CHAPTER 7

REPRODUCTION

Introduction

7.1 One of the aspects of sheep husbandry which was unanimously criticised by non-industry groups was the poor reproductive performance of Australian sheep, particularly in comparison with European sheep. As discussed in Chapter 3, such comparisons are potentially misleading, given the different breeds of sheep raised in the two regions and the differing climatic conditions in which they are raised.

7.2 Lamb losses and preventive measures have been considered in Chapter 3. In this chapter, the Committee will consider the welfare aspects of the reproductive process itself, rather than its aftermath. Issues such as the timing, length and frequency of joining of rams with ewes, the number of rams used and the size of mating paddocks will be considered, as will the influences of such factors as nutrition and breed. The Committee will then analyse the welfare aspects of some methods of manipulating reproduction, such as artificial insemination, embryo transfer and genetic engineering. Finally, the Committee will consider the breeding objectives of the wool and sheepmeat industries and their implications for sheep welfare.

Traditional sheep reproduction

7.3 The reproductive performance of Australian sheep, measured by lamb marking percentages, was 78 per cent for 1986-87. It varied from 92 per cent in Tasmania to 62 per cent in

Queensland, reflecting the influence of climate and breed of sheep.[1] In other words, the genetic potential for reproduction is not being realised in most Australian pastoral enterprises.

7.4 The reasons for this are economic - it is generally not financially worthwhile to hand-feed, when pasture is deficient in quality or quantity; nor is it generally financially worthwhile, or indeed sometimes even possible, to increase human labour input. Whether or not it is desirable for a sheep to realise its reproductive potential is a moot point in any case. An ability to reproduce generally suffices to ensure that a ewe is not culled, while multiple births, unaided, and particularly in Merinos, can be a health hazard to the ewe.

7.5 The timing of joining depends firstly on the time the sheep are sexually active. In most British breeds of sheep, this is generally between February and June. In Merinos the breeding season is much longer, from December to September, and even in the intervening months a high proportion of the ewe flock can be induced to sexual receptivity and ovulation by the introduction of rams.[2]

7.6 The main breeding season in most Australian States is autumn, allowing the lambs to be born in spring after a gestation period of from 147 to 152 days. This is possibly the optimum choice for the welfare of ewes and lambs, as a spring lambing normally coincides with improving weather and new pasture growth. However, its corollary is that the ewes mate and are pregnant at times when pasture is at its least plentiful and least nutritious, resulting in a greater susceptibility of the ewes to dystocia.

7.7 It is unlikely, however, that "encouraged" matings at a time when the ewe flock is largely anoestrous in spring are positively harmful in welfare terms, though they may be less successful.[3]

7.8 The length of joining has more welfare implications. Ewes are in oestrus at intervals of 17 days on average, with a range of 15 to 20 days,[4] while the oestrus itself lasts for 24 to 36 hours.[5] A joining period of six weeks, as recommended by the New South Wales Agriculture and Fisheries[6] allows ewes two cycles in which to conceive, yet restricts the lambing period to a manageable length. A prolonged joining period would result in an equally prolonged lambing period, resulting in the likelihood of some lambs being marked very late and others being weaned very early. Late-lambing ewes may not regain appropriate liveweight and condition before the next mating period, thus jeopardising their chances of a successful outcome.

7.9 Other factors affecting the success of mating are the age of both rams and ewes, the number and fertility of rams used and the size of the mating paddocks.

7.10 The fertility of the ewe is at its peak at four years of age and remains constant at that level until eight.[7] British breeds are more precocious than Merinos, and in good conditions can reach puberty at four months, though it is generally accepted that they should not give birth until they are two years old.[8]

7.11 Ram welfare also needs to be considered before and at joining time. Merino rams can attain puberty from four months to two years[9] but are at their peak in reproductive terms from two to three years of age. Rams need to be carefully examined before being introduced to the ewes to ensure they are in good physical health. As the usual joining ratio of rams to ewes is 1:50, it is important that the ram is not suffering from arthritis, foot abscesses or abnormalities of the testis, epididymis or penis, any of which would make his duties potentially painful. Recent surveys of flocks in New South Wales and Victoria have shown that between 15 and 20 per cent of rams were unsound for breeding,[10] suggesting that more attention needs to be paid to the condition of rams before joining, for both welfare and sound management reasons. Blood tests for ovine brucellosis should be carried out and replacement rams should be acquired from ovine brucellosis-free accredited flocks. Crutching and jetting of the rams is advisable if there is any danger of their being flystruck, as that can reduce fertility.[11]

7.12 Large mating paddocks, and especially undulating ones with sheltered gullies, are not a welfare hazard per se, but may result in lower conception rates as rams may simply fail to find all the ewes or have to expend much more energy in doing so. If such areas have to be used, commonsense and animal welfare considerations would both dictate that a higher percentage of rams be used.

7.13 Nutrition, in both a qualitative and quantitative sense, is the dominant influence on reproductive success. Mating of stock should not be contemplated in conditions of fodder scarcity, if the owner is not prepared to hand-feed as and when necessary. Nature intervenes to some extent in this situation, as ewes below a certain critical liveweight (30-35 kg, depending on breed and strain) will not get in lamb. Once in lamb, however, and especially in the six weeks before birth, it is vital for both ewe and foetus that the food supply be increased in order to prevent pregnancy toxaemia and to ensure a good milk supply.[13]

Breeding objectives

7.14 The end products of the sheep-raising industry are wool and meat, the relative importance of which varies among the different parts of Australia. Sheep breeders are constantly aiming to improve the overall standard of their flock by selecting sheep for increased fleece weight, for a specific fibre diameter, for reproductive performance or for body weight.

7.15 Substantial progress can be attained by rigorous selection for the desired characteristics. In research flocks at Trangie, New South Wales, after eight generations (23 years) a 20 per cent increase in wool production was achieved. However, at that point, the flock ceased to respond to further selection. Also, the gains were made at the expense of fibre diameter, which increased from 19 to 21.2 microns.[14]

7.16 Body weight and early growth rate respond well to selection, with an established heritability figure of 0.35.[15]

7.17 Increasingly, however, attention is being paid to other breeding objectives, such as "easy-care" sheep resistant to flystrike, fleece rot and internal parasites and which require little assistance at lambing.

7.18 While such objectives are obviously highly desirable in sheep welfare terms, and have been enthusiastically supported by many animal welfare groups, there are two major problems concerning their realisation. Firstly, there can be incompatibilities among objectives, and secondly, as Professor Kennedy pointed out to the Committee, in conventional quantitative genetics, the improvements which can be made are very slow.[16] The establishment of large group breeding schemes is helping to overcome the problem of slow genetic response to selection within small private flocks.[17]

7.19 Selection for resistance to flystrike, for example, is a possible long-term solution to the problem of flystrike. According to New South Wales Agriculture and Fisheries researchers Raadsma and Rogan[18] the heritability of liability to body strike and to fleece rot, one of the major predisposing causes of body strike, is about 0.4.[19] though other researchers have cited a lower figure.[20] However, it seems that fleece rot and fleece weight are positively correlated, so that by selecting against fleece rot, a producer may find his animals produce less wool.[21] Similarly, by opting to produce heavier fleeces, a producer will be faced with wool of increased fibre diameter.

7.20 In their review of genetic parameters for reproductive traits, Purvis and colleagues[22] concluded that many traits, such as maternal rearing ability, would respond better to management decisions than they would to selective breeding programmes.

7.21 An interesting development in manipulating sheep prolificacy has been the use of Booroola Merinos, named for the Cooma property whose Merino ewes were noted in 1958 for their twinning propensity. In mixed-age Booroola research flocks, mean litter sizes of 2.5 have been observed. Research has shown that a single major gene, now known as the F gene, affects the Booroola ovulation rate additively - one copy of the gene increases ovulation by up to 1.5 eggs, two copies by 3 eggs. However, in breeds of high prolificacy, second copies of the F gene are less dominant.[23] The gene appears not to affect body weight, fleece weight or fibre diameter. The most promising results from the use of the Booroola Merino are in crosses with British breeds, where the high litter sizes are exploited for increased prime lamb production.[24]

7.22 The Committee is concerned that attempts to exploit the potential of the Booroola strain also take into consideration the problem of lower lamb birth weight and greater lamb losses, especially amongst higher order births.

7.23 The development of WOOLPLAN in 1984 by a sub-committee of the Sheep Performance Recording Co-ordinating Committee, established by the Standing Committee on Agriculture, has enabled breeders to use objective measures in their selection programmes. WOOLPLAN is the national performance recording scheme for Merino and other non-pedigreed wool sheep breeds. It ranks animals on predicted breeding value according to breeding objectives selected by the producer, and is available through accredited wool testing laboratories.[25] It could be the stimulus for co-operative sheep-breeding research projects which could lead to real genetic progress in the national wool sheep flock.

7.24 Even were producers to be swayed to the welfare rather than the economic side of the selective breeding debate, dramatic results could not be expected in the short term. Professor Kennedy suggested that, with conventional selective breeding, improvements in fleece weight of about only one per cent per annum could be achieved. More dramatic changes are unlikely because of the sheep's natural balancing or homeostasis.[26]

7.25 The Committee believes that every effort should be made to encourage research into breeding for resistance to deleterious and heritable diseases and parasites. It accepts that most producers cull animals with obvious defects from their flocks. However, more can and should be done to lessen our dependence on chemicals and to lessen the problems associated with parasitic resistance to chemicals.

Manipulation of reproduction

7.26 Reproduction can be artificially manipulated in a number of ways, involving no direct contact between ram and ewe in the process of fertilisation. They include artificial insemination, embryo transfer and genetic engineering.

Artificial insemination

7.27 Artificial insemination is a method of breeding in which semen is obtained from the male and introduced into the female reproductive tract by means of instruments.[27] Semen can be collected from the ram by training him to use an artificial vagina or by the use of an electro-ejaculator, while the ewe is inseminated cervically or vaginally by pipette, or laparascopy is used to deposit the semen directly in the uterus.[28] Either fresh or frozen semen may be used.

7.28 The technique of artificial insemination is widely used throughout the world, especially in the cattle industry. It appears to be gaining ground slowly but steadily in Australia in the sheep industry. In the 1988-89 season, it is estimated that less than half of one per cent of the total ewe flock will be artificially inseminated.[29]

7.29 The advantages of artificial insemination are many. With conventional mating, a ram is expected to cover generally 50 and up to 100 females per year, while with intrauterine insemination of frozen-stored semen, it is estimated that up to 25,000 ewes could be inseminated from a single ram each year.[30] Even allowing for the reduced fertility sometimes experienced with artificial insemination, the number of lambs per ram will be far in excess of that achieved naturally. The influence of superior rams can thus spread further, faster.

7.30 Semen, whether fresh or frozen, can be transported more easily and cheaply than rams and can be obtained from valuable animals which may be prevented by some infirmity from mating. Semen banks can preserve frozen semen for use long after the death of the provider ram, and when his progeny have proved themselves to be superior animals.

7.31 When synchronised breeding is used in conjunction with artificial insemination, lambing and lamb marking can be more easily managed at appropriate times for both animals and producer.

7.32 Artificial insemination has some potential hazards, however. If the rams used are not thoroughly checked for diseases, then those diseases may be spread much more rapidly than otherwise. Similarly, as Professor Kennedy pointed out, unfavourable genes can be spread rapidly.[31]

7.33 The methods used to collect semen, while not in themselves hazardous, may cause some discomfort to the ram, particularly electro-ejaculation. In this method, a probe in the rectum transmits low voltage electric pulses to stimulate output of spermatozoa. The ram is restrained on his side for the procedure. Studies by Martin and colleagues have reported significantly elevated plasma concentrations of cortisol and prolactin for up to two hours following electro-ejaculation.[32]

7.34 The use of an artificial vagina, a device which imitates the vagina and provides temperature and pressure stimulation to the erect penis of the ram, seems to be a preferred option, where possible. Rams are trained to use the device easily, by the presence of a "teaser" oestrous ewe restrained in a bail. While cortisol and prolactin levels still rise with the use of an artificial vagina (as they do with natural mating) they do so to a far lesser extent and return to normal levels more quickly.[33]

7.35 It was unclear to the Committee how widespread the use of electro-ejaculators is. The Committee accepts that their use may be necessary on health grounds for semen examination when the ram is unable to use an artificial vagina. However, for semen collection purposes, artificial vaginas would appear to be preferable.

7.36 Artificial insemination is certainly more stressful to the ewe than natural mating, as it involves human handling and, in the case of intrauterine insemination, minor surgery. The simplest method, and one used extensively in Western Australia with apparently good results, is to walk the oestrous ewes through a race, restrain each one momentarily and insert the semen via plastic pipette into the vagina. Cervical insemination involves locating the entrance to the cervix with a speculum and depositing the semen there with a pipette. The ewe's hindquarters need to be elevated for this to be done successfully. Larger quantities of semen are required for both these methods than for intrauterine insemination, which involves the use of a local anaesthetic, after which small incisions are made in the abdominal wall to allow the passage of a laparoscope to identify the organs and a pipette to place the semen.

7.37 Intrauterine insemination is the most successful of the three procedures and is the preferred option of many of the major studs, such as Collinsville, which uses the procedure on more than 50 per cent of its ewes.[34] The resulting conception rates at Collinsville currently average 70 per cent, meaning that 30 per cent of the ewes undergo the stress of minor surgery to no avail. Laparoscopy has the advantage of being the only technique to be able to use (thawed) frozen semen, so that neither ewes nor ram have to be transported.

7.38 A management difficulty associated with artificial insemination is the need to synchronise the oestrus period of the ewes, as under normal pastoral conditions the number of ewes in oestrus on any given day is highly variable. The most common method in current use involves the insertion in the ewes of intravaginal sponges soaked in progestagen. The sponges are removed after 12 to 14 days, and the ewes injected with pregnant mare serum gonadotrophin (PSMG). Sometimes teaser rams are introduced to the flock at the same time. Fifty-five to 56 days later, the ewes are in oestrus and ready for insemination.[35] The dose of PSMG is varied according to the age and breed of the ewe and to the season of the year. PSMG is known to cause a decline in fertility, but this is partly compensated for by a higher ovulation rate.[36]

7.39 The Committee accepts that artificial insemination is of valuable assistance in the genetic improvement of sheep in Australia and as such should be encouraged. However, the Committee would like to see further research into the efficacy of non-invasive techniques using (thawed) frozen semen to keep the stresses associated with the process to a minimum. It would also like to see continued research into methods of synchronising oestrus.

Embryo transfer

7.40 This method involves the removal of embryos from a desirable donor ewe after two to six days of development and their transfer to the reproductive tracts of synchronised recipient ewes. The method of transfer uses a laparoscopic technique similar to that used in artificial insemination. General anaesthetic is commonly used for both the collection and transfer of embryos.[37] Sometimes the donor ewe is encouraged to superovulate by prior treatment with PSMG. Success rates of from 50 to 70 per cent can be achieved.[38]

7.41 Compared to artificial insemination, embryo transfer is likely to be more stressful for the ewes concerned. Surgery may cause adhesions of the reproductive tract.[39] Apart from its cost, embryo transfer is unlikely to have the same impact as artificial insemination as fewer than 100 embryos can be transferred from a single ewe in her lifetime and her influence could never match that of a ram which, via artificial insemination, fathered thousands of offspring.[40]

7.42 A further refinement of the embryo transfer process is the recently developed technique of splitting embryos microsurgically. If the implanted embryo results in a highly successful animal, its frozen clones will be able to be used to create identical creatures even well into the future.

7.43 Concern was expressed to the Committee by the Australian Veterinary Association that in some States, non-veterinarians were performing such "sophisticated invasive techniques" as laparoscopic insemination and embryo transfer.[41] The veterinary surgeons legislation varies somewhat from State to State, but frequently it contains provisions for properly accredited persons who are not veterinarians to perform artificial insemination. Owners, whether competent in the procedures or not, are exempt from the provisions of the legislation.

7.44 As artificial breeding is becoming more popular, the Committee believes it is important to ensure that all persons who perform either laparascopic insemination or embryo transfer in sheep are competent in the procedures. It considers that it is the responsibility of the Veterinary Surgeons' Board in each State to ensure that only properly accredited persons, either veterinarians or technicians with certificates of competency, perform the procedures.

<u>Genetic engineering</u>

7.45 Isolating a gene from one organism and transferring it to another is known as genetic engineering. The most visually dramatic research to date involves genes coding for growth factors. "Supermice" have been bred since 1982 by transferring copies of the human growth hormone gene into one-cell mice embryos. These transgenic mice grow to twice the size of their normal litter mates, and the changes are passed on to successive generations.[42]

7.46 Work has been conducted by the CSIRO into the growth hormone gene in sheep, with the aim of producing larger, faster growing sheep with leaner meat for the prime lamb market. Four transgenic sheep have been bred but none has survived a year and all have had the classical signs of growth hormone toxicity, such as diabetes and swollen joints.[43] In the case of sheep, the yield of transgenic sheep born following micro-injection of foreign DNA is very low. Fewer still of these express the foreign gene, because the control mechanisms are still not well understood.

7.47 CSIRO researchers are now attempting to transfer into sheep the bacterial genes which make the enzymes for cysteine synthesis, so that the transgenic sheep could make extra cysteine to increase their wool production significantly.[44]

7.48 Genetic engineering holds enormous promise as the means of transferring single desirable genes or genetic combinations to Australia's sheep. However, the technology is still in the experimental phase. Retrieving embryos for manipulation in the laboratory often requires repeated surgery; in many cases the foreign DNA does not "take" or the embryo fails to develop; and researchers cannot readily control the placing of the foreign gene or how it works.[45]

7.49 Most important economic traits in sheep, such as growth rate, fleece weight and milk production are multigenic and hence present major transfer difficulties. Single gene differences include fecundity, as expressed by the F gene in the Booroola Merino. This gene appears to operate to increase ovulation rate by reducing the activity of the hormone inhibin, but this effect is difficult to achieve using current genetic engineering technology.[46]

7.50 That we cannot predict all the consequences of adding foreign genes to adult domestic animals was graphically illustrated by the case of the Beltsville pig. Growth hormone genes introduced to pigs in the United States Department of Agriculture farm at Beltsville, Maryland in 1986 produced a severe side effect in the form of crippling arthritis in the one animal which survived to adulthood.[47]

7.51 In their evidence to the Committee, CSIRO researchers also pointed to the possibilities of using genetic engineering techniques to breed animals with greater inherent resistance to disease.[48] While accepting that this is a laudable aim, as is the genetic improvement of the Australian sheep flock, the Committee urges caution with regard to the extent to which genetic manipulation should be allowed. The Committee supports continued research into genetic manipulation in sheep, provided that it is not detrimental to sheep welfare and provided that all research proposals are scrutinised attentively by the relevant ethics committees.