

GETTING THE MOST OUT OF RAMS, BULLS AND BOARS

INTRODUCTION

M.A.de B. BLOCKEY*

Mating management of males in the sheep, cattle and pig industries has two features in common. First, farmers in each industry mate more males per 100 females than is necessary to ensure good herd or flock fertility. Second, little attention is paid to genetic, nutritional, social and breeding soundness aspects when males are prepared for and used for mating.

The reason why farmers use too many males is that they have not had the means of identifying males which are of low fertility or those males which can be successfully mated to a large number of females for example, 100 ewes or 60 cows. Methods of identifying males of low or high fertility, methods which measure the male's serving capacity and sperm production, have been developed in the last decade. This series describes these methods as well as making recommendations on how many females to mate to each male on the basis of its serving capacity and testicle size. This series also describes how farmers can get the most out of males by selecting for fertility, by providing for the nutritional and social needs of males during rearing and mating and by the annual culling of males unsound for breeding.

SERVING CAPACITY OF RAMS AND FLOCK FERTILITY

R.J. KILGOUR**

Recent experiments have shown that a measure of the serving capacity (SC) of the ram during a pen mating test is a very useful indicator of his flock mating ability (Mattner et al. 1971; Kilgour and Whale 1980). This paper reports further **research** into the measurement of serving capacity in the ram and its usefulness in predicting flock fertility.

MEASUREMENT

The SC test consists of placing a **ram with** four oestrous ewes in a 6 m × 6 m **pen** and counting the number of services it performs in a period of time. Some rams are sexually inhibited during their first and sometimes second test so it is necessary to give rams a **20-minute** introductory test to accustom them to the pens. This test is then followed one day later by two tests to measure their SC. The repeatability of rams' performance between these two tests depends on whether rams are allowed visual contact with one another during pen mating tests. At Trangie where rams were allowed visual contact, the repeatability between tests for 96, **18-month-old** rams was 0.72 ± 0.13 (SE) and for 76 of these rams when they were **30-months-old** the repeatability between tests was 0.61 ± 0.11 . At Glen Innes and Hamilton, Victoria where rams were prevented from seeing one another by **hessian** between the mating pens the repeatability between tests was 0.80 and 0.86, respectively. Eliminating visual contact between rams removes the "audience effect" in which the serving activity of some rams is lower if they are watched by dominant rams during pen mating tests than if they were mated alone (Lindsay et al. 1976).

Although the author has routinely used a **3-hour** test the SC test can be of shorter duration and still predict a ram's SC accurately. The number of services

* Pastoral Research Institute, Hamilton, Vic. 3300.

** Agricultural Research Station, Trangie, N.S.W. 2823.

performed during the first 20 minutes, the first 40 minutes, the first hour and the first 2 hours of the 3-hour test are all highly correlated with the total number of services achieved during the 3-hour test ($r = 0.92, 0.95, 0.96$ and 0.99 , respectively). However the advantage of the longer test time is that the range in services achieved is wider (0 to 5 in 20 minutes *cf* 0 to 16 in 3 hours) so one can be more confident of distinguishing between rams of high, medium and low SC.

PREDICTION OF FLOCK FERTILITY

Syndicate mating

When joined at 4 rams/200 ewes, a syndicate of high SC rams raddled more ewes during the first oestrous cycle (190 vs 166, $P < 0.01$) and inseminated a greater proportion of those raddled (90.5 vs 75.9%, $P < 0.01$) than a syndicate of low SC rams (Kilgour and Wilkins 1980). However after a 6-week mating period there was little difference in pregnancy rate between the two flocks (95.3 and 93.5% for high and low SC flocks, respectively). This was because after the first oestrous cycle there were insufficient oestrous ewes to allow the high SC rams to continue to exert their superiority.

Single sire mating

An experiment was conducted at Trangie to determine the relationship between SC and flock fertility when rams were joined at 1 ram/200 ewes (Kilgour 1979). Fifteen rams were selected on the basis of SC and were arbitrarily designated high (5), medium (5) and low (5). Each ram was mated to 200 ewes for 17 days. SC, whether measured over 20 or 40 minutes, 1 or 3 hours, was only moderately correlated with flock fertility (Table 1).

TABLE 1 Coefficients of correlation among measures of pen mating and flock mating

Serving capacity in	Services observed in 33 h flock mating	Raddled	No. of ewes	
			inseminated	Pregnant
3-hr	0.54*	0.37	0.52*	0.47
1-hr	0.56*	0.36	0.53*	0.49
40-min	0.55*	0.38	0.54*	0.53*
20-min	0.54*	0.37	0.51*	0.50
Services observed in 33-hr of flock mating		0.59*	0.73**	0.76***

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

SC reliably indicated the mating performance of rams of high SC (97.8 ± 9.1 ewes pregnant) and medium SC (64.4 ± 11.0 ewes pregnant) but not that of rams of low SC (67.6 ± 15.9 ewes pregnant).

When each ram was observed for 33 hr during paddock mating it was apparent that three of the low SC rams had higher serving capacity than their pen performance indicated. The low SC that these rams displayed in the pen tests may have been due to the audience effect because rams were allowed visual contact with one another during the pen mating tests.

The number of services a ram performed during 33 hr of paddock mating was well correlated with number of ewes it inseminated and impregnated during the 17-day mating period (Table 1).

It is concluded that a ram's serving capacity during paddock mating does strongly influence the fertility of its ewe flock when it is mated to 200 ewes but that the pen test used to predict a ram's SC during paddock mating needs modification to improve its predictive accuracy and to increase the speed with which rams can be tested.

TESTICLE SIZE IN RAMS AND FLOCK FERTILITY

P.B. GHERARDI^{*†}, D.R. LINDSAY* and C.M. OLDHAM*

Individual rams vary markedly in their paired testes weight from 100 to 800 g, and each gram of testicular tissue produces about 20×10^6 sperm per day irrespective of testicle size (Knight 1973). Thus, larger testicles produce more sperm each day. Furthermore, a ram's testicle size and its daily sperm production increase rapidly in response to feeding lupins (Lindsay et al. 1976; Oldham et al. 1978). These findings raise a number of questions. Can rams with large testicles successfully mate more ewes than rams with small testicles? If so, what is the minimum amount of testicular tissue and the minimum number of rams required per 100 ewes without lowering flock fertility? Can rams with testicles enlarged by supplementary feeding with lupins successfully mate more ewes than unsupplemented rams? This paper reports a series of experiments designed to answer these questions.

MATERIALS AND METHODS

The experiments were conducted under field conditions on a number of commercial farms running Merino sheep in south western Australia.

Rams

The aim was to produce groups of rams with widely differing testicular size which could be joined at comparable ram:ewe ratios. In the first and second experiment the rams were divided into two groups 8 weeks before joining, and one group was supplemented with 500 to 1000 g of lupin grain per day. In the third and fourth experiments the rams were selected for large or small testicular size at the time of joining.- In selecting these rams care was taken to ensure that the body weights of rams of both groups were similar. Testicular size was measured by the technique of Oldham et al. (1978) using palpation and comparison with a calibrated orchidometer, a series of testis-shaped beads ranging from 50-400 ml.

(i) Experiment 1: On three farms, rams were selected from the supplemented and the control unsupplemented groups and were allocated to four flocks of 300 ewes on the following basis:

Group 1 - Control rams mated at the usual ram proportion for the farm (mean 2.3% - 1100 g testicular tissue/100 ewes).

Group 2 - Supplemented rams mated at the same proportion as group 1 (mean 2.3% - 1600 g testicular tissue/100 ewes).

Group 3 - Supplemented rams mated at a proportion so that the combined weight of their testes was equivalent of the rams in group 1 (mean 1.3% - 1000 g testicular tissue/100 ewes).

Group 4 - Control rams mated at the same proportion as group 3 (mean 1.3% - 750 g testicular tissue/100 ewes).

* Dept of Animal Science, University of Western Australia, Nedlands, W.A. 6009.

† Present address: Department of Agriculture, South Perth, W.A. 6151.

(ii) Experiment 2: On one farm, rams were selected from supplemented and control groups and were allocated to four flocks of 400 ewes as shown in Table 2.

(iii) Experiment 3: Rams on two farms were selected on high and low testicular size and joined to a flock of 400 ewes at a ram:ewe ratio of 1% as shown in Table 3.

(iv) Experiment 4: Rams on two farms were selected on large or small testicular size and joined to flocks of 460 ewes at either 1.6 or 0.9% on farm 1, or 1.2 or 0.9% on farm 2 as shown in Table 4.

RESULTS

(i) Experiment 1: There was no difference between the treatments; the pooled lambing percentages for groups 1, 2, 3 and 4 were 79, 82, 80 and 80%, respectively.

(ii) Experiment 2: As in Experiment 1, 700 g of testicular tissue was adequate for optimum fertility but there was a decrease in fertility when rams with only 500 g of tissue/100 ewes were joined (Table 2).

TABLE 2 Results of experiment 2 in which rams were supplemented with lupins before joining

Flock No.	Treatment	No. of rams/100 ewes (%)	Testicular tissue/100 ewes (g)	% Ewes Marked	% Lambing
1	Control	6/400 (1.5)	700	85	73
2	Supplemented	4/400 (1.0)	700	81	72
3	Control	4/400 (1.0)	500	83	65
4	Supplemented	6/400 (1.5)	975	81	72

(iii) Experiment 3: The flocks mated at 275 g testicular tissue/100 ewes had lower lambing percentages than flocks mated at 625 g/100 ewes. On property 2 this difference was significant; on property 1 it was not (Table 3).

TABLE 3 Results of experiment 3 from two farms where rams were selected for testicular size and joined at 1%

Testicular tissue/ 100 ewes (g)	Ewes Farm 1		Ewes Farm 2	
	% Marked	% Lambing	% Marked	% Lambing
625	81	64	Flock lambing	75
275	88	61	87	58

(iv) Experiment 4: There were only small differences between groups in the percentage of ewes lambing. These differences are attributable as much to the low percentage of rams as to the small amount of testicular tissue/100 ewes (Table 4).

TABLE 4 Mating and lambing results on two farms on which rams of high or low testicular size were mated at two ewe:ram ratios

Flock no.	Farm 1			Farm 2		
	Testicular tissue/ 100 ewes (% rams)	% Ewes Marked Lambed		Testicular tissue/ 100 ewes (% rams)	% Ewes Marked Lambed	
1	849 (1.6)	87	62	656 (1.2)	92	81
2	559 (1.6)	90	63	492 (1.2)	91	79
3	548 (0.9)	84	58	507 (0.9)	83	77
4	258 (0.9)	87	59	330 (0.9)	84	73

DISCUSSION

In most of the experiments reported above, the number of rams per 100 ewes and the amount of testicular tissue per 100 ewes were much lower than one might expect to use at a normal joining. Despite this, there were no cases of a dramatic fall in the number of ewes that lambed relative to control groups. We are still not able to predict accurately the exact amount of testis per 100 ewes below which fertility is reduced, but it is obvious that in most cases there is a wasteful overuse of rams in normal flock joining. Rams are generally able to cover ewes adequately at percentages around 1%. Furthermore, provided that about 400 g of testis is allocated per 100 ewes the sperm-producing capacity of the rams is adequate to achieve normal fertility in Western Australian flocks.

Both experiments 1 and 2 showed clearly that rams with testicles enlarged by 8 weeks of lupin feeding can successfully mate more ewes than unsupplemented rams. The reduction in rams needed per 100 ewes, from 2.3% to 1.3% in experiment 1, and from 1.5% to 1.0% in experiment 2, makes lupin feeding (cost less than \$10/ram) a more profitable method of providing the minimum amount of testicular tissue per 100 ewes than buying additional rams.

Most mating is done on a safety basis when two or three times as many rams as necessary are joined. We believe that by the simple expedient of assessing the sperm-producing capacity of the ram by measuring the size of his testes, the ram bill can be reduced dramatically without endangering the number of lambs produced.

USING THE SERVING CAPACITY TEST TO GET THE MOST OUT OF BEEF BULLS

M.A.de B. BLOCKEY

Beef bulls vary markedly in their serving capacity during paddock mating (Blockey 1976). And a bull's serving capacity (SC), namely the number of services it achieves during a paddock mating period, influences the proportion of oestrous cows it impregnates (Blockey 1978a). A yard test which predicts a bull's serving capacity during paddock mating with 90% accuracy has been developed. It consists of a) restraining heifers in service crates, b) sexually stimulating bulls by allowing them to watch other bulls mounting the restrained females, and c) counting the number of services performed in a 40-min period. This varies from 0 to 20 services. This paper outlines uses of the SC test in getting the most out of beef bulls.

TESTING YOUNG SALE BULLS

The author contends that *for* a bull to be an economic proposition in a commercial herd it must be joined to 40 females over 10 to 12 weeks and *impreg-*

nate 90% or more of them. The minimum SC a bull must have to achieve that task is three in 40 min. Bulls of SC 0, 1 or 2 when mated to 40 females achieved first oestrus conception rates of 4 to 40% and pregnancy rates after 10 weeks of 4 to 67%, whilst bulls of SC 3 or more impregnated 55 to 78% of heifers on their first oestrus and 89 to 100% of heifers after 10 weeks of mating (Blockey 1978b). An examination of 1355, 18-to 24-month-old sale bulls revealed that 10% of them had SC of 0, 1 or 2. Such bulls should be withdrawn from sale.

This same experiment of Blockey (1978b) showed that as the SC of the bull joined to 40 heifers increased from 3 to 7, the first oestrus conception rate increased from 55 to 73% whilst increases in SC from 7 to 11 were not accompanied by an increase in conception rate. Two points emerge. First, bulls of SC 7 or more when mated to 40 cows will achieve not only higher pregnancy rates but an earlier calving with concomitant increases in weaning weight and subsequent pregnancy rate than bulls of SC 3 to 6. Thus bulls of SC 7 or more make a more profitable purchase than males of SC 3 to 6 if the intention is to join them to 40 females. Second, it is wasteful to mate bulls of SC more than 7 to only 40 females. Because bulls generally distribute their services equally over the cows on heat (Blockey 1976) these high SC bulls should be mated to a large number of females. To test this proposition the author mated three bulls of SC 6, 11 or 17 to 100 heifers each, all females cycling in 20 days. They achieved conception rates of 57, 65 and 70%, respectively. Work at this Institute is now concentrated on the development of a simulation model to predict the number of females to mate to bulls of different SC.

TESTING HERD BULLS ANNUALLY

Herd bulls 3 years and older should undergo an annual examination which includes the SC test. Penile deviation and haematoma can only be positively detected in the SC test and 38% of 101 arthritic bulls could only be detected in the SC test. In all 70% of herd bulls with an abnormality likely to decrease their fertility had the abnormality detected in the SC test (Blockey 1979a).

The annual examination is necessary because 27% of 464, 3-to 11-year-old herd bulls examined on 14 farms were unsound for breeding (Blockey 1979a). Evidence that the annual culling of unsound bulls influences herd fertility comes from a 4000 cow herd in which culling unsound bulls each year increased the calving percentage from 70 to 85 and maintained it at the latter level (Blockey 1979a).

USING BULLS WISELY

After purchasing young bulls of high SC and culling herd bulls with an unsoundness, maximum performance can be extracted from bulls if: (i) the highest SC bulls are joined to heifers. Early conception in heifers is a key to high herd productivity and this is maximised when high SC bulls are joined to them; (ii) in multiple joining, bulls of the same age are mated together. Old bulls socially dominate younger bulls and inhibit their serving activity. Joining bulls of a mixed age results in lower fertility and the old bull siring 62 to 76% of the calf drop (Blockey 1979b) and (iii) 2-year-old bulls are checked frequently during mating to detect and remove those that damage their penises.

TESTICLE SIZE IN BULLS

M.A.de B. BLOCKEY

Testicle size in bulls is conveniently and accurately measured by drawing both testicles into the scrotum and measuring the scrotal circumference with a metal tape (Hahn *et al.* 1969). Beef bulls 2-years-old and older vary in scrotal-circumference from 26 to 43 cm. In this paper data will be presented to show that bulls with a scrotal circumference of less than 30 cm are of poor fertility, that bulls with a large scrotal circumference void sufficient sperm to successfully mate a large number of cows and that breeders have the tools to produce bulls with large testicles.

TESTICLE SIZE AND FERTILITY

Evidence from three Australian studies strongly indicates that most bulls with a scrotal circumference of less than 30 cm void poor quality semen. Of the 444, 18-to 24-month-old Hereford and Poll Hereford bulls examined by Freer (1979) in New South Wales, the 9 bulls with a scrotal circumference of less than 30 cm had poor quality semen. Of the 1301 Tasmanian Angus bulls examined by Thain (unpublished data) those with a scrotal circumference less than 30 cm rarely had satisfactory semen quality. A study of 735 Hereford and Angus bulls by the author showed that 9 of the 10 bulls with a scrotal circumference of less than 30 cm had soft testicles indicative of poor semen quality. In all three studies only 4 to 4.6% of bulls with a scrotal circumference of 30 cm or more had poor quality semen or soft testicles. It is noteworthy that in the author's study 10% of the 200 bulls with a scrotal circumference 30 to 33 cm had soft testicles while only 2% of the 525 bulls with a scrotal circumference 34 cm or greater had soft testicles.

Those bulls with a scrotal circumference of less than 30 cm that produce semen of satisfactory quality, achieve poor fertility because they void insufficient sperm per ejaculate. The author joined 9 bulls to 40 cows each and measured each bull's first service conception rate. Conception rates were low for bulls with scrotal circumference less than 30 cm (0, 26, 20 and 50% for scrotal circumferences of 26, 27, 28 and 29 cm, respectively) and satisfactory for bulls with a scrotal circumference of 30 cm or greater (83, 71, 57, 58 and 60% for scrotal circumferences of 30, 31, 32, 34 and 35 cm, respectively).

TESTICLE SIZE AND MATING LOAD

Because scrotal circumference and sperm production in bulls are highly correlated (Hahn *et al.* 1969) it seems logical that bulls with large testicles can be successfully joined to more cows than bulls with small testicles. To quantitate the relationship between scrotal circumference and mating load the author joined 17 bulls varying in scrotal circumference to either 60 or 75 oestrous heifers for 20 days and recorded their first service conception rates. When joined to 60 heifers, bulls with a scrotal circumference less than 32 cm achieved low to marginal conception rates (22, 44 and 55% for scrotal circumferences of 27, 30 and 31 cm, respectively) while bulls with a scrotal circumference 32 cm or more had good conception rates (68, 71, 72, 83, 62 and 74% for a scrotal circumference of 32, 33, 34, 35, 36 and 37 cm, respectively). At the higher mating load of 1:75, bulls with a scrotal circumference 33.5 cm or greater had satisfactory conception rates (58, 61, 52, 53 and 63% for a scrotal circumference of 33.5, 35, 36.5, 37.5 and 38.5 cm, respectively) while the three bulls with

scrotal circumferences of 26, 30 and 32 cm achieved the lower conception rates of 10, 43 and 46%, respectively.

Bull breeders have two main tools to use in producing a high proportion of bulls with large testicles and a small proportion of bulls with a scrotal circumference of less than 30 cm. They should use sires which have large testicles for scrotal circumference is highly heritable and is positively correlated with growth rate and live weight. They should also feed bulls well over the period 6 to 13 months of age. Testicular growth is very rapid around puberty (Lunstra et al. 1978) and bulls which are poorly fed over this period achieve slow growth of testicles and have smaller testicles at maturity than bulls well fed around puberty (Reeves and Johnston 1978).

From the data presented here the following conclusions can be drawn:

(i) the minima in scrotal circumference for a bull to be joined successfully to 40, 60 and 75 cows are 30, 32 and 33.5 cm, respectively. Low to marginal fertility can result if bulls with a scrotal circumference smaller than minimum are joined at these mating loads and (ii) whenever possible, cattlemen should purchase 2-year-old bulls with a scrotal circumference of 34 cm or greater.

SEXUAL BEHAVIOUR OF THE BOAR

P. H. HEMSWORTH*

In modern pig production it should be the aim of producers to maximise the copulatory performance of the breeding boar so that it can successfully mate the greatest number of female pigs possible. This will ensure intensive use of genetically-superior sires and enable a reduction in breeding boar numbers. It is the objective of this paper to identify the major factors that may influence the copulatory performance of the boar. Since copulatory performance is dependent upon sexual motivation and mating competency of the boar, the factors influencing copulatory performance will be considered under these two headings.

SEXUAL MOTIVATION

This is measured by time to first mount (reaction time) over a number of copulations and provides a good estimate of a boar's copulatory performance (Hemsworth, unpublished data).

From very limited data it appears that copulatory performance may be improved through selection. A breed difference in copulatory performance has been reported between Swedish Landrace and Swedish Yorkshire boars, and between Hampshire and Yorkshire boars (Wiggan according to Hafez and Signoret 1969). Unpublished data by the author indicates a highly significant between-litter variation in the copulatory performance of the boar.

The social environment, both during rearing and after puberty, is an influential determinant of the sexual behaviour of the boar. Physical contact with pigs during rearing is essential for the development of high copulatory performance (Hemsworth et al. 1978; Hemsworth and Beilharz 1979). Therefore, when designing pens for growth performance testing, producers should ensure that the pre-pubertal boar has physical contact with other pigs. If producers are purchasing a breeding boar then the rearing environment should be considered. In addition, the boar should be observed at mating since desire and ability to mate, together with leg weakness and penis problems, can be easily observed. With the purchase of a pre-pubertal boar it is desirable to establish a contract whereby

* Animal Research Institute, Department of Agriculture, Werribee, Vic. 3030

the exact guarantee and conditions under which a non-working boar will be replaced are clearly stated. Isolation of mature boars from female pigs severely reduced copulatory performance (Hemsworth et al. 1977). The presence of female pigs, regardless of their stage of the oestrous cycle, appears to be necessary to maintain a high copulatory performance in the mature boar (Hemsworth et al. unpublished data).

"Psychic impotence" generally refers to a psychological condition in bulls that inhibits copulation (Kendrick 1954). A painful experience at a previous mating appears to produce this condition. The author has observed a similar condition in boars where either a wet slippery floor or a flighty female has resulted in the mounting boar falling heavily to the floor. Therefore, a specific mating pen with a dry, non-slip floor and free of obstructions that may cause injury, such as feeders, drinkers and slatted floor, is recommended. An octagonal-shaped pen may provide the boar with easier access to the female.

High environmental temperatures may reduce the sexual behaviour of the boar (Steinbach 1972). In summer if producers fail to take measures to reduce heat load in the mating shed, then boars should be mated early in the day when temperatures are more likely to be low. Cold environmental temperatures do not appear to reduce sexual behaviour (Swierstra 1970).

MATING COMPETENCY

Copulatory performance may be reduced by poor physical condition interfering with mating competency. Lameness and locomotor **disfunction**, due to skeletal diseases such as arthritic lesions of the limbs and spinal cord and **erysipelas**, are a primary cause of reduced copulatory performance in the boar (Einarsson 1968; Rasbech 1969). Exercise has been shown to reduce the incidence of certain leg weaknesses (Perrin and Bowland 1977). Therefore, characteristics of boar pen such as floor area and type, may affect the incidence of leg weakness.

Inanition or obesity may adversely influence copulatory performance by producing a poor physical condition that will reduce mobility. However, sexual behaviour should not suffer if the boar is fed a balanced ration that will produce normal growth or maintain normal health.

Penis problems, which include **hypospadias**, **haemorrhage** from lacerations or abrasions, inadequate erection and protrusion, coiling of penis in the preputial sac and persistent **frenulum**, will reduce the copulatory performance of the boar by affecting mating competency (Adams 1970; Vente 1972). When a penis problem is suspected the boar should be observed and examined at mating.

THE "FERTILITY" AND "FECUNDITY" OF THE BOAR

P.H. HEMSWORTH and B. MULLAN*

In addition to copulatory performance, impregnation rate ("fertility") and the size of the litter that the boar sires ("fecundity") have important effects on the reproductive efficiency of the boar. Although there are enormous gaps in our knowledge of these two variables, it is the objective of this paper to discuss some of the main factors that may influence the fertility and fecundity of the boar.

* Dept of Animal Science, University of Western Australia, Nedlands, W.A. 6009.
Present address: Dept of Agriculture, Three Springs, W.A. 6519.

AGE AND COPULATORY FREQUENCY

Differences in age and copulatory frequency account for much of the variability in semen characteristics of the boar. However, little scientific information is available on the effects of these two factors on fertility and fecundity.

The development of spermatogenetic function depends more on body weight than age (Niwa 1954). However, with commercial diets and levels of feeding, producers can commence working young boars at 6.5 to 7 months of age (Lagerlöf and Carlquist 1961). Swierstra (1974) has shown that regular 3-day semen collections commencing at this age do not adversely affect present or subsequent semen characteristics.

A number of studies with the adult boar indicate that ejaculates collected every 2 days or even daily are of acceptable quality, although total sperm numbers per ejaculate are reduced, particularly for the latter collection frequency (Gerrits *et al.* 1962; Johnson *et al.* 1969; Swierstra and Dyck 1976; Shulimov *et al.* 1979). In the study by Swierstra and Dyck, sows inseminated with semen collected daily had a higher pregnancy rate than those inseminated with semen collected at 3-day intervals. However, some boars were more fertile on the daily than on the 3-day collection schedule while the reverse was true for other boars. Therefore, it would be very valuable if producers could work boars on the basis of their individual capacity to maintain high fertility and fecundity at high work loads. An important selection criterion here may be the size of the testes. The second author has found that daily sperm production in the adult boar is principally a function of testicular weight. Therefore, the work load of individual boars could be based on the size of their testes together with their copulatory performance. However, it is still to be demonstrated that any drop in fertility that may be associated with a high copulatory frequency is due to limiting sperm numbers. Even twice daily semen collections over 10 days provided markedly more sperm per ejaculate than is normally required in an artificial insemination (Niwa 1961). Several studies on boars of unsatisfactory fertility have shown that a high percentage of morphological abnormalities of the head, mid-piece and tail of the sperm are the outstanding aspects of the ejaculates (Cerovsky 1979; Rostel *et al.* 1979).

GENETIC BACKGROUND

Testis size, epididymis weight and sperm production may be moderately heritable (Du Mesnil due Buisson *et al.* 1978). Therefore, producers may be able to select for sperm production.

HIGH ENVIRONMENTAL TEMPERATURE

Studies at the Animal Research Institute, Werribee have shown that a high temperature cycle of 40° C (day-time) and 30° C (night-time) produces major changes in semen characteristics in at least half of the boars exposed for more than 4 days (Winfield *et al.* 1979). Changes in percentage morphological abnormalities, motility and total sperm numbers were considered sufficient to markedly reduce fertility and fecundity for a period of up to 4 weeks commencing 2 to 3 weeks after treatment. Poor impregnation rates were observed in boars exposed to a high temperature cycle for a considerably longer period (Wetteman *et al.* 1977). Therefore, measures should be taken to reduce heat load on boars in piggeries in those areas where there is a high probability of hot weather exceeding 4 days in duration. One possible measure to reduce heat load on boars is intermittent sprinkler cooling (Wetteman *et al.* 1977).

NUTRITION AND DISEASE

Nutrition of the boar has not been extensively studied. Nevertheless, it appears that provided boars are not allowed to become physically weak, fertility is usually satisfactory (Tassell 1967).

In general, boars can be affected by most of the diseases which affect sows. Poor quality semen may be produced for a considerable period after a boar has contracted an infection that may produce a fever, for example acute erysipelas or acute pneumonia (Wrathall 1975).

SELECTION FOR FERTILITY IN RAMS AND BULLS

R.J. KILGOUR and M.A.de B. BLOCKEY

In the preceding papers we have presented data which indicate that rams and bulls of high serving capacity or with large testicles are more effective in impregnating females than males of low to moderate serving capacity or with small testicles. Should breeders wish to select for serving capacity and testicle size, what response to selection might they expect? How are those traits correlated and how is each correlated with other selection criteria such as growth rate or fleece weight and most importantly, how are these male fertility traits related to female fertility traits?

LIKELY RESPONSE TO SELECTION

Serving capacity (SC) in both bulls and rams could be improved by selection. In bulls, it is very highly heritable (0.59 ± 0.15 for both Hereford and Angus; Blockey *et al.* 1978), it shows wide variation among bulls and is highly repeatable from test to test. In rams there is wide variation in SC, it is moderately repeatable from test to test and there is evidence that the character is genetic in nature. Mattner *et al.* (1973) showed that sons of sires of high SC had a higher SC than the sons of sires of low SC. In the Trangie flocks there are highly significant differences in the serving capacity of different flocks of Merino rams (Kilgour, unpublished data).

Testicle size in rams can be improved by selection. The realised heritability of testis diameter is about 0.4 (Land and Lee 1976). In beef bulls testicle size is likely to be improved by selection since it is highly heritable with estimates ranging from 0.69 ± 0.15 (Coulter and Keller 1979) to 0.40 ± 0.15 (Blockey *et al.* 1978), it shows wide variation within-breed and within-age group (Coulter and Keller 1979) and is very highly repeatable in its measurement (Hahn *et al.* 1969). It is probable that maximum response to selection will only be achieved if bulls are well fed during the pubertal spurt in testicular growth, from 6 to 13 months of age.

Testicle size as a selection criterion in both rams and bulls has the advantage over SC of being more easily measured and being measured at a younger age (12 months vs 18 to 24 months).

CORRELATION BETWEEN TRAITS

In bulls and rams 18 months or older the phenotypic and genetic correlations between serving capacity and testicle size are near zero (Blockey *et al.* 1978; Kilgour unpublished data). However there is an excellent relationship in rams between testis diameter at 12 months and serving capacity at 18 months of age ($r = 0.92$, $n = 90$; Kilgour, unpublished data).

Selection for growth rate in bulls would improve scrotal circumference because it is significantly correlated with growth rate (0.28 to 0.42; Coulter, unpublished data) and with live weight. With age held constant the partial correlation coefficients between scrotal circumference and live weight were 0.32 to 0.52 for beef bulls (Coulter, unpublished data) and 0.58 for Holstein bulls (Coulter and Foote 1977).

Serving capacity in bulls was not phenotypically correlated with live weight, growth rate, temperament and such measures of conformation as height, length and width (Blockey et al. 1978).

CORRELATION OF MALE AND FEMALE FERTILITY TRAITS

Over the last decade evidence has accumulated to show that testicle size is well correlated with female fertility traits. In one group of mice selected for ovulation rate for 12 generations and in another group of mice selected for testis size for 5 generations, there were correlations between testis size and ovulation rate of 0.82 (Land 1973) and 0.25 to 0.50 (Islam et al. 1976), respectively. In the sheep, ewes bred from rams with a large testis diameter were younger at puberty, commenced their breeding season earlier, had a higher ovulation rate at 7 and 19 months of age and a lower proportion of dry ewes than ewes bred from rams with a small testis diameter (Land and Lee 1976; Land 1977). And in cattle, Brinks et al. (1978) found a genetic correlation of -0.71 between the scrotal circumference of 180 yearling bulls and the age of puberty in 357 half-sib heifers.

Little is known about the correlation between serving capacity and any female traits. Wilkins and Kilgour (1978) found that a higher proportion of 7 month old Merino ewes sired by rams of high SC were mounted and impregnated than ewes sired by rams of low SC. A subsequent experiment could not implicate age at puberty as a reason for the different pregnancy rates (Wilkins and Kilgour, unpublished data). Differences in duration of oestrus between the two groups of progeny may be implicated.

SUMMARY AND CONCLUSIONS

M.A. de B. BLOCKEY

In the last decade methods of measuring the sexual activity and sperm producing capacity of rams, bulls and boars have been developed. In rams and bulls serving capacity (SC) is an accurate measure of a male's sexual activity during paddock mating and can be predicted in a short yard test. A good estimate of the long-term copulatory performance of a breeding boar is provided by its reaction time over a number of copulations. In rams, bulls and boars the larger the male's testicles, the greater is its sperm-producing capacity.

We consider that these methods of assessing SC and sperm-producing capacity should be used in two ways : i) in determining which males are likely to achieve low fertility when mated to a "minimum" number of females, e.g. 50 ewes or 40 cows and ii) in determining to how many females the remaining males can be joined.

Males likely to be of poor fertility when mated to a "minimum" number of females are bulls of SC less than 3 or with testicles less than 30 cm in scrotal circumference and, to extrapolate from the data of Gheradi et al. rams must have 200 g of testicular tissue to achieve good fertility when joined to 50 ewes. What the minimum SC a ram must have to be joined successfully to 50 ewes is unknown.

When mated at "minimum" mating loads rams and bulls of high SC impregnate a higher proportion of females at their first oestrus than males of medium SC. However at minimum mating loads rams and bulls with large testicles do not achieve higher fertility than males with moderate-sized testicles. The advantage that males of high SC and with large testicles enjoy over less well-endowed males is that they can be successfully joined to a larger number of females. For example, bulls of scrotal circumference 32 or 33.5 cm achieve good fertility when joined to 60 or 75 cows, respectively. Rams with 400 or 800 g of testicular tissue produce sufficient sperm to be mated to 100 or 200 ewes, respectively. What are needed urgently are formulae to predict the number of females to which rams and bulls of different SC can be mated. And to get the most out of individual boars, producers need the means to determine each boar's copulatory frequency beyond which fertility and fecundity may significantly suffer.

These papers have highlighted ways in which the SC and sperm-producing capacity of the males on the farm can be maximised. Both traits are moderately to highly heritable so that an increasing proportion of males with high SC and with large testicles can be bred. Young bulls and probably young rams and boars should be well fed around puberty to maximise rapid growth of testicles over this period and young boars should be reared in physical contact with other pigs. Producers should ensure that the breeding males they purchase have satisfactory SC and testicle size. Before mating males should be examined to detect and eliminate those animals with locomotor or penile abnormalities. During mating males should be provided a social and physical environment and in the case of boars, a climatic environment, that will enable them to perform to their potential.

It is concluded that the use of rams, bulls and boars of high SC and with large testicles would increase fertility and/or reduce the number of breeding males required and that males can be maintained at their maximum serving capacity and sperm-producing capacity by good management.

REFERENCES

- ADAMS, W.M. (1970). In "Effect of Disease and Stress on Reproductive Efficiency in Swine", editors Lucas and Wagner. University of Nebraska Co-op Extn. Service. p.16.
- AMANN, R.P. and ALMQUIST, J.D. (1961). J. Dairy Sci. **44**:1537.
- BLOCKEY, M.A.de B. (1976). Theriogenology **6**:393.
- BLOCKEY, M.A.de B. (1978a). J. Anim. Sci. **46**:389.
- BLOCKEY, M.A.de B. (1978b). J. Anim. Sci. **47** Suppl. 1:254.
- BLOCKEY, M.A.de B., STRAW, W.M. and JONES, L.P. (1978). J. Anim. Sci. **47** Suppl. 1:253.
- BLOCKEY, M.A.de B. (1979a). Proc. Dookie Short Course on Bull Fertility, p.5.
- BLOCKEY, M.A.de B. (1979b). Appl. Anim. Ethol. **5**:15.
- BRINKS, J.S. MCINERNEY, M.J. and CHENOWETH, P.J. (1978). Proc. West. Sect Sci. **29**:28.
- CEROVSKY, J. (1979). Anim. Breed. Abstr. **47**:463.
- COULTER, G.H and FOOTE, R.H. (1977) J. Anim. Sci. **44**:1076.
- COULTER, G.H and KELLER D.G. (1979). J. Anim. Sci. **49** Suppl. 1:288.
- DU MESNIL DU BUISSON, F. PAQUIGNON, M. and COUROT, M. (1978). Live. Prod. Sci. **5**:293.
- EINARRSON, S. (1968). Nord. Vet. Med. **20**:616.
- ELMORE, R.G., BIERSchwal, C.J. and YOUNGQUIST, R.S. (1976). Theriogenology **6**:485.
- FREER, R.E. (1979). Proc. A.A.B.G. Conf. p.160.
- GERRITS, R.J., GRAHAM, E.F. and COLE, C.L. (1962). J. Anim. Sci. **21**:1022.

- HAFEZ, E.S.E. and SIGNORET, J.P. (1969). In "The Behaviour of Domestic Animals" 2nd Ed. p.349. editor E.S.E. Hafez, Bailliere, Tindall and Cassell, Lond.
- HAHN, J., FOOTE, R.H. and SEIDEL, G.E. (1969). J. Anim. Sci. 29:41.
- HEMSWORTH, P.H., WINFIELD, C.G., BIELHARZ, R.G. and GALLOWAY, D.B. (1977). Anim. Prod. 25:305.
- HEMSWORTH, P.H., FINDLAY, J.K., BIELHARZ, R.G. (1978). Anim. Prod. 27:201.
- HEMSWORTH, P.H. and BIELHARZ, R.G. (1979). Anim. Prod. 29:311.
- ISLAM, A.B.M.M., HILL, W.G. and LAND, R.B. (1976). Genes Res. 27:23.
- JOHNSON, L.A., GERRITS, R.J. and YOUNG, E.P. (1969). J. Reprod. Fert. 19:95.
- KENDRICK, J. (1954). Corn. Vet. 44:289.
- KILGOUR, R.J. (1979). Rev. in Rur. Sci:Behaviour 4:43.
- KILGOUR, R.J. and WHALE, R.G. (1980). Aust. J. Exp. Agric. Anim. Husb. 20:5.
- KILGOUR, R.J. and WILKINS, J.F. (1980). Aust. J. Exp. Agric. Anim. Husb. (in press).
- KNIGHT, T.W. (1973). Ph.D. Thesis, University of Western Australia.
- LAGERLÖF, N. and CARLQUIST, H. (1961). Proc. IVth Int. Congr. Anim. Reprod. AI., The Hague, 4:818.
- LAND, R.B. (1973). Nature 241:208.
- LAND, R.B. and LEE, G.J. (1976). Anim. Prod. 22:137.
- LAND, R.B. (1977). ABRO Report 1977, p.23.
- LINDSAY, D.R., DUNSMORE, D.G., WILLIAMS, J.D. and SYME, G.J. (1976). Anim. Behaviour 24:818.
- LINDSAY, D.R., GHERADI, P.B. and OLDHAM, C.M. (1976). Proc. Int. Cong. on Sheep Breeding, Muresk. p.294.
- LINO, B.F. (1972). Aust. J. Biol. Sci. 25:359.
- LUNSTRA, D.D., FORD, J.J. and ECHTERNKAMP, S.E. (1978). J. Anim. Sci. 46:1054.
- MATTNER, P.E., BRADEN, A.W.H. and GEORGE, J.M. (1971). Aust. J. Exp. Agric. Anim. Husb. 11:473.
- MATTNER, P.E., BRADEN, A.W.H. and GEORGE, J.M. (1973). CSIRO Animal Physiology Annual Report. P.3.
- NIWA, T. (1954). Bull. Nat. Inst. Agr. Sci., Series G., 8:17.
- NIWA, T. (1961). Proc. IVth Int. Congr. Anim. Reprod. AI., The Hague, 1:83
- OLDHAM, C.M., ADAMS, N.R., GHERARDI, P.B., LINDSAY, D.R. and MACKINTOSH, J.B. (1978). Aust. J. Agric. Res. 29:173.
- PERRIN, W.R. and BOWLAND, J.P. (1977). Can. J. Anim. Sci. 57:245.
- RASBECH, N.O. (1969). Br. Vet. J. 125:599.
- REEVES, K.R. and JOHNSON, B.H. (1977). J. Anim. Sci. 46:264.
- ROSTELL, W., MEYER, I. and PETERSEN, U. (1979). Anim. Breed. Abstr. 47:31 (Abstr.)
- SHULIMOV, A.G., THACHUK, M.M. and BANDURA, O. (1979). Anim. Breed. Abstr. 47:331 (Abstr.).
- STEINBACH, J. (1972). Proc. 7th Int. Congr. Anim. Reprod. A.I., Munich, p.2081.
- SWIESTRA, E.E. (1970). In "Effect of Disease and Stress on Reproductive Efficiency in Swine". p.8. editors Lucas and Wagner. University of Nebraska Co-op. Extn. Service.
- SWIESTRA, E.E. (1974). J. Anim. Sci. 39:575.
- SWIESTRA, E.E. and DYCK, G.W. (1976). J. Anim. Sci. 42:455.
- TASSELL, R. (1967). Br. vet. J. 123:82.
- VENTE, J.P.L. (1972). Proc. 7th Congr. Anim. Reprod. A.I., Munich, p.1801.
- WETTEMAN, R.P., WELLS, M.E., OINTVEDT, I.T., POPE, C.E. and TURMAN, E.J. (1976). J. Anim. Sci. 42:664.
- WILKINS, J.F. and KILGOUR, R.J. (1978). Proc. Aust. Soc. Reprod. Biol. p.22.
- WINFIELD, C.G., HEMSWORTH, P.H., GALLOWAY, D.B. and MAKIN, A.W. (1979). Proc. Aust. Soc. Reprod. Biol., pp.29.
- WRATHALL, A.E. (1975). In "Reproductive Disorders in Pigs". C.A.B., England.