BEYOND CALF EXPORTS: THE EFFICACY, ECONOMICS & PRACTICALITIES OF SEXED SEMEN AS A WELFARE-FRIENDLY HERD REPLACEMENT TOOL IN THE DAIRY INDUSTRY

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INTRODUCTION

Sexed semen has been available commercially for a number of years, although the uptake by the dairy industry has been low until recently. The concerns over slaughtering of unwanted male dairy calves and the possible shortage of dairy replacements and beef cattle have led to a greater demand for sexed semen. This report reviews information on sexing semen and its use in dairy herds and provides some recommendations on initiatives to increase use of sexed semen.

Advantages of sexed semen

1. Technology is now well proven with reliable sex ratio.
2. Reduced numbers of unwanted male calves.
3. Fewer cases of dystocia (calving difficulties).
4. More crossbred calves available for beef sector.
5. Increase in the number of dairy heifer calves. These can be reared and sold as replacements (currently, there is a shortage of replacement heifers throughout Europe).
   Alternatively, having enough replacements reduces the need to buy in stock and improves farm biosecurity.
6. Improved dairy farm margins from sale of surplus stock (heifers or beef cross calves).

Concerns about sexed semen

1. Sexed semen is presently recommended only for use on maiden heifers. The conception rates with milking cows are lower than with unsexed semen. The issue of low conception rates for milking cows is a concern for the whole dairy farming industry and not a specific issue for sexed semen use.
2. Information to farmers about the efficacy of sexed semen may be out of date.
3. Restricted number of sires available and the fact that currently demand is greater than supply.

SUMMARY

1. In terms of the UK dairy or beef industry, there is little to suggest any significant problems arising from a switch to sexed semen. On the contrary, the technology would reduce the number of low value male dairy calves and increase the number of more valuable beef cross calves for the beef industry.

2. Use of sexed semen is recommended by breeding companies and vets as being likely to give satisfactory conception rates for maiden heifers. However, there are still doubts about conception rates when sexed semen is used for inseminations on milking cows. Farmers will need to breed from milking cows as well as maiden heifers to produce enough replacements and farmers usually wish to breed replacements from cows with good production or type characteristics. Improving fertility in milking cows is an issue that will need to be resolved before sexed semen can be used on them with confidence.

3. Results from experimental work on the use of sexed semen on maiden heifers and milking cows also suggests that due to poorer conception rates with milking cows sexed semen use should at present be confined to maiden heifers.

4. Differences in fertility exist between bulls and the procedures for freezing and thawing the semen are more critical for sexed semen than unsexed semen.

5. Farmers' attitudes to the use of sexed semen are linked to the fertility of sexed semen, availability of semen from the most popular sires and restriction to its use to maiden heifers. Some of these concerns may be based on out-of-date information.

6. Demand for sexed semen is currently greater than the supply. Market forces are, however, likely to bring supply and demand into balance, provided that a long term demand can be demonstrated.

7. The number of surplus male calves could also be reduced by improving the longevity of dairy cows, a move towards a more dual-purpose breed, or increasing yield per cow and reducing the number of dairy cows needed. These strategies are sometimes contradictory. However, the use of sexed semen can be used alongside these other strategies.

RECOMMENDATIONS

i) There is a need for further research to improve conception rates with sexed semen used on milking cows. Research which has been undertaken has shown low conception rates especially when management is not at a high standard. Given that conception rates are falling with unsexed semen the research work should focus on improving fertility in milking cows and not solely on sexed semen.

ii) The use of sexed semen should increase the rate of genetic progress, if fewer cows are required to breed the next generation of heifers. There could, however, be increased problems with inbreeding. Therefore, there is a need to calculate changes in annual genetic progress with varying use of sexed semen for a range of traits including those pertaining to health and welfare.

iii) There is reluctance amongst dairy farmers to use sexed semen, although once they have started to use it the farmers contacted for this report were enthusiastic about it. Therefore there is a need to model the effects of using sexed semen within different types of dairy herds (seasonal calving, all-year calving) with varying conception rates.

iv) An evaluation should be undertaken of the efficacy of the supermarkets' schemes that offer a discount, on the cost of sexed semen, to their dedicated farmer suppliers. This should be undertaken after 15 months, to include the farmers' experiences of using sexed semen and the second-year uptake of sexed semen.

v) Farmers who are using sexed semen need to be made aware of the information and training courses that already exist on improving dairy herd fertility.

vi) There should be a controlled evaluation, across a number of herds, on the efficacy of sexed- versus unsexed semen. This would need to be a robust examination of different management systems, milk yields, differing health status and a wide range of sires.

vii) The industry should establish a series of farmer focus-group discussions ('farmers' jury'), where farmers are asked their opinion of sexed semen before attending a meeting. At the meeting, the up-to-date facts about sexed semen should be presented in a neutral context. After the event, the farmers would be questioned again. The results from such discussions could form the basis of a report, or press information.

viii) Breeding companies and independent consultants are two sources of accurate information and advice. The advice must take into account the suitability of a particular sire for individual farm circumstances and not just focus on sexed semen. There is also evidence that farmers consider their veterinary surgeon to be a good source of advice on a range of farm matters, including management topics as well as herd health. It is therefore essential that vets are aware of the latest information on sexed semen (channelled, for example, from a range of breeding companies) to be able to provide impartial advice. The majority of UK dairy veterinary surgeons are members of the British Cattle Veterinary Association (BCVA), which could be an appropriate channel through which to get the information to veterinary surgeons.

SECTION 1 SEMEN SEXING TECHNOLOGY

Technology

Several procedures have been proposed for sexing sperm, such as albumin gradient separation, sex-specific antibody binding, multitube swim-up, fractionation on a discontinuous Percoll gradient and free-flow electrophoresis (Joerg *et al*, 2004). At present, the fastest, most reliable and potentially most cost-effective procedure for sperm sexing is flow cytometry (Garner *et al*, 1983; Welch and Johnson, 1999; Seidel and Garner, 2002). The basis of flow cytometers is that the female (X-bearing chromosome) contains 3.8% more DNA than the male (Y-bearing chromosome). The sensors detect this difference in DNA content when the sperm cells pass by a laser beam, one at a time in a fluid stream. A charge is applied to the droplets containing the desired cells which are subsequently deflected into either male or female populations (Cogent, 2007). Flow cytometry is currently the only routine procedure for sexing cattle sperm that is currently available for practical applications (Maxwell et al, 2004). Cogent developed the Harmony Freeze technique in 2002 that leaves a higher (16%) proportion of viable sperm after thawing (Cogent 2007).

Pregnancy rates with sexed semen

Fertility of sexed semen is typically lower than that of conventional semen (Weigel, 2004). The lower fertility is caused by the lower insemination dose (2 x 106 vs. 10 to 20 x 106 spermatozoa) and also by physical and chemical stresses that occur during the sorting process. These stresses include high dilution of gametes, staining with the DNA binding dye Hoechst 33342, mechanical forces during sorting, light from the UV laser beam and projection into the collection tube under high pressure and centrifugation (Garner, 2006). The pregnancy rate obtained using sexed cattle sperm in field conditions was reported by Cerchiaro *et al* (2007) at slightly greater than 50%. The pregnancy rate of sexed sperm observed by Cerchiaro *et al* (2007) was similar to that obtained with sexed semen in several trials reviewed by Weigel (2004) that ranged from 48 to 57%. Fertility of sexed semen was also studied by Seidel and Schenk (2002) who reported a conception rate ranging from 31 to 46%. In one study with heifers balanced among three bulls and two inseminators (Schenk *et al*, 2005) the pregnancy rate was 56% compared with the control pregnancy rate of 61% with unsexed semen. However, it has been reported that pregnancy rates with sexed semen are very low when management levels are marginal (not at the highest level). The main issue with sexed semen appears to be that management issues which reduce fertility with unsexed semen have a larger effect with sexed semen (Schenk and Seidel, 2007).

There is general agreement that conception rates with milking cows (multiparous animals) are lower with sexed semen than unsexed semen. For example, Andersson *et al* (2006) reported a conception rate of 21% with sexed semen compared to 46% with unsexed semen, using AI. The main management issue is that high-yielding modern dairy cows have a longer period of negative energy balance in early lactation, when feed energy intake is unable to meet the energy demand for milk production. Maiden heifers, which are not producing milk, do not have this period of negative energy balance.

Other factors

Differences in pregnancy rates among bulls are well documented in the literature for both unsexed (Donovan *et al*, 2003) and sexed semen (Seidel et al, 1997; Bodmer *et al*, 2005). If bulls have poor fertility with sexed semen then the semen suppliers only market unsexed semen from these sires. The demand for semen is also a factor in whether sexed semen is marketed. Two thousand straws can be produced per ejaculate with unsexed semen whilst only 300 straws can be produced per ejaculate with sexed semen.

Cerchiaro *et al* (2007) reported that the age of heifers at Artificial Insemination (AI) with sexed semen did not affect conception rate. These results agree partly with those reported by Donovan et al (2003), who reported that pregnancy rate was not related to age at first service and was negatively influenced by the hot season in a field study on 601 maiden Holstein heifers.

Sexed semen is also more fragile and needs careful handling at insemination to ensure correct thawing. This may be an issue limiting its uptake on commercial farms many of which rely on DIY AI, where the farmer or herdsman is trained to use AI, rather than someone from a breeding company. More progressive farmers have become aware of the need for better heat detection and attention to detail when inseminating cows. The financial consequences of poor fertility have been well documented and there are a number of courses on improving fertility available to farmers. Improved fertility has also been a focus for other companies e.g.: the feed supply industry.

Seidel (2007) found that abortion rates were similar with sexed semen and that the calves born were normal in other respects (Table 1.1). Embryo survival rates appear here not to be lower with sexed semen. However, other work has shown higher embryo losses with sexed semen. Bodmer *et al* (2005) reported 5/29 among cows inseminated with sexed semen compared to 1/18 with non-sexed semen – note small number of animals in the study by Bodmer *et al* (2005) and differences are unlikely to be significant

TABLE 1.1 Normality of calves from sexed sperm

(From Seidel, 2007)

	Sexed	Control
Numbers	1158	787
Abortion rate (%)	4.5	5.0
Gestation length (Days)	279	279
Neonatal deaths (%)	3.5	4.0
Calving ease score	1.22	1.23
Birth weight (kg)	33.9	34.1
Live at weaning (%)	91.7	91.5
Weaning weight (kg)	239	241

Sex ratio

Semen sorting has been shown to be a reliable method for sex preselection in cattle (Seidel and Garner, 2002). Typical figures indicate 85 to 95% female calves from sexed semen.

Discussion

In recent years, the UK cattle industry has been able to avail of sorted semen from a limited number of sires, at a premium above the price paid for unsorted semen. This 'choice' has been widened to an extent by the advent of a second provider into the UK marketplace, a scenario that at least offers some prospect of more competitive pricing. However, while such competition can ensure that pricing is realistic, there will be a threshold below which commercial interests could not survive (Seidel, 2003). To shift that threshold, presuming it to be high (i.e.: where units of sorted semen are relatively expensive), existing technologies would need to be further refined and/or superseded by alternatives to an extent that significantly reduces costs per unit sold (e.g.: by greater throughput per hour, by better yield of saleable product per ejaculate, by simplification of procedures). Ideally, also, such advances would be associated with an improvement in the conception rate associated with 'sexed' semen. This could be crucial to survival of commercial companies in this field because currently the inferior conception rate associated with sexed semen (Weigel, 2004; Olynk and Wolf, 2007) is a major disincentive to its uptake, and as long as it is an issue will be likely to remain so, particularly in the beef cattle sector (Seidel, 2003) where calving interval is a key determinant of herd performance. Small wonder that Johnson (2005) considered the process of making this technology widely available for use by commercial producers 'agonisingly slow' given the roles it could play.

In addressing issues regarding the commercial implementation of sexed semen, where limitations include conception rate and price, Weigel (2004) noted that: "*…we have three options. First we can dwell on these limitations and wait for them to go away, if ever. In other words, we can let reproductive biologists 'tweak' the current method (or develop a new method) that will provide conception rates comparable with unsexed semen and will produce thousands of units of sexed semen each day. Second, we can ignore these limitations and use sexed semen in the same way we have used unsexed semen for decades. Third, we can recognise these limitations and develop new breeding strategies that are 'tailor-made' for sexed semen.*"

In view of this insight, and recognising that Option 2 is a non-runner (Weigel (op. cit.) noted it would merely result in failure and a conclusion that the technology doesn't work). Since the birth of the first gender pre-selected cattle and sheep via AI, the latter at SAC premises in Aberdeen (Cran *et al*, 1997), the technology that achieved those breakthroughs – namely, flow cytometric sorting of sperm on the basis of DNA content (Cran and Johnson, 1996) – has been refined to the extent that it now is available commercially for cattle in several countries and many tens to hundreds of thousands of calves have been born with a gender selection accuracy of ninety per cent (Cran, 2007; Seidel, 2007). Moreover it has not been superseded thus far by protocols that seek to distinguish by other means spermatozoa with X-chromosomes from those that have a Y-chromosome. That said, it is encouraging to note that alternative technologies are being pursued and some of these too have received support and attention from commercial interests.

A case in point is the technology employed by Ovasort Ltd and featured recently in 'Advances Wales' (Anon., 2007). As noted in that article, the protocol involves separation of X-bearing boar spermatozoa from those with a Y-chromosome on the basis of differences in cell surface properties. Dr Ian Cumming, the scientist responsible for the work, is optimistic that this or a similar procedure can be made applicable to cattle also (pers. comm.). Perusal via the Internet of 'patent' and 'intellectual property' websites (e.g. http://www.wipo.int/) confirms that filtration, agglutination and electrophoretic procedures are among those sperm separation and processing alternatives being pursued and tested in various laboratories with a view to commercial application. Additional alternatives include the distinguishing and separation of spermatozoa on the basis of differences in motility parameters (Holt *et al*, 2007).

Laboratory-based efforts to refine sperm sorting technologies based on detecting differences in DNA content have included investigations of effects of pressure (aimed at increased throughput), laser intensity, staining conditions and catalase (Suh *et al*, 2005; Garner, 2006; Schenk and Seidel, 2007). While advances arising from such work are gradually improving the efficiency and rapidity of semen sorting (and thus, production cost per unit of sorted semen sold), a positive influence on enhancing fertilising ability of sorted sperm is not forecast as yet (Schenk and Seidel, 2007).

Other work includes studies aimed at determining effects of site and method of semen deposition on outcome following AI with sex-sorted sperm (Grossfeld *et al*, 2005; Kurykin *et al*, 2007) and also the extent to which low-dose inseminations versus sperm sorting *per se* is responsible (Seidel *et al*, 1999; Bodmer *et al*, 2005; Schenk *et al*, 2006) for lower fertilisation incidence. Moreover, because the ability to store (fresh) or cryopreserve sorted sperm has a significant impact on subsequent breeding outcomes (Parrilla *et al*, 2005; de Graaf *et al*, 2007a) factors that influence this warrant attention including, for example, sire diets (de Graaf *et al*, 2007b) and post-separation processing protocols.

This section ought not to conclude without at least acknowledging the existence of a viewpoint which sees the mammalian female as having some influence on the gender of her offspring and perhaps thereby being capable of contributing to inefficiencies following insemination with 'sorted' sperm (Grant and Chamley, 2007). More importantly, however, there will be an ongoing need to ensure that any and all sperm separation technologies that are developed with a view to commercial applications in the livestock sector do not undermine the health, normality and welfare of offspring so derived. Concerns have been raised – and understandably so – regarding the vulnerability of DNA in spermatozoa to laser exposure as well as to fluorescent dyes or other potential mutagens. Reassuringly, however, it has recently been reported – on the basis of within-farm comparisons of calves sired by control versus 'sexed' sperm (the latter thereby having been exposed to laser and fluorescent dye) from the same bulls – that there were no abnormalities attributable to the process and there was no evidence of an increased incidence of abortion (Tubman *et al*, 2004; Seidel, 2007). As acknowledged by Seidel (2007), of course those trials could not (nor indeed could any others) provide absolute proof that there is no genetic damage to 'sexed' spermatozoa exposed to conventional separation processes. It will therefore be important to continue to closely monitor offspring produced by whatever X- versus Y-chromosome-bearing sperm separation processes are used in years to come. On the basis of current evidence, however, scarcity of offspring (i.e.: conception-rate limitations associated with low-dose inseminations using ‘sorted’ spermatozoa) is likely to be the major constraint for the foreseeable future.

There may be some concern that sexing semen is another technique which ‘plays with nature’. Artificial insemination is not a major issue with most consumers and sexing semen should be considered as an extension of AI. There are two options open to the industry:

a) Introduce sexed semen without any publicity to the general public considering that they already accept AI, if they know about it at all.

b) Provide information about sexed semen as a technique that selects sperm (not embryos) and will lead to a reduction, and possible elimination, in the slaughter of unwanted male calves.

Whilst the conception rates with sexed semen are lower, this is offset by the high proportion of calves produced of the desired sex. With maiden heifers, a delay in calving due to poorer conception rates is not as important as it is with milking cows. Each day’s delay in conception has been estimated to cost £2.70 in lost production, however with increased milk prices this is more likely to be nearer £4 per day (Mason:personal communication). The importance of delayed calving due to lower conception rates differs depending on herd calving pattern. With a very tight, seasonal, calving pattern a delay with maiden heifers is important, whilst with all the year calving the effect is less important. A 365-day calving interval is very important for seasonal calving herds, or herds with lower than average milk sales per cow (<7,500 litres). With a higher-yielding herd, delayed insemination and a longer calving interval may be a more economic option. However, in both cases, unsuccessful AI is expensive, in terms of semen/insemination costs and in the longer-than-planned calving interval. The effects of lower fertility need to be modelled for different farming systems, along with the benefits of producing only dairy heifer calves and an increased number of beef cross calves (see Table 3.1).

The fertility of older cows is inherently poorer than that of maiden heifers, even when using unsexed semen. Any factor affecting the viability of the semen, egg or embryo will therefore have a more marked effect on milking cows than on maiden heifers. More handling, physical or chemical disturbance (such as during flow cytometry) can be regarded as having a detrimental effect on the semen.

SECTION 2 USE OF SEXED SEMEN

Introduction

Semen companies reported an increasing demand for sexed semen over the last two years and that at present demand is outpacing production. One company reported that over 50% of their customers are now using sexed semen as a part of their semen requirements. (This does not mean that 50% of the semen sales are sexed semen, since farmers are usually only using sexed semen on maiden heifers). Sexed semen is now available from bulls of a range of dairy breeds including Holstein Friesian, Ayrshire, Jersey, Friesian and Brown Swiss. The semen companies mentioned that a blockage to uptake of sexed semen is not the demand but the supply.

Farmers

The topic of using sexed semen was raised at two farmer discussion groups in October 2007. Two questions were asked and the farmers discussed the topic without any further guidance or prompting from SAC staff. The membership of these two groups were not typical of UK dairy farmers but could be described as more progressive, commercial dairy farmers. Only one farmer had used sexed semen on maiden heifers and conception rates had been satisfactory. The reasons given by the other farmers for not using sexed semen were:

i) Low fertility when they were already concerned about fertility levels in their herds.

ii) Sexed semen was not available from the most popular sires, this relates to the demand for semen and only 300 straws/ejaculate for sexed semen compared with 2000 straws/ejaculate for unsexed semen. The supply of semen from the most popular sires is therefore a commercial decision for the AI companies, except for individual 'popular' sires which may have lower fertility and therefore their semen may not be suitable for sexing.

iii) It is not unusual for dairy heifers to be mated by natural service with a beef bull. The reasons for this are that the correct choice of beef sire will reduce the risks of difficult calvings and those often maiden heifers are only inspected once a day and therefore it is difficult to detect which animals are in heat. Farmers who operate this system realise that they are reducing the genetic merit of their herd by not breeding from the highest genetic merit animals (maiden heifers). However they are willing to accept this lower genetic progress for easier youngstock management. Since in this situation AI is not used on maiden heifers, sexed semen was not an option.

iv) Cost of sexed semen.

An average cost for sexed semen is £25 to £35/straw and unsexed semen from sires with similar genetic merit is £10 to £15/straw (personal communication from Cogent).

The reasons given by these farmers were similar to those reported for beef farmers by Telford *et al* (2003).

Five farmers who had used sexed semen on their herd were asked about their opinions on using sexed semen. This sample cannot be taken as representative of the industry and one of the conclusions of this report is that a comprehensive survey should be undertaken. However the farmers in this small sample were satisfied with the results obtained from using sexed semen on heifers and they would also use it on cows if they could be assured of satisfactory conception rates. In addition to the reduced number of dairy male calves, two of these farmers also indicated that heifer rearing was easier if they had a group of calves of more similar age to rear. This can be achieved with sexed semen, provided farmers do not want to breed replacements solely from their best cows.

Industry

Interest in promoting sexed semen has also been expressed by supermarkets. Some are offering incentives to their dedicated milk suppliers to use sexed semen. Early indications from supermarkets are that these incentives have increased the demand for sexed semen. One company reported that 20% of its dedicated farmer suppliers had taken up the offer of a preferential rate for sexed semen. It is too early to assess the long-term impact of such schemes. However, as far as SAC can ascertain, none are making the use of sexed semen compulsory; the choice of whether to use it or not is still entirely at the discretion of the individual farmer.

Sexed semen is acceptable to the organic sector but does depend on the techniques used. Other sectors of the industry (breed societies, recording organisations) were supportive of the use of sexed semen. However they identified the same issues on uptake as listed above. There may be a risk that using sexed semen is seen as 'tampering with nature', but considering the acceptance of sexed semen and AI by the organic sector, this risk appears to be low.

Other ways to reduce the number of surplus male calves

1. Within the UK, reducing the number of cull cows and replacements would reduce the number of surplus male calves. It also confers the advantage in animal welfare/ethical terms, of increasing the longevity of milking cows.

2. For a given national milk production level, if cows are higher-yielding, fewer of them are needed, and therefore fewer replacements need be bred (which would mean consequently fewer male calves).

3. A change in breeding policy towards using more dual-purpose cows.

The three examples given here would not work in conjunction to one another. For example, pursuing the first option may have a detrimental effect on the second and hence not improve the overall situation. However these other examples could also be used in conjunction with sexed semen.

SECTION 3 CONSEQUENCES OF USING SEXED SEMEN IN THE DAIRY HERD

Two scenarios are given in Table 3.1. Using sexed semen on heifers and breeding all replacements using sexed semen is also discussed.

Scenario A: Sexed semen used on heifers for two inseminations followed by a sweeper bull. Conception rate was assumed to be at 60%. Unsexed semen used on milking cows assumed a replacement rate of 25% and 10% deaths.

Scenario B: Same replacement and death rate as for Scenario A but all replacements bred from milking cows using unsexed semen. Maiden heifers run with beef bull.

TABLE 3.1 Scenarios using sexed (A) and unsexed (B) semen

% of calves before deaths	Sexed	Control
Dairy heifer calves from maiden heifers	21	0
Beef cross calves from maiden heifers	4	25
Dairy heifer calves from milking cows	14	35
Dairy male calves from milking cows	14	35
Beef cross calves from milking cows	47	5

It can be seen from Table 3.1 that using sexed semen on maiden heifers reduces the number of dairy male calves from 35 to 14%. However there is still a need to inseminate some (28%) of milking cows with dairy semen to maintain herd size. Therefore sexed semen, if confined to maiden heifers, is unlikely to be used to expand herd size or meet the deficit in dairy heifers in Europe.

If all replacements were to be bred from sexed semen then another 14 female dairy calves would be required. The number of inseminations required to produce these 14 calves would depend on conception rate (between 28 and 56 inseminations for conception rates between 50 and 25%). It is therefore possible to breed all dairy replacements using sexed semen. The issue, which needs further study, is the effect of lower conception rates on annual milk production.

If all replacements were bred by sexed semen then there would be very few dairy male calves. If male sexed semen was used for the beef cross calves this would increase the value of the beef cross calf.

There are likely to be fewer calving difficulties (figure 3.2) with sexed semen since on average, heifer calves are 2kg lower liveweight than bull calves and cause less dystocia even at same birth weight. The exact effect on calving difficulties will depend on farm management and selection of beef bulls to cross on dairy cows (Table 3.3). Farmers who have previously used an easy calving beef sire on their maiden heifers need to be aware that there may be more calving difficulties if they use sexed Holstein Friesian semen on maiden heifers. This demonstrates the importance of using calving ease data when available when selecting either dairy or beef sires.

TABLE 3.2 Distribution of male and female calf calving ease scores from the CIS database from 2003-2007 (unedited, all breeds)

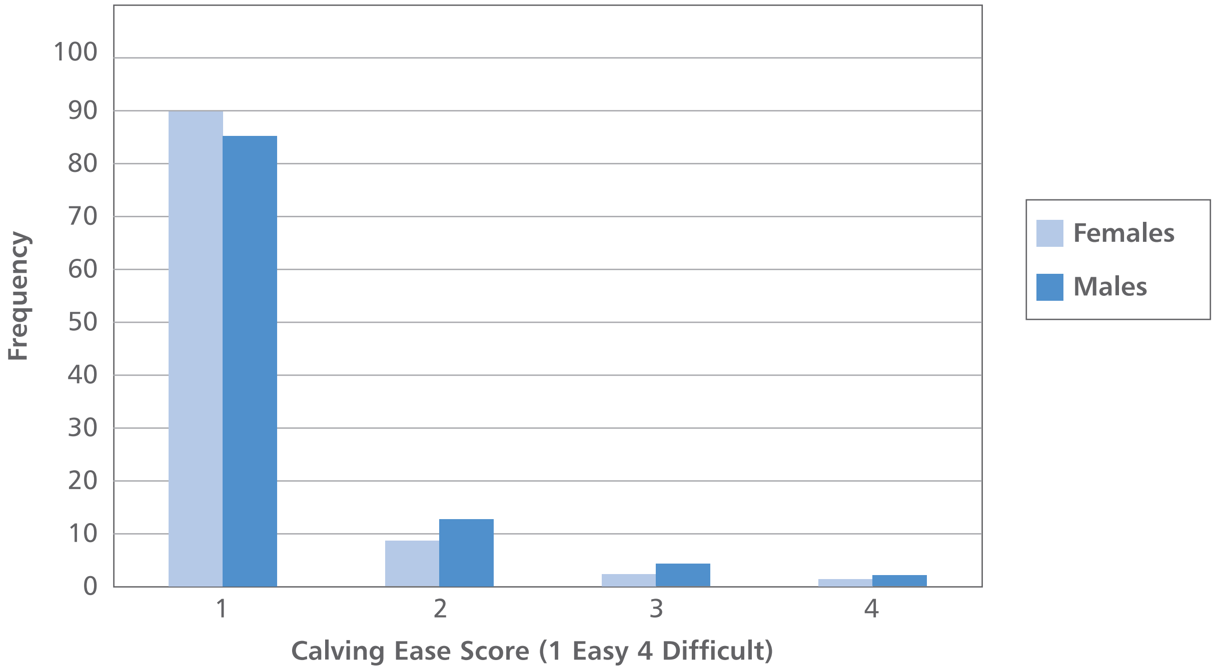

TABLE 3.3 Summary of breed differences in calving difficulty, mortality, weaning weight and carcass traits in Ireland

(From EAAP publication 'Cattle breeds in Ireland')

Sire breed	% difficult calvings	Gestation length (days insemination - birth)	Mortality (% dead at 28 days)	Weaning weight (kg at average 226 d)	Cold carcass wt (average age)	Conformation (1-15 Europ scale)
Holstein	6.1	281.9	3.3	N/A	319.2 (778 d)	4.7
Belgian Blue	9.6	283.7	2.7	301.8	336.0 (774 d)	7.8
Charolais	7.1	287.9	1.6	318.8	357.8 (707 d)	8.3
Limousin	5.1	289.5	1.7	290.2	333.6 (747 d)	7.5
Aberdeen Angus	5.2	283.1	3.4	258.1	301.4 (750 d)	5.9

Rate of genetic progress

The impact of using sexed semen both in matings to produce commercial replacement heifers and in matings of elite animals to produce bulls for progeny testing has been reviewed by Van Vleck (1981). He estimated that annual genetic progress for milk production would increase by 15%. Similar work by Dematawewa and Berger (1998) using different input assumptions estimated a 9% increase in annual genetic progress. Increases in genetic progress are intrinsically good.

There is however a debate on selection goals (production compared with functional traits). This debate is about the overall objectives of a breeding programme and is not linked to sexed semen. Sexed semen could lead to increased inbreeding; however, information and computer programmes are available to avoid unacceptable levels of inbreeding if sexed semen is used more widely.

SECTION 4 THE UK BEEF MARKET

4.1 The current situation

Table 4.1 provides an overview of the UK beef market. The MLC forecast net production of 913,000t in 2007, which is well up on 2006. UK beef production has recovered strongly since the 2001 outbreak of foot-and-mouth disease (FMD). However it is the consequences of the easing of restrictions introduced for another disease – BSE – which has had the biggest impact most recently. The reintroduction of cow beef into the food chain in late 2005 has significantly lifted domestic production.

As consumption of beef has grown only steadily in recent years, the extra UK production has displaced imported beef. The Republic of Ireland is the biggest exporter of beef to the UK. Only very limited volumes of Brazilian beef is imported. It is also notable how exports of UK beef have also jumped in the last two years thanks mainly to foreign demand for cow beef. The MLC forecasts have been updated to take the disruption caused by the 2007 FMD outbreak into account.

TABLE 4.1 UK Market situation and outlook

'000 tonnes	2002	2003	2004	2005	2006	2007	2008
Net production	692	696	709	762	847	913	880
Number slaughtered							
Imports	314	323	346	299	295	260	305
Exports	0	7	8	11	46	50	70
Consumption	987	1,010	1,041	1,057	1,094	1,122	1,115
UK suckler cows (June census '000 head)	1,657	1,700	1,736	1,751	1,737	1,695	
UK beef heifers in-calf (June census '000 head)	257	239	230	192	192	na	
UK dairy cows (June census '000 head)	2,227	2,192	2,129	1,998	1,979	1,956	
UK dairy heifers (June census '000 head)	470	441	460	446	444	na	

Source: Defra, MLC. Forecasts in bold. All figures subject to revision.
UK cattle numbers based on BCMS data since 2005.

Although UK beef production remains well below the 1987 level of 1,105,000t, it is at a relatively similar level to the years immediately prior to the market problems caused by the BSE restrictions introduced in 1996.

In short, although UK beef production has recovered since the difficulties caused by BSE in 1996 and FMD in 2001, the UK remains well short of being self-sufficient (78% in 2006). The use of sexed semen – female for dairy herd replacements and male for beef cross calves – would help to alleviate the shortage of UK beef production since the male beef cross calves would be more acceptable to UK beef finishers. There would be an implication for breeding of beef cross suckler cows but this is unlikely to be an issue since market forces would operate and some farmers would continue to use a beef bull on their dairy heifers and some cows.

4.2 The outlook

UK beef production may have already peaked. The MLC predicts that domestic production will ease back to 880,000t in 2008 mainly because of a reduced number of cows killed. Although consumption is also forecast to ease back, extra imports will be drawn in to meet the shortfall. The likelihood is that UK beef production may contract further over the medium term. Indeed, the European Commission predicts that beef production across the whole EU is set to contract through to 2014 at least. Two factors explain the gloomy outlook for both the UK and EU.

- Decoupling of headage payments: Farm support is no longer linked to beef production in most of the UK (a small beef calf premium does remain in Scotland). The loss of the Beef Special Premium has particularly hit the economics of producing Holstein bull beef. Those processors that specialised in the slaughter of young bulls had noted a large drop in numbers even before the big rise in feed costs (milk powder and cereals) earlier this year. BCMS data show that the UK beef herd has also contracted over the past couple of years. Again, the loss of the Suckler Cow Premium and Extensification Premium probably explains the easing back in cow numbers. In the short term, the downsizing of the national suckler herd has temporarily boosted domestic beef production as an increased proportion of heifers are slaughtered rather than retained for breeding. Unless the price of suckler bred cattle markedly rises in the near future, or an alternative form of support is introduced (e.g.: suckler grazing for agri-environmental purposes), the UK suckler herd will decline further in the medium term.

- International competition: Increasing beef exports from South America are expected to fill the void left by declining home production. Since 1973, the UK beef market has been protected from cheap beef imports by border protection that now takes the form of tariffs. Despite these tariffs, South American imports of steak cuts have grown significantly in recent years. A further reduction in these tariffs (and/or a rise in import quotas) is expected to result from either a multi-lateral trade agreement (WTO) or a bilateral agreement between the EU and the key South American countries (so called Mercosur countries). Political concern about the inflationary consequences of expensive beef may explain why EU politicians will accept more imports from outwith the EU.

Until recently a third reason was given for an ongoing fall in UK (and EU) beef production – declining dairy cow numbers. But recent changes to the balance of global dairy commodity markets are cautioning some forecasters to review their predictions.

The reduction in the size of the UK (and EU-15) dairy herd is a well established trend caused by the ongoing rise in cow productivity (i.e.: yield) and a national milk quota. The EC estimates that the EU-15 dairy herd contracted by nearly 32% between 1990 and 2005.

But low milk prices have possibly accounted for much of the 12% reduction in the size of the UK dairy herd since 2002. For unlike most other EU-15 countries, the UK has failed to fill its milk quota in recent years. It is too early to judge whether the recent marked improvement in farmgate milk prices will stop, or even reverse, the long-term drop in national herd size. Anecdotal evidence suggests that some dairy farmers are considering expansion based on the assumption of milk prices stabilising near current levels. Given that the EC is expected to phase out milk quotas by 2015, UK dairy farmers will not be constrained by the cost of acquiring extra quota. The implications of a potential increase in the UK dairy herd are considered more fully in the next section.

Meanwhile the overall consumption of beef in the UK is expected to rise in future because of population growth. Per capita consumption of red meat has generally stabilised at just under 18kg after two decades of decline caused chiefly by strong competition from poultry meat. Steak cuts remain popular, but there has been a marked increase in the volume of beef consumed as mince offset by a fall in demand for roasting joints.

The direct substitutability of mince by chicken breast is a key factor limiting retailers' scope to lift the retail price of beef. In short, consumers tend to buy an alternative protein if the retail price of beef rises relative to these other sources. A further limitation on the scope to lift the general price of cattle is the increased polarisation of consumer purchases. Most beef is bought through supermarkets, which sell their fresh meat through three ranges; premium, standard and value. Sales through the standard range dominate but consumer research shows that growth is greatest in the premium and value ranges. Only the consumers of premium range beef would be expected to be price insensitive.

4.3 The opportunity for dairy beef

To summarise, the UK has a structural deficit in beef and this deficit is likely to increase in the medium term other things remaining equal. Of course, the latter condition need not apply. Producing more beef from the domestic suckler herd is unlikely because of the high cost of production. Suckler production systems will no doubt evolve in response to the tougher business environment, yet the best outcome is possibly one of limiting the decline rather than increasing suckler bred beef *per se*. The recent report[1] covering suckler production in Northern Ireland provides a good appreciation of the problems facing suckler producers.

The prospects of introducing changes in UK dairy systems to yield more beef are, by comparison, good. Traditionally, most of the beef produced in the UK was a by-product of the UK dairy industry. While a rise in the size of the national suckler herd in the past 20 years accounts for part of the decline in this contribution, most of the decline is related to changes in the national dairy herd. With a national milk quota, the ongoing rise in cow yields means fewer cows are needed. Unfortunately, the surplus Holstein bull calves are of much lower value for beef finishing than the traditional Friesian bull calves produced.

Prior to the BSE restrictions introduced in 1996, a large number of black-and-white bull calves were exported for veal production. After the export ban, many of these calves were diverted into domestic bull beef systems that were profitable due to headage support and generally low grain prices. However, in the subsequent years the declining quality of pure-bred bull calves resulted in a rising number of calves being shot at birth. The number shot rose with the decoupling of support, though the reopening of live calf exports provided a new market outlet and only the very worst pure-bred bull calves were shot. The reintroduction of the calf export ban caused by this summer's FMD outbreak, has resulted in a jump in the number of calves shot.

Neither live calf exports nor shooting calves are considered acceptable by a range of individuals and organisations including the Royal Society for Prevention of Cruelty to Animals (RSPCA) and Compassion in World Farming, hence the reason for this project. Yet, it is growing retailer fears about the outlook for beef supplies that may be the bigger motivator in developing the technology and systems for getting more beef from the UK dairy herd.

As explained in the previous section, the majority of fresh beef sold through the big retailers falls in their standard range, with only limited shares through the premium and value ranges. The premium ranges, including organic, will largely require beef from suckler bred systems. Dairy bull beef is very suitable for both the standard and (the growing) value ranges.

[1]Northern Ireland Red Meat Industry Task Force: Strategy Review (2007).

A blueprint for providing cattle for the standard and value ranges is already available. The Beef Calf Partnership is operated by Genus ABS and Blade Farming to supply dairy bred beef to Tesco and McDonald's via the processor Southern Counties Fresh Foods. Dairy farmers agree to use semen from selected beef bulls. The dairy farmer supplies a healthy young calf to Blade who place it with rearers before batching and movement to finisher units. The system is based on contracted prices and, as such, is more akin to the business models used in the poultry and pig industries. It is understood that Blade Farming has a general turnover of around 16,000 calves annually so has considerable experience with dairy beef systems.

Calf quality is absolutely critical for the success of such systems. In principle, sexed semen is attractive because it reduces the number of pure-bred dairy bull calves. The following analysis sets out the potential impact of using sexed semen on calf supply in the UK. In this scenario, sexed semen is used on dairy heifers. It is important to remember that for most dairy farmers, the prime objective is milk production.

The MLC estimates that 550,000 to 570,000 black-and-white bull calves were born in the UK in 2006. Based on a UK dairy herd of just under 2,000,000 head, that indicates only about 56% are bred to dairy breeds. This percentage is lower than the 66% benchmark traditionally considered necessary to keep the national dairy herd in a steady state. While cows from dispersal sales will no doubt be providing some of the replacements needed by continuing producers, more dairy semen will be required soon to provide heifer replacements simply to prevent a big drop in national herd size.

If dairy farmers want to expand herds in anticipation of milk prices stabilising at much better levels, a much higher proportion of the national herd will be bred to dairy sires. It is not unreasonable to budget on a dairy herd of 100 cows needing 40 live heifers a year to meet a steady state replacement rate of 30% and provide 5% or so for expansion. It is assumed that the balance of heifers will be lost through, for instance, infertility.

Using the conventional breeding approach, the implication is that at least 80% of dairy cattle will be mated to dairy bulls in the near term. Consequently, the number of low-quality pure-bred dairy bull calves could grow significantly in the next few years. Many of these animals would be shot assuming that their shape cannot be improved (by better bull selection) in the short term. Moreover, if the cost of milk powder and cereals remains high, a far higher proportion of these bull calves will be shot. Re-establishment of the live export marketing channel would probably both reduce the number of calves shot and reduce the number of calves retained in the UK for beef production.

Anecdotal evidence from dairy consultants strongly supports the view that most of the UK dairy herd is being mated to dairy bulls at present.

If, on the other hand, sexed semen is used on dairy heifers universally, some 60% of the UK dairy herd could be bred to beef bulls. The majority of these animals would be good enough for dairy beef systems that are more extensive in nature than the traditional pure-bred dairy bull systems. Such systems generally have a better image and are less sensitive to volatile cereal markets

However, the findings of this project suggest that uptake of sexed semen by dairy farmers will be limited until the technology allows much better conception rates and a wider choice of bulls. This issue may however only be a perception and hence it is crucial to have independently verified examples from dairy farmers using sexed semen. In terms of the UK beef industry, there is little to suggest any significant problems from a switch to sexed semen. On the contrary, the technology would keep beef farmers and processors in business and provide UK retailers with locally-produced beef of assured quality.

Economic assessment of the use of sexed semen on beef produced from the dairy herd

The economics of all beef production systems in the UK are generally very poor at present. Dairy based systems would typically be expected to be more competitive because the calf is a by-product of the dairy enterprise (i.e.: is not carrying the cost of its mother). However, the high cost of milk powder and cereals has significantly increased production costs for all dairy beef systems.

Costing for various systems are given in Appendices 1 and 2; input and output prices are very volatile at present and the gross margins are likely to be out of date within weeks. They therefore need to be recalculated using up to date prices on a regular basis. The gross margins/head are given in Table 4.2.

TABLE 4.2 Gross margins for various beef enterprises (Dec 2007)

Enterprise	GM £/HEAD
Rearing Holstein calf to 3 months	2
Rearing dairy cross calf to 3 months	2
Holstein bull finishing	-130
Holstein steer finishing	-163
Crossbred steer finishing	57
Crossbred heifer finishing	70

The gross margins in Table 4.2 can be linked with the two Scenarios given in Table 3.1. Using sexed semen (Scenario A) produced 14 male dairy calves and 51 crossbred calves. Scenario B produced 35 male dairy calves and 30 crossbred calves. The average gross margin/head is +£22 and -£41 for scenarios A and B respectively, assuming Holsteins are finished as bull beef. The use of sexed semen technology would have the double advantage of reducing the number of low value male dairy calves and increasing the number of more valuable beef cross calves for the beef industry.

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BEYOND CALF EXPORTS: THE EFFICACY, ECONOMICS & PRACTICALITIES OF SEXED SEMEN AS A WELFARE-FRIENDLY HERD REPLACEMENT TOOL IN THE DAIRY INDUSTRY

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