ADVANCES IN MALE REPRODUCTION

INTRODUCTION

P.J. CHENOWETH*

Male animals play a major role in animal production through their effects on pregnancy rates (both overall and per female cycle) and their transmission of genetic traits, Assessment of male reproductive function in farm animals differs from the human field in that quantitative considerations assume at least equal importance with the qualitative. The male animal must not only produce sufficient spermatozoa of suitable "quality" to cope with high mating demands, but must also be eager and able to identify and service oestrous females as quickly as possible. Thus sperm production, seminal quality, libido and mating ability are all important. We have long known that male animals vary greatly in their reproductive capabilities and that genetic considerations contribute strongly to this variation. We are also competent in identifying males at the bottom end of the fertility spectrum. The challenge is to accurately predict male reproductive performance across the whole fertility spectrum and plan our breeding programs accordingly. Recent research in the fields of reproductive physiology and behaviour have enhanced our knowledge of male development, assesment and management. The following sections will discuss recent advances in reproductive research in bulls, boars, stallions and rams.

BULL PERFORMANCE

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Breeding soundness examination (BSE)

Bulls vary greatly in their reproductive capabilities and this variation can markedly affect both pregnancy rates and weaning weights. Apart from illness or injury, the reproductive performance of a bull is influenced by one or more of three factors: (i) seminal characteristics (quantitive and qualitive); (ii) sex-drive (libido) and mating ability; and (iii) social interactions between animals in the breeding paddock.

In America, the Society for Theriogenology has recommended a breeding soundness scoring system which employs three criteria: (a) spermatozoa1 motility, (b) spermatozoa1 morphology, and (c) scrotal circumference. This system is shown in Table 1.

TABLE 1 Composite breeding soundness examination (BSE) score

Category	Motility	Morphology	Scrotal circum.	Score
Very good	20	40	40	100
Good	12	24	24	60
Fair	10	10	10	30
Poor	3	3	10	16

Society for Theriogenology (1976).

Using this system, bulls with a composite score of 60-100 are generally classified as satisfactory, those scoring 30-59 are questionable and those scoring less than 30 are regarded as unsatisfactory.

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Trials were conducted to determine relationships between the components of this system and the reproductive performance of bulls (Mateos et al. 1978). Pre-breeding BSE values of"31 Bos taurus bulls (aged 2-5 years) were compared with the pregnancy rates they achieved when individually mated with groups of heifers (mean of 20 per group) whose oestrous cycles had been synchronised. Correlations between BSE values and pregnancy rates are shown in Table 2.

TABLE 2 BSE values and pregnancy rates

Category	Correlation (r) with pregnancy rate
BSE score	0.33
Scrotal circumference	0.58*
Percent motility	0.47*
Rate of motility	0.38
Primary abnormalities	-0.12
Secondary abnormalities	-0.37
Total abnormalities	-0.40*

*$P < 0.05$

Mateos et al. (1978)

Significant correlations ($P < 0.05$) were observed between pregnancy rates achieved by bulls and their scrotal circumference, spermatozoa1 motility and abnormal spermatozoa1 morphology (r = 0.58, 0.47 and -0.40 respectively).

Pregnancy rates achieved by bulls of questionable or satisfactory BSE categories are shown in Table 3.

TABLE 3 Pregnancy rates and bull classification

BSE Category and range of scores	No. of bulls	Females pregnant (%)
Questionable (44-58)	8	43.15
Satisfactory (60-100)	17	53.62

Mateos et al.(1978)

These data indicate that the three components selected for the BSE scoring system were related to the reproductive performance of naturally mated bulls. Also, the overall score was of value in identifying higher fertility bulls.

Scrotal circumference measurement has assumed major importance in the BSE since Hahn et al. (1969) reported a strong relationship between testicular growth and daily sperm output in young Holstein bulls. This measurement is highly repeatable within and among technicians (Hahn et al.1969), and scrotal size is highly heritable (Coulter et a1.1976; Coulter and Foote 1979). Importantly, Brinks et al. (1978) reported significant favourable estimated genetic correlations between age at puberty in heifers and scrotal circumference (and other BSE components) in their half-sib brothers (Table 4).

TABLE 4 Estimated genetic correlations between reproductive traits in bulls and age at puberty in half-sib heifers

	Bulls traits		
	Scrotal circum.	% Normal sperm	% Primary abnormalities
Heifer age at puberty	−0.71	−0.37	0.36

Brinks _et al_. (1978)

These data suggest that young bulls with superior scrotal circumference and spermatozoa1 morphology should sire heifers with earlier inherent ages at puberty than lesser bulls.

Libido and sexual behaviour

Libido (or sex-drive) in bulls is an important trait influencing overall pregnancy rate, particularly early in the breeding season (Blockey 1978b).

A comparison of three methods of sex-drive assessment (libido score,scoring capacity and reaction time) in 113 yearling beef fulls showed that libido score was slightly more repeatable than serving capacity score ($r=0.67$ and 0.60 respectively) while reaction times to either first mount or first service were not sufficiently repeatable for practical use (Chenoweth _et al_. 1979).

An heritability estimate of 0.59 ± 0.16 was reported for sex-drive (serving capacity) in young beef bulls (Blockey 1978a). Another study showed that production traits (ADG and final test weight) were not favourably related to sex-drive in young beef bulls (Ologun _et al_. 1981). Sex-drive and BSE components have been shown to be unrelated in Beef bulls (Blockey 1975; Chenoweth _et al._ 1977).

Social interactions between bulls can influence their reproductive performance when they are mated in groups (Osterhoff cited by Blockey 1975; Chenoweth 1981; Rupp _et al_. 1977). Although such studies have shown that dominant bulls usually sire more offspring or achieve more services than subordinate ones when placed together in groups with females, they have not established whether dominance andreproductiveperformance are synonymous or not. In one study (Ologun _et al._ 1981) it was found that dominance in yearling bulls was negatively correlated with sex-drive. Another report (Ologun 1978) showed that dominance and BSE components were unrelated in bulls. Thus in a multi-sire breeding herd, the dominant bull (or bulls) could lower herd reproductive rates by failing to service or impregnate all the females under his (or their) control and by preventing the more subordinate bulls from compensating.

This deleterious effect of social interactions on reproductive performance of bulls is probably most evident when young bulls are placed together with older bulls. Such an effect was observed in one study where mixed-age groups of bulls achieved lower pregnancy rates than did groups of young, similarly aged, bulls (Blockey 1979). This leads to the conclusion that more efficient sire exploitation would be achieved in multi-sire breeding programs if the bulls employed were all young and of similar age than if older bulls were included in the groups.

Theoretically, the most efficient method of breeding cattle would be by using single-sire breeding groups. This is not practical for most producers whose next best alternative is to use homogenous groups of young bulls for multi-sire breeding. Where single-sire breeding groups are employed, the potential for disaster is higher than with multi-sire groups. This potential can virtually be eliminated if the bulls are assessed for breeding soundness, libido and mating ability prior to mating and are regularly monitored for mishaps during the breeding period,

The effort which the bull expends in seeding receptive females is related to the number of females concurrently in late pro-oestrus or oestrus. If this number is sufficient, they will generally form a sexually active group (Williamson et al. 1972; Blockey 1979) which is very mobile and which seeks out the bull (or bulls). If no such group is formed, the bull spends proportionally more time investigating the status of females. This investigation takes the form of licking and sniffing the perineal and hind regions of females. Recent work has shown that the bull uses his tongue to transfer fluid to a short incisive spur which is located on the dental pad (Jacobs et al. 1980). Another tongue movement compresses the dorsal palate, and this is believed to create a vacuum that transfers the fluid to the vomero-nasal organ (VND) which is believed to be the site of pheromone identification. This augments the hypothesis that bulls generally rely more upon visual (and perhaps auditory) cues to detect receptive females and initiate sexual interest from a distance, than olfactory cues.

THE BOAR

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Modern intensive pig husbandry systems considerably influence the way in which boars are used during their reproductive lives. The management of the boar, as a sire, differs in several important respects from most other species.

Boars are selected almost entirely on growth and carcass quality with less attention being paid to conformation and little or none to fertility. They are selected immediately after puberty and then used for a short working life (usually only 6 to 12 months) before being culled. During this time they may never reach their full sperm production potential. There is no seasonal reproductive pattern in pigs, and boars are used continually throughout the year with at least two to four services a week. Frequently boars are housed away from the breeding females and oestrous sows are brought to them for immediate supervised mating. The sows are then returned to their pens. This only allows a very short and often stressful period for courtship.

In this section aspects of the reproductive physiology of the boar will be discussed with the aim fo determining how well boars are suited to this form of husbandry.

The development of puberty in the boar

If puberty is defined as the time of first appearance of spermatozoa in the seminiferous tubules (Nalbandov 1976) then the boar reaches puberty relatively early in life. When earlier studies of testicular development in the boar (Phillips and Andrews 1936; Phillips and Zeller 1943; Green and Winters 1945) are compared with more recent investigations (Swierstra and Dyck 1976; van Straaten and Wensing 1978; Flor Cruz and Lapwood 1978) it can be seen that puberty is reached slightly earlier in the modem boar with less variation between boars in the time of onset. The more recent studies show puberty can be attained by 140 days of age compared with a range of 150 to 180 days in earlier studies. Recent studies using Large White/Landrace boars showed that although some boars reached puberty

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by 85 days of age, most took between 100 and 115 days. However, the presence of sperm in the epididymis was generally not observed until 130 days of age (Cameron, unpublished data).

These findings indicate that such boars, selected as sires at6.5 to 7 months of age, will have reached puberty and also will be capable of ejaculating motile sperm. Another finding was that the boar testis commenced changes heralding the onset of spermatogenesis at 40 or 50 days of age and that this often coincided with a stressful growth period.

Few workers have investigated factors influencing the onset of puberty in boars. Poor nutrition has been shown to delay puberty (Kim et al. 1977) but this is unlikely to occur in a well managed piggery. Early puberty, with increased libido, was observed in boars subjected to increased photoperiods during decreasing natural photoperiod (Berger et al. 1980).

Sperm production in the young boar

Although most boars are capable of ejaculation by six months of age, maximum sperm production is not achieved until about two years of age. Sperm output of boars increases with age, particularly between 7 and 12 months. After 12 months of age it increases at a lower rate up to about 35 months of age (Hauser et al. 1958; Swierstra 1973; Rohloff 1973; Cerovsky 1975).

The seminal characteristics of 35 boars studied by Cameron (1980) are presented in Table 1. These results show that there is considerable variation among sperm production rates in boars less than 12 months of age compared with older boars, and also among boars in similar age groups.

TABLE 1 Seminal characteristics* of 35 boars aged between 8 and 18 months

Seminal characteristics	Age (months) 8 - 12		13 - 15.5		16 - 18	
Total volume (ml)	290.6	(109.6)	381.1	(145.2)	297.5	(130.1)
Fluid volume (ml)	180.1	(59.8)	205.2	(47.2)	197.9	(79.0)
Gel volume (ml)	110.1	(57.2)	174.2	(104.7)	97.0	(58.5)
Sperm conc. (10^6)	117.7	(60.3)	169.2	(44.1)	202.2	(90.6)
Total sperm (10^9)	18.9	(6.2)	33.5	(9.1)	35.4	(14.6)
Daily sperm output (10^9)	8.1	(2.6)	14.3	(3.9)	15.2	(6.2)

* Means of final 6 ejaculates collected during 6 weeks of three collections/week ± S.D.

The correlations of boar seminal characteristics with age (Table 2) show that there is a poor correlation between seminal volume and age but a stronger correlation between sperm output and age (Table 2).

TABLE 2 Correlations between age and seminal characteristics in the ejaculate of 35 boars

Semen characteristics	Correlation coefficient (r)
Total volume	0.001
Fluid volume	0.064
Gel volume	0.050
Sperm conc.	0.545**
Total sperm	0.662**
Daily sperm output	0.634**

**$P < 0.01$

Factors influencing qualitative and quantitative seminal characteristics in young boars:-

(i) Frequency of ejaculation There is general agreement that seminal volume and sperm numbers per ejaculate decrease with increasing collection frequency (Radford 1961; Gerrits et al. 1962; Johnson et al. 1969; Swierstra 1973; Hurtgen et al. 1980). In ejaculates collected more frequently than three times a week (or every 72 hours), seminal volume, sperm concentration and total sperm numbers are considerably reduced (Swierstra 1973; Swierstra and Dyck 1976; Cameron 1980; Hurtgen et al. 1980). Seminal quality was not affected by collections as frequent as every two hours during a 12 hour period (Cameron 1980), which is in agreement with a similar study by Hurtgen et al. (1980). This indicates that the practice of mating young boars with only one sow per week (two of three services) is unlikely to result in reduced fertility. However, because of reduced sperm numbers per ejaculate with high ejaculate frequencies, more frequent use, especially in boars less than 12 months of age, would be unwise.

(ii) Libido A study involving over 100 collections showed that normal mating behaviour (reaction time, number of mounts and ejaculation time) before and during copulation was not related to sperm numbers per ejaculate. However, significant correlations were found between ejaculation time and both total ejaculate volume and gel volume ($P < 0.01$). Sperm output in boars was not influenced by the number of false mounts prior to collection (du Mesnil du Buisson and Signoret 1970). Alternatively, Hemsworth and Galloway (1979) found more sperm in the ejaculates of boars stimulated by false mounts. The author considers that normal mating behaviour without extra stimulation does not influence sperm numbers per ejaculate although a suitable study was not conducted to test this hypothesis.

Prolonged work loads, especially in confined housing systems, will reduce the boar's interest in sows and the intensity of mating behaviour. High ambient temperatures and too frequent matings were considered by Leman and Rodeffer (1976) to also contribute to lowered libido.

(iii) Testicular size The anatomy of the boar allows only testicular length and width to be measured through the scrotal wall. In boars of similar age and weight at the time of selection (6 to 7 months of age) the difference between these testicular measurements is usually very small and in a study by the author, when a difference could be detected, it was not significantly correlated with sperm output. An accurate measurement of testicular weight may be the only means of predicting sperm production, but this is difficult in the live boar (Davis and Hines 1977).

In practice, where boars of maximum growth and of similar age are selected, slight differences in testicular dimensions (as measured through the scrotal wall) are unlikely to be of value in predicting sperm production.

(iv) Season Season was not shown to have an adverse effect on semen production or quality over a three year period (Table 3). This is in general agreement with the findings of Hurtgen et al. (1980) but differs from other studies (Jensen 1964; Thibault et al. 1966; Lawrence et al. 1970). Where a seasonal effect has been seen, it is usually associated with extreme seasonal variation in both temperature and photoperiod.

From the author's studies, it appears unlikely, at least under reasonably good housing conditions, that normal seasonal changes greatly influence quantitative or qualitative seminal characteristics in boars in a climate similar to that sub-tropical Queensland. The practice of mating boars all year round in such climates should not be influenced by season.

TABLE 3 The seminal characteristics of 34 boars collected thrice weekly for six weeks (17 of the boars were collected during the summers and the other 17 during the winters over a three year period)

Seminal characteristics	Season	
	Summer	Winter
Total volume (ml)	367**	274
Fluid volume (ml)	202**	182
Gel volime (ml)	163**	92
Sperm conc. (10^6)	144.6	164.1**
Total sperm (10^9)	27.9	27.3
Daily sperm output (10^9)	11.9	11.7

*P < 0.01

Cameron (1980)

Seminal characteristics were shown-to be influenced by day length (Mazzarri et al. 1968). When boars were kept at 15°C with exposure to daylight lengths of either 10 hours or 16 hours, the boars exposed to 16 hours daylight had the lower pregnancy rate (associated with lower seminal quality). Under local housing systems (with natural lighting), photoperiod is unlikely to be of major importance, but further research into the effect of light on boar fertility is required.

(v) Heat stress A number of studies have shown that the seminal quality of boars and subsequent fertility can be severely affected by elevated ambient temperatures (Mazzarri et al. 1968; McNitt and First 1970; Christenson et al. 1972; Wettemann et al. 1976; Cameron and Blackshaw 1980). It appears that the temperature required to produce adverse seminal changes is 35°C or greater for a period of 24 hours or longer. However, there is considerable variation between individuals in their response to heat stress. Boars normally conditioned to lower ambient temperatures may not need to be exposed to temperatures as high as 35°C to become infertile. There is evidence that boars adapt quite well to high ambient temperatures (Cameron and Blackshaw 1980).

The influence of the boar on pregnancy rate and litter size

Boar effects on swine reproductive rates vary considerably in different studies. Dzaparidze (1935) and Musson (1946) found no boar influence on litter size in studies with large numbers of litters. However, Skjervold (1963), Rasbech (1963) and Rahnefield and Swierstra (1970) found important sire effects on litter size.

Kennedy and Moxley (1978) showed a difference among breeds, but not among sires within breeds, on reproductive performances in pigs.

Two surveys carried out in seven herds showed that the influence of the boar on litter size was, at most, 7.09%. In one survey, a significant difference was found among boars in mean litter-size, percentage of small litters (less than eight progeny) and returns to service (Cameron unpublished data).

STALLION FERTILITY

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Reproductive rates of the domestic horse (Equus caballus) have been far from satisfactory for many years. Overseas studies indicate that foaling percentages have averaged approximately 53% from 1815 to 1973 (Merkt et al. 1979). Similar figures were published by Sanders (1926) and Voss and Pickett (1976). An examination of the Australian Trotting Year Book and the Australian Stud Book indicates that a similar problem with horse fertility exists in this country (Table 1). While volumes have been published on fertility problems in the mare, comparatively little research into stallion fertility has occurred, particularly in Australia.

TABLE 1 Australian breeding records

	Thoroughbred (1971-75)	Standardbred (1973-77)
No. of stallion seasons	1410	1841
No. of live foals per 100 mares served	49	64
Average no. of mares served per sire	39	29

Definition of fertilitv

Foaling percentage, or percentage pregnant mares, has been the traditional criterion for expressing the reproductive performance of a stallion. While these parameters give some indication of stallion fertility, they give no indication of the number of services involved. Even stallions of questionable "fertility" can obtain satisfactory pregnancy rates if the mares receive sufficient services. With the limited breeding season (September 8 to December 31 in Australia) it is essential to achieve the maximum number of pregnancies with the minimum of services (preferably one service per pregnancy). This has lead to the suggestion that the criterion of stallion fertility should be percentage pregnancies per service (Kenneyet al. 1971). This could be easily calculated as most matings are supervised and the number of services received by each mare is recorded. A study by Dowsett and Pattie (1982) in southern Queensland and northern New South Wales, over four breeding seasons (1974/75 to 1977/78), involving 1664 mares and 66 stallion seasons, has shown the average pregnancy rate to be 79.6%(range 0 to 100) and percentage pregnancies per service to average 25.3% (range 0 to 100) or four services per pregnancy. There was, an average of 45.5% pregnancies per mare oestrous cycle (range 0 to 80), i.e. approximately two oestrous cycles per pregnancy.

Breed differences in fertility

Breed differences in equine fertility in Australia are apparent from the foaling percentages published in the Australian Trotting Year Book and the Australian Stud Book. This observation was substantiated by a study (Dowsett and Pattie 1982) which showed that stallion fertility, as judged by percentage preg-

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nant mares or percentage pregnancies per service, was significantly influenced by breed. However, this was mainly due to the low fertility of stallions in two of the seven breeds studied.

Reproductive seasonality

The mare is classified as being seasonally polyoestrous, with increasing daylength being the major stimulus to reproductive activity. Peak ovarian activity occurs from December to February in Australia (Osborne 1966). Hormone levels in the stallion are also influenced by season, with peak levels of FSH and LH occurring in spring and peak levels of testosterone occurring in summer (Byers et al. 1979). Berndtson et al. (1974) also found that peak levels of testosterone in the stallion occurred during summer. This seasonal influence is also evident in the seminal characteristics of the stallion. Seminal volume, volume of the gel fraction, spermatozoa1 concentration, total spermatozoa per ejaculate and spermatozoa1 abnormalities are all influenced by season (Davis and Cole 1939; Nishikawa and Waide 1951; Pickett 1970; Cornwall et al. 1972; Pickett et al. 1976; Dowsett 1982) Generally, the data indicates that largest volumes of semen with highest spermatozoal concentrations and lowest numbers of abnormal spermatozoa are produced during the spring and summer, coinciding with hormone secretion patterns. This seasonal pattern of stallion seminal and hormonal characteristics is similar to the mare's seasonal ovarian activity. However, this physiological pattern is ignored by the Australian equine breeding industry which commences the season when only approximately 10% of mares are cycling normally and stallion daily sperm output is low, and terminates it prior to the peak of ovarian and testicular activity.

Seminal characteristics and fertilitv

Several studies relating stallion seminal characteristics with fertility have been reported (Bielański 1950; Haag 1959; Hendrikse 1966; van Duijn and Hendrikse 1968; Kenney et al. 1971; Voss et a1.1981; Dowsett and Pattie 1982). While a significant correlation ($r = 0.25$, $P < 0.01$) was obtained between the percentage of normal spermatozoa and pregnancy rate (van Duijn and Hendrikse 1968) and a negative correlation ($r = -0.37 \pm 0.1$) between the percentage of spermatozoa with primary abnormalties and pregnancy rate (Bielański 1950), there is still controversy over the relationship between stallion seminal characteristics and fertility. Both the concentration and motility of spermatozoa have been suggested to play important roles in stallion fertility (Day 1940; Haag and Werthessen 1956; Haag 1959; Hendrikse 1966). This was in conflict with Bielański (1950) who suggested that good motility was no guarantee of fertility and that concentration had little influence on fertility.

Voss et al. (1981) showed that the relationship between spermatozoa1 motility and mare pregnancy rate was poor and that spermatozoa1 morphology was not a useful indicator of stallion fertility. They suggested that survival time of spermatozoa in extender or in the uterus may be important for fertility. All these authors used overall pregnancy rate as their measure of stallion fertility. When an Australian study used this as the criterion of fertility, the only seminal characteristics significantly related were percentage dead spermatozoa ($P < 0.01$), sperm number ($P < 0.05$), percentage distal droplets ($P < 0.01$), and percentage abnormal tails ($P < 0.05$). The patterns of association of with fertility were almost random and so of no diagnostic value (Dowsett and Pattie 1982). When percentage pregnancies per service was used as the measure of fertility, all seminal characteristics examined were significantly related ($P < 0.01$) and it was found to be a more sensitive measure than percentage pregnant mares. However, the only characteristics with meaningful patterns of association with percentage pregnancies per service were total semen volume, gel-free volume, spermatozoa1 concentration and total number of live spermatozoa (Dowsett and Pattie 1982). Therefore, if seminal characteristics are to be used in an attempt to assess prospective stallion fertility, the most sensitive measure is percentage pregnancies per service and the most reliable characteristics for predicting fertility are those listed above which can all be assessed in the field.

Number of mares per stallion

If the traditional breeding season (September 8 to December 31) is adhered to, there are 114 days on which a stallion may be used for service. Stallion semen data has indicated that most stallions are only capable of two "fertile" services per day (Pickett and Wotowey 1971; Dowsett 1982), so the maximum number of services during the breeding season is 228. If an average of 4 services is required per pregnancy (Dowsett and Pattie 1982), then the maximum number of mares that should be "booked" to a stallion during the breeding season is 57.

Anabolic steroids

The use of anabolic steroids and testosterone to improve the growth and performance (both athletic and reproductive) of colts and stallions has been the subject of much debate. A study by Pickett et al. (1979) showed that neither anabolic steroids nor testosterone caused a significant growth response in the treated groups of stallions as compared with controls. There was no significant effect, due to treatments, on seminal volume (gel-free or gel), but significant decreases ($P < 0.01$) occurred in spermatozoa1 motility, spermatozoa1 concentration and numbers of spermatozoa per ejaculate of the treated groups. This was accompanied by a significant decrease ($P < 0.01$) in scrotal width and testicular weight of the treated stallions which was found to be the result of testicular degeneration. From these findings, it may be concluded that anabolic steroids and testosterone have deleterious effects on the fertility of stallions.

LIBIDO TESTING OF RAMS

M.D. RIVAL* and P.J. CHENOWETH*

For many years, researchers have been investigating the possible relationships between pen mating observations on rams and their reproductive performance in the paddock (usually measured in terms of proportion of ewes lambing, lambing percentages, or pregnancy rates to first service).

Libido tests reported in the literature have generally utilised either oestrous-induced ovariectomized ewes or entire ewes in natural oestrous. Both techniques are time and labour intensive and require accurate identification of ewes in oestrous to minimize stimulus variation.

Establishment of the behavioural principle that the greatest single stimulus to a bull or a ram to attempt mounting or service is an immobile object resembling the rear end of a female (Blockey 1975; Chenoweth 1981) has led to the successful use of restrained females for libido testing of bulls (Blockey 1975; Chenoweth et al. 1979). As it is reasonable to assume that restrained non-oestrous ewes would provide an adequate stimulus for rams in pen libido tests, the following procedure was developed.

Four ewes were restrained in service crates approximately 2 metres apart in a 5 × 7 metre pen. The ewes' necks were restrained in a bail and their rumps were immobilized by side bars. Ewes were prevented from collapsing in the crates by neck and belly ropes.

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Prior to testing, rams were allowed to observe mating activity in an adjacent pen for 30 minutes. Thirteen four-year-old, four two-year-old, and eleven eighteen-year-old Merino rams were subjected to two 30 minute tests each day (a.m. and p.m.) on successive days, in randomised groups of four. Fifteen minute scores within tests were also recorded and compared. A libido score (similar to that reported by Chenoweth et al. (1979) with beef bulls) was used. The libido score ranged from 0 (no interest) to 10 (two services followed by more services and/or sexual interest).

The data were analysed to determine: (i) the repeatability of test results (ii) the effect of time of day on test results, and (iii) the method which would produce the most representative scores for individual rams.

The repeatability of individual ram scores was estimated by comparing their four libido scores in a one-way analysis of variance (ADV). There were no significant differences between scores one, two, three or four for either the 30 minute score or the 15 minute score ($P < 0.50$). This indicated that the 15 minute test provided as much comparative information on ram libido as the 30 minute test and that multiple tests were not necessary to adequately assess libido in these rams.

To determine the effect of time of day on test results, each day was divided into 14 half-hour periods (6.30 a.m. to 10.00 a.m. = 1 to 7; 2.30 p.m. to 6.00 p.m. = 8 to 14). Eight ram libido scores were compared within each period. Results showed non-significant differences between periods for both the 30 minute and 15 minute scores (both $P > 0.75$), indicating that time of day did not influence test results.

Three ways of assessing individual ram scores were tested:

(i) A two way ADV comparing 15 and 30 minute scores with the four scores for the 28 rams revealed no significant differences ($P > 0.75$).

(ii) The single best score from the four 30 minute and 15 minute tests revealed no significant differences ($P > 0.75$).

(iii) The average of four scores compared against length of test (15/30 minutes) was not significantly different ($P > 0.50$).

To date, no trials have been conducted comparing the mating efficiency of rams subjected to such tests but encouraging aspects of the test are its high repeatability and the marked variation in scores within a ram population. While it is appreciated that dominance patterns in ram groups may affect individual scores (Lindsay et al. 1976), the randomisation of rams among tests serves to minimise such effects.

Other workers have recorded encouraging relationships between various pen libido test results and the paddock mating performance of rams (Kilgour 1979; Kilgour and Whale 1980; Kilgour and Wilkins 1980). In addition, Kilgour (1979) has reported significant relationships between ram serving capacity and the reproductive performance of ewe offspring.

These findings provide impetus for further work in this area of male reproduction, to encourage libido testing of stud rams prior to sale, teaser rams for use in artificial breeding programmes, and as a screening test by sheep breeders prior to their ram joining programmes.

CLINICAL REPRODUCTIVE ABNORMALITIES OF RAMS

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Ram fertility is rarely considered to be a major cause of flock infertility because of the tendency for most sheep breeders to "overmate" their ewe flocks with high ram joining percentages. Despite this, it is imperative that ram flocks be free of clinical reproductive abnormalities in order to maximise the number of successful services per ewe oestrus, to minimise the effects of poorly fertile dominant rams and to prevent extended joining periods. A relatively quick and simple pre-joining assessment of ram breeding soundness would eliminate most rams which have reproductive abnormalities (Miller and Moule 1954).

To ascertain the prevalence of ram reproductive problems, a survey of 899 mixed age Merino rams in 17 commercial flocks was conducted in the Goondiwindi district of southern Queensland. This revealed a high level of ram wastage due to pathological processes (Table 1).

TABLE 1 Clinical reproductive abnormalities in Merino rams of different ages in the Goondiwindi district

			Clinical abnormalities		
Age (yrs)	Repres. in age groups %	Normal rams %	Epid. (Head) %	Epid. (Tail) %	Test. Abn. %
1.5	28.8	88.4	0.8	5.0	5.8
2.5	9.0	100.0	0.0	0.0	0.0
3.5	14.8	88.7	1.5	10.5	4.5
4-6	34.9	78.8	2.9	16.9	10.2
6	12.5	63.4	5.4	23.2	23.2
Total	100.0	82.8	2.1	11.7	8.8

Overall, 17.2% of rams examined had clinical abnormalities of the testes and/or epididymides likely to impair fertility. The incidence of lesions increased with age. These findings, although high, reflect earlier surveys by Miller and Moule (1954) and Murray (1969) and indicate that ram infertility could well be a contributing factor to low lambing percentages in the Goondiwindi district.

The aetiology of clinical reproductive abnormalities was estimated by subjecting rams with reproductive abnormalities to a complement fixation test (CFT) on single peripheral blood samples for *Brucella ovis* and *Actinobacillus seminis*. A positive titre to either test was regarded as diagnostic of infection (Table 2).

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TABLE 2 Prevalence of positive serological titres for *Br. ovis* and *A. seminis* in rams with clinical reproductive abnormalities

Ram flock	No. of rams with palpable abnormalities of epididymis	*Br. ovis* reactors	*A. seminis* reactors
1	1	1	0
2	12	7	0
3	2	0	2
4	3	0	2
5	21	8	not tested
6	13	4	not tested
7	13	5	5
Other flocks (10)	59	0	0
Total	124	25	9

Serology indicated that 20.2% and 7.3% of cases of pathological epididymides were associated with positive serological tests to *Br. ovis* and *A. seminis* respectively. In infected ram flocks, 41.7% and 50.0% of cases were caused by *Br. ovis* and *A. seminis* repectively.

The majority of cases of epididymitis with a positive CFT to *Br. ovis* involved the tail of one epididymis; however, some lesions were bilateral and some were associated with secondary testicular atrophy. These findings are in accord with present knowledge of the pathogenesis of this disease (Hughes 1981). The five rams reacting to *Br. ovis* in flock 7 were different from the rams reacting to *A. seminis*, even though cross-reactions can occur (possibly because of shared antigens) (Rahaley, cited by Hughes 1981).

As *Br. ovis* and *A. seminis* organisms can localise in accessory sex glands (Al-Katib 1980; Hughes 1981) and be undetected clinically, the actual prevalence of these infections in rams may be higher than that indicated here. To determine overall infection rates would require serological testing of all rams, regardless of clinical signs, which was not practical in this study.

SUMMARY AND CONCLUSIONS

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These discussions emphasise the importance of reproductive assessment in male animals, not only for direct beneficial effects on pregnancy rates but also for indirect effects. Both scrotal size and libido are heritable in bulls and it can be assumed that they are also heritable in the other species. Physical disabilities causing impairment of breeding soundness have also been shown to be heritable in bulls and boars. Breeding soundness components (such as scrotal size and seminal quality) and behavioural factors (such as libido and dominance) are apparently not related to each other, indicating that a proper assessment of male reproductive function should embrace all of these factors. This is of even greater importance when males are exposed to higher mating stresses than usual, such as in synchronisation programmes employing bulls. Of considerable interest are the findings on relationships between components of male and female fertility. These include relationships between scrotal size in bulls and age at puberty in heifers, relationships between ram libido and ewe fertility and fecundity and boar effects on litter size. Thus,selection for fertility components in males can have beneficial subsequent effects on herd and flock reproductive rates.

It would appear that with a reasonable standard of husbandry and an understanding of reproductive capabilities and limitations of the boar, management can be manipulated to achieve the extremely high level of reproductive efficiency necessary in modern intensive pig units. The modern boar is early maturing and capable of a reasonable work load even when less than 12 months of age. Considerable variation exists among individuals and there is no easy way of predicting seminal production and fertility of the individual boar prior to breeding. The boar has adapted well to intensive pig production in the sub-tropics, but can be affected by heat stress resulting in lowered fertility when ambient temperatures suddenly increase above 35°C.

For the first time, extensive data are presented relating stallion seminal characteristics with reproductive rates obtained by natural service. The recommendations that stallion fertility be assessed by percentage pregnancies per service and that "normal" stallions should not have more than 50-60 mares "booked" per season have wide implications for the equine stud industry, particularly in the context of the disastrously low reproductive rates reported for the industry.

Survey data indicating that between 10% and 20% of rams have clinically detectable reproductive problems is in accord with surveys of bull populations. These figures are conservative as they do not include infertility due to non-detected factors such as poor libido. Wider exploitation of behavioural assessments, such as the ram libido testing procedure described herein, would indubitably raise these figures.

With our rapidly expanding knowledge of male reproductive physiology and behaviour, and our improved techniques of male fertility assessment, it is disappointing that the animal industries do not utilise this information more readily. This is a challenge for extension. In the meantime, although advances have been made as illustrated in these discussions on the bull, boar, stallion and ram, the scope for future research in male reproduction is still great.

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