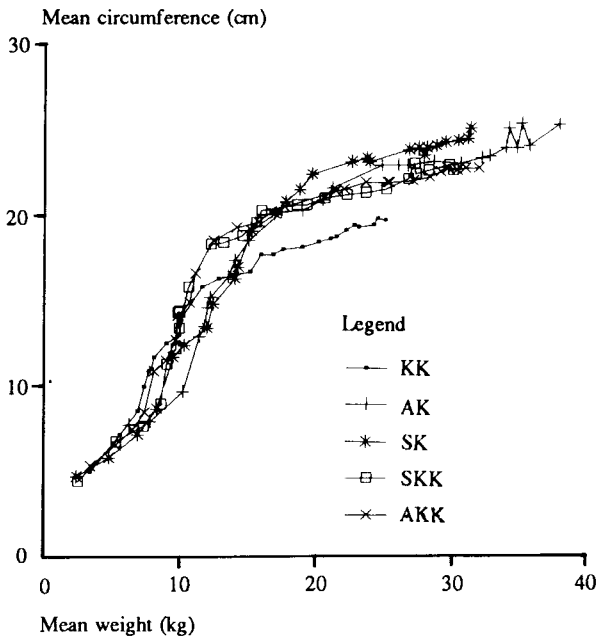

Figure 5. The relationship between testicular circumference and body weight of goat

and are more fertile than backcrosses of SKK and AKK. Testicle circumference, therefore, can be used as a selection parameter in goats.

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References

Abdul Wahid, S. and Jaafar, M. Y. (1989). Variability in libido and semen quality of purebred and crossbred Katjang goats. Presented at Ile Colloque International de Niort 'Goat Diseases and Productions', 26–29 June 1989, Niort, Cedex, France

Amann, R. P. (1970). Sperm production rates. In *The Testis.* (A. D. Johnson, W. R. Gomes and N. L. Van Demark, ed.) N. Y.: Academic Press

Bindon, B. M. (1974). Plasma luteinizing hormone of the prepubertal lamb: possible early indication of fecundity. *Nature,* (London)

Bongso, T. A., Jainudeen, M. R. and Zaharah, S. (1982). Relationship of scrotal circumference to age, body weight and spermatogenesis in goats. *Theriogenology 18*: 513–24

Bongso, T. A., Hassan, M. D. and Nordin, W. (1984). Relationship of scrotal circumference and testicular volume to age and body weight in swamp buffalo *(Bubalus bubalis). Theriogenology 22:* 127–34

Borgohain, B. N., Benjamin, B. R., Baruah, B. and Joshi, B. C. (1983). Testicular consistency and scrotal circumference in relation to the seminal characteristics among goats *(Capra hircus). Ind. J. Anim. Sci. 53:* 1233–5

Braun, W. F., Thompson, J. M. and Ross, C. V. (1980). Ram scrotal circumference measurements. *Theriogenology 13:* 221–9

Cole, H. H. (1969). Physiological characterization of gonadotropins. In *Reproduction in domestic animals.* (H. H. Cole and P. T. Cupps, ed.) 2nd. ed. p. 17–45, N. Y. and London: Academic Press

Coulter, G. H. and Foote, R. H. (1977). Relationship of body weight to testicular size and consistency in growing Holstein bulls. *J. Anim. Sci. 44:* 1076–9

Elmore, R. G., Bierschwal, C. J. and Youngquist, R. S. (1976). Scrotal circumference measurements in 764 beef bulls. *Theriogenology 6:* 485–94

Hulet, C. V. (1977). Prediction of fertility in rams: Factors affecting fertility and collection, testing and evaluation of semen. VM/SAC, *72*: 1363–7

Islam, A. B. M. M. and Land, R. B. (1977). Seasonal variation in testis diameter and sperm output of rams of breeds of different prolificacy. *Anim. Prod. 25*: 311–7

Land, R. B. (1970). The mating behaviour and semen characteristics of Finnish Landrace and Scottish Blackface rams. *Anim Prod. 12:* 551–60

____ (1973). The expression of female sex-limited characteristics in the male. *Nature (London), 241:* 208–9

____ (1974). Physiological studies and genetic selection for sheep fertility. *Anim. Breed. Abstr. 42:* 155–8

Land, R. B. and Sales, D. (1977). Mating behaviour and testis growth of Finnish Landrace, Tasmanian Merino and crossbred rams. *Anim. Prod. 24:* 83–90

Lino, B. F. (1972). The output of spermatozoa in rams II. Relationship to scrotal circumference, testis weight and the number of spermatozoa in different parts of the urogenital tract. *Austr. J. biol. Sci. 25:* 359–66

Luginbuhl, R., Kaufman, M. A. and Crum, L. (1985). *SAS User's Guide: Statistics, Version 5 Edition.* (Joyner, S. P., ed.). SAS Institute Inc. Box 8000, Cary. North Carolina, U.S.A.

Ott, R. S. and Memon, M. A. (1980). Breeding soundness examinations of rams and bucks, a review. *Theriogenology 13:* 155–61

Simon, J. C. (1976). A compilation of current information on breeding soundness evaluation and related subjects. The Society for Theriogenology Journal. (Simon, J. C., ed.), p. 7

Smith, M. C. (1980). Caprine Reproduction. In *Current Therapy in Theriogenology,* (D. Morrow. ed.), p. 991, Philadelphia: Saunders W. B. Co.

Thompson, L. H. (1979). Testicular size - Getting a handle on fertility, Univ. Ill. Coop. Exten. Serv. Sheep Report, February, 1979

Willett, E. L. and Ohms, J. I. (1957). Measurement of testicular size and its relationship to production of spermatozoa by bulls. *J. Dairy Sci. 40:* 1559–62

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