The 'Clean, Green and Ethical' Concept in Animal Production

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Summary

In response to changes in society and thus the marketplace, animal industries need to become 'clean, green and ethical' (CGE). To be 'clean', the industries need to minimise the use of drugs, chemicals and exogenous hormones. To be 'green', the industries need to minimise their impact on the environment. To be 'ethical', the industries need to avoid practices that compromise animal welfare. Importantly, CGE practices must apply to all participants in the supply chain, from producer to consumer. This paper presents our approach for CGE management of small ruminants on farms in Australia, a context that is directly relevant to the Uruguayan sheep industry because there are so many common aspects in livestock management in the two countries. The major topics are: 1) control of the timing of reproductive events by using socio-sexual signals (the 'male effect'); 2) 'focus feeding' – short periods of nutritional supplementation that are precisely designed for each event in the reproductive process; 3) 'nutritional pharmacology' – the possibility of using forages containing 'bioactive' compounds to improve health, efficiency and environmental impact; 4) maximizing offspring survival by a combination of management and nutrition; 5) genetic selection to improve reproductive efficiency and animal heath. These tools involve novel ways of manipulating the endogenous control systems of the animals and many of them can be applied to cattle production systems. Ultimately, CGE management can be cost-effective, increase productivity and, at the same time, greatly improve the image of meat and milk industries in society and the marketplace.

Key words: animal ethics, sustainable production, biostimulation, reproduction, nutrition

Resumen

El Concepto 'Limpio, Verde y Ético' en Producción Animal

En respuesta a los cambios en la sociedad y por lo tanto en el mercado, las industrias animales necesitan hacerse 'limpias, verdes y éticas' (LVE). Para ser 'limpias', las industrias necesitan minimizar el uso de drogas, químicos y hormonas exógenas. Para ser 'verdes', las industrias necesitan minimizar su impacto en el ambiente. Para ser 'éticas', las industrias necesitan evitar las prácticas que comprometen al bienestar animal. Es importante que las prácticas LVE apliquen a todos los participantes de la cadena industrial, desde los productores hasta los consumidores. Este artículo presenta nuestra aproximación al manejo LVE de pequeños rumiantes en establecimientos en Australia, un contexto que es directamente relevante para la industria ovina del Uruguay, dado que hay muchos aspectos comunes en el manejo de ganado entre los dos países. Los temas principales son: 1) control del momento de los eventos reproductivos usando señales socio-sexuales (el 'efecto macho'); 2) 'alimentación enfocado' – períodos cortos de suplementación nutricional que son diseñados específicamente para cada evento en el proceso reproductivo; 3) 'farmacología nutricional' – la posibilidad de usar forraje que contiene compuestos 'bioactivos' para mejorar la salud, la eficiencia y el impacto ambiental; 4) maximizando la supervivencia de las crías por una combinación de manejo y nutrición; 5) selección genética para mejorar la eficiencia reproductiva y la salud animal. Estas herramientas implican nuevas maneras de manipular el sistema endógeno de control de los animales y, muchos de los mismos pueden ser aplicados a sistemas de producción de ganado. Por último, el manejo LVE puede ser rentable, aumentar la productividad y, al mismo tiempo, mejorar enormemente la imagen de las industrias carniceras y lácteas en la sociedad y el mercado.

Palabras clave: ética animal, producción sustentable, bioestimulación, reprodución, nutrición

Introduction

In response to changes in society, and thus the marketplace, we have developed a vision for the future of our animal industries in which management practices are 'clean, green and ethical' (CGE):

Clean – reduced usage, if not elimination, of practices that depend on drugs, chemicals and exogenous hormones; despite the lack of scientific evidence in many cases, the market is a dominant force and often does not always follow logic or evidence;

Green – minimal damage to the environment, making the industry more sustainable for the long-term. On farms, the most important are ruminant production of greenhouse gases, production of animal waste, and excessive use of fertilisers to generate animal feeds. The need to minimise environmental impact also applies to the allied industries … those that participate in the processing of the products from the farm (eg, transport, abattoirs, milk factories);

Ethical – the obvious focus is the attitude of the industry to animal welfare, a major concern for all industries that are working in sophisticated markets where the consumers expect their products to be derived from animals that have been managed sympathetically. This can be a complex issue because a 'clean' image may involve avoiding the use of antibiotics, perhaps compromising animal welfare. In addition, ethical standards will vary among cultures. Finally, ethical judgement needs to be applied to more than animal management – it should include 'clean' and 'green' aspects of the transport, manufacturing and processing sectors. We need look no further than the milk melamine crisis in China to see the potential dangers.

In many countries, regulatory authorities have already imposed these conditions on producers, importers and exporters. This has been necessary to overcome resistance in the industry, yet 'clean, green and ethical' need not be difficult or costly. On the contrary, at farm level, CGE management can be developed from a better understanding of the animals and can improve productivity and profitability. Moreover, there is a strong positive aspect in the demand for CGE products from modern, high-priced markets in which consumers have discretionary spending power that widens profit margins.

In this paper, we present our approach for CGE management in small ruminants. We will focus on five possible strategies: 1) Control of the timing of reproductive events by using socio-sexual signals (the 'male effect') to induce synchronised ovulation in females; 2) 'Focus feeding' - short periods of nutritional supplementation that are precisely timed and specifically designed for each event in the reproductive process; 3) 'Nutritional pharmacology' – a term that reflects the possibility of using forages containing 'bioactive' compounds to improve rumen health and efficiency with environmental benefits through the reduction of methane emissions from ruminants; 4) Maximizing offspring survival by a combination of management and nutrition; 5) Genetic selection for fertility, fecundity, behaviour and health.

These tools involve novel ways of manipulating the endogenous control systems and production of animals, so the paper will begin with a short review of that topic. Our context may be Australian but is relevant to Uruguayan livestock industries because there are so many aspects in livestock management are common to the two countries. In addition, the CGE concept can be extended to other industries, such as beef cattle. This paper has been developed from others on the topic, particularly: Martin *et al.*, 2004; Martin and Kadokawa 2006; Scaramuzzi and Martin 2008; Martin *et al.*, 2009.

CGE Reproduction in Small Ruminants

The productivity and profitability of our meat and milk industries depend on reproductive performance. For over 100 years, we have been trying to improve reproductive output by developing exogenous hormone regimens, high-level reproductive technology and molecular genetics. We now have some remarkable and effective technologies, but they do not always impress modern consumers and they have little direct, short-term benefit for animal industries in extensive production systems (Martin, 1995; Martin *et al.*, 2004).

Our Approach

We concentrate on the natural control systems that have evolved in the animals so they can cope with environmental challenges and ensure reproductive success (Martin, 1995). Most important are inputs from the external environmental factors. At brain level, these external inputs ultimately converge with internal inputs and culminate in a final common pathway that controls the secretion of gonadotrophin-releasing hormone (GnRH; Fig. 1). Each input into the control of the reproductive system provides us with an opportunity for management.

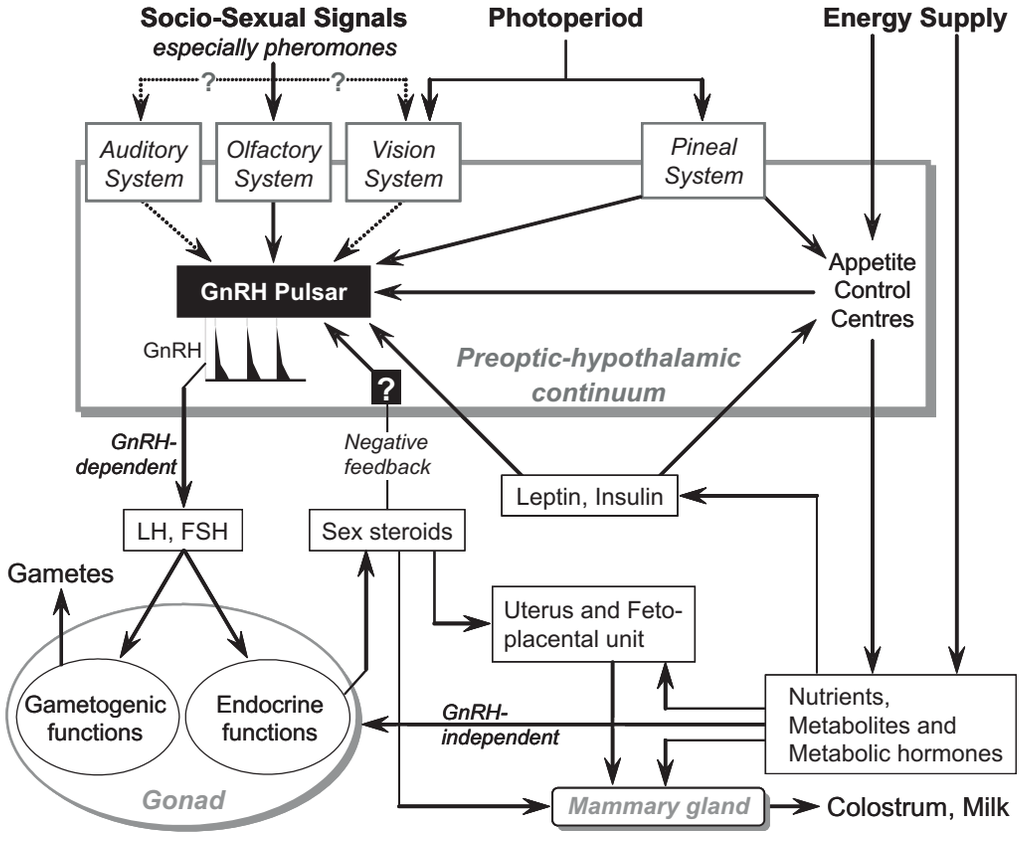


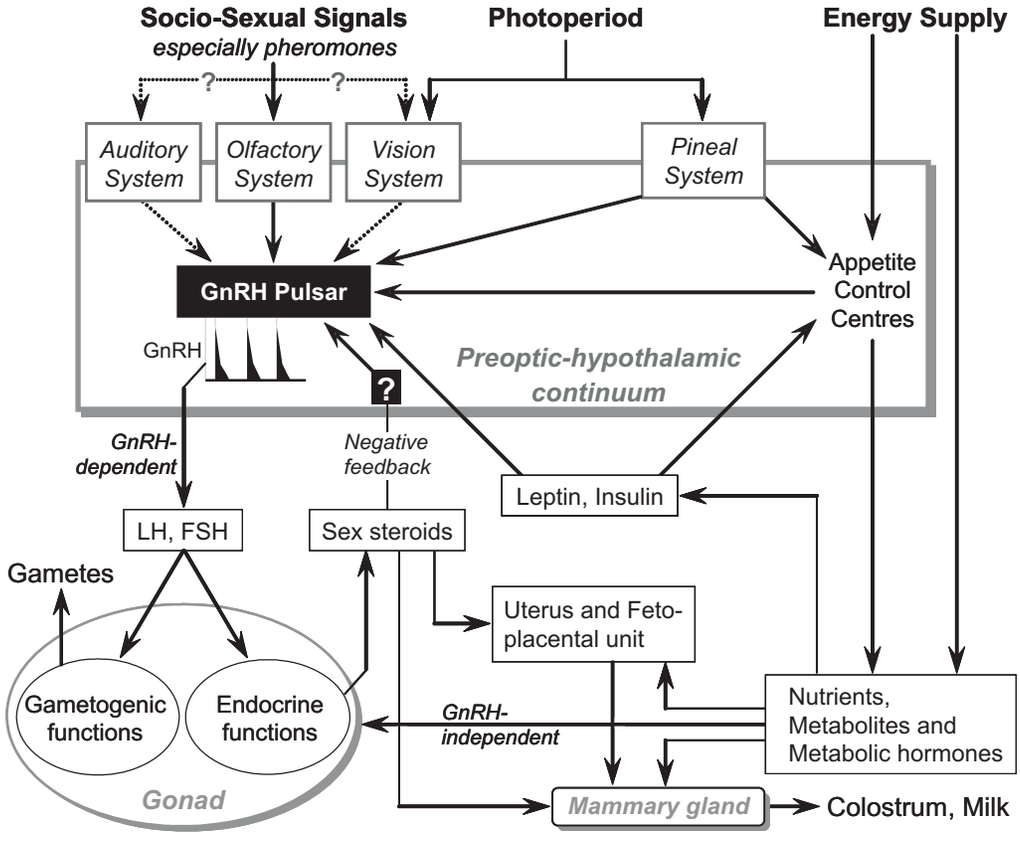
Figure 1. Environmental inputs into reproduction operate through a variety of pathways, many of which ultimately affect the «pulsar» (Martin, 1984) that controls the pulsatile secretion of GnRH. Socio-sexual signals are primarily pheromonal (Hawken *et al.*, 2009) and work through the main olfactory system (Delgadillo *et al.*, 2009). Nutritional signals are received at brain level via multiple pathways and affect a range of neural systems that affect the reproductive centres (Blache *et al.*, 2007), but there are also nutritional and metabolic inputs directly into reproductive tissues (Scaramuzzi and Martin, 2008).

1) Control of the timing of reproductive events

Three aspects of timing prevent the producers from deciding when their animals will conceive: puberty, seasonal breeding, and postpartum anoestrus. In all three situations, the lack of ovulation is due to lack of GnRH output, so exogenous hormones can be used very effectively to overcome the problem, but they raise issues of danger to human health ('clean') and pose risks with liberation of sex steroids into environment ('green') with, for example, the disposal of used intravaginal devices. Expense is also a problem because the treatments are too costly for extensive management systems. Finally, as we shall see below, control of timing is a major impediment for the implementation of 'focus feeding'. For these reasons, we need an efficient, non-pharmacological method for accurately controlling the timing of reproductive events.

a) The male effect

In sheep and goats, the sudden introduction of novel males can induce ovulation in females that are reproductively quiescent because they are pre-pubertal, out of season, or lactating (review: Ungerfeld, 2007). The male effect can therefore be used to advance puberty, overcome seasonal anoestrus and shorten post-partum anoestrus. Most importantly, the induced ovulations are sufficiently synchronised among a group of females to allow the use of strategies such as AI, focus



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feeding (see below) to improve litter size, fetal programming and neonatal survival. For cattle, there is also strong evidence of a male effect (review: Ungerfeld, 2007) but far more research is needed to explore its potential as a management tool.

b) Changing the night-length

This could be attractive for small producers because it requires a relatively small investment. There are limits for females because they would begin to cycle over a range of days or even weeks, and farmers with relatively large flocks do not have the facilities to control night lengths. It is a far more attractive proposition for treating males so that their reproductive axis is working at maximum efficiency when they are used for mating or for the male effect (Delgadillo *et al.*, 2002).

c) Ultrasound

Skilled operators with modern instruments can provide two important types of information (Viñoles *et al.*, 2009b). First, identification of single-bearing and multiple-bearing females allows the use of strategies to manage their specific requirements during pregnancy and after parturition. Second, accurate estimation of fetus age allows the use of precisely timed nutritional supplements during fetal development (see below). This is applicable to cattle as well as small ruminants.

2) Nutrition – the concept of 'Focus feeding'

For all animal enterprises, there is constant economic pressure to reduce the amount of feed used and then to ensure that the feed available provides the greatest benefit. With this in mind, we can focus on boosting sperm production, maximising potential litter size, programming offspring productivity, and maximizing postnatal survival and development (Fig. 2). For each period of focus feeding, we need to consider both the composition and duration of the diet so they are cost-effective for the various enterprises and environments. At any or all of these times, we could use conserved or stored feed or we could shift the entire reproductive process so that the critical periods are aligned with peaks and troughs in the availability of pasture.

a) Maximize sperm production

Feeding males a supplement for 8 weeks before mating will ensure maximum testicular size and sperm production (review: Martin and Walkden-Brown, 1995). An important issue here is the concept of «fit but not fat» – males that are overweight and do not get exercise can perform poorly, even when they have maximum testicular mass (Combrink and Schoeman, 1993).

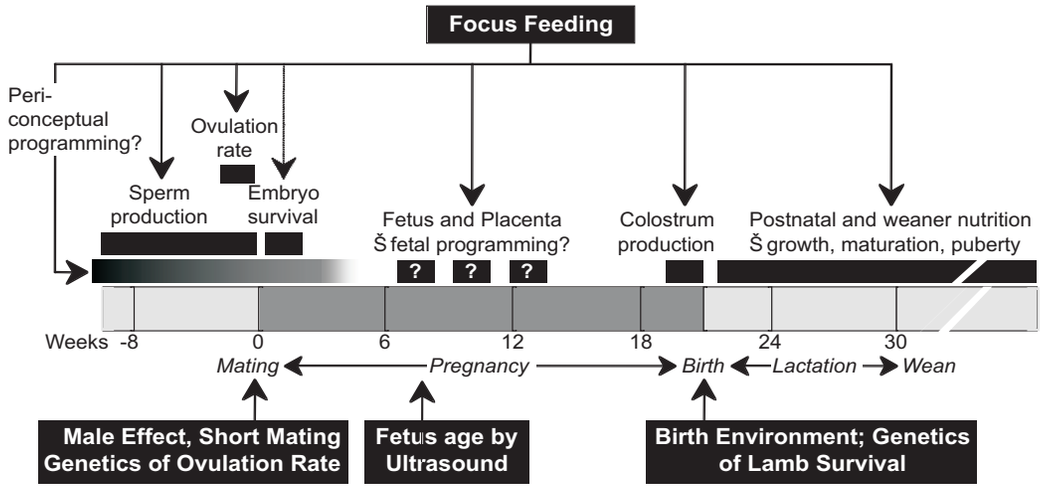

Figure 2. A 'CGE Package' for managing reproduction in sheep: periods of focus feeding are used to control the reproductive process, mostly to improve reproductive success. Mild undernutrition during the peri-conceptual period (15% loss of body mass) can cause premature births. To accurately time the periods of feeding, mating must be controlled and brief, or ultrasound must be used to classify the mothers based on the age of their fetuses. Finally, the survival of the new-born must be maximised by a combination of good genetics and good management. Redrawn after Martin *et al.*, 2004.

b) Maximize potential litter size (ovulation rate)

The upper limit of prolificacy, and thus productivity, is determined by the ovulation rate. For small ruminants, the upper limit is determined genetically and so can be improved through selection, but the expression of that genetic potential is greatly influenced by the nutritional regime before mating (review: Scaramuzzi and Martin, 2008). This is evident from the correlations between body condition and litter size but, more importantly in the context of focussed feeding, there is also an acute effect – feeding a supplement for as little as 4 days in the final stages of the oestrous cycle will increase the frequency of twin ovulations by 20-30% (Viñoles *et al.*, 2005; 2009a). The same can be achieved using high-quality pasture (Viñoles *et al.*, 2009a). In cattle, ovulation rate is a difficult problem and nutrition and genetics have very little influence.

c) Fetal programming – the future productivity of the offspring

At least three aspects of sheep production are known to be affected by the nutrition of the mother during fetal life (review: Martin *et al.*, 2004): i) initiation and development of secondary follicles in the skin; ii) muscle fibre formation; iii) development of the reproductive axis.

d) Colostrum production and survival of the new-born

An energy supplement given in the last week of gestation can more than double the amount of colostrum available to lambs at birth (review: Banchero *et al.*, 2006). In addition to the nutritional and immunological benefits, colostrum in the gut improves the lamb's ability to recognise its mother, thus contributing to the establishment of the ewe-lamb bond (Goursaud and Nowak, 1999). The outcome is better neonatal survival (Goodwin and Norton, 2004).

3) 'Nutritional pharmacology'

For a ewe, there is little strategic sense in responding to an acute, finely-timed supplement (eg, 500 g lupin grain daily for 3 days during the final 3-6 days of the late luteal phase) by doubling her fecundity with all the risks that are incurred 5 months later. It is difficult to imagine that this is a normal biological response developed during evolution. It therefore seems likely that this type of supplement 'deceives' the reproductive control systems so that they respond in the same way as they would to a sustained period of good nutrition leading to heavy body reserves. This has led us to the concept of 'nutritional pharmacology' (Martin *et al.*, 2008). We have since developed a second aspect to the topic (see below) based on the possibilities of bioactive compounds in forage that might improve health and productivity.

a) Energy supplements and 'down time' in reproduction

There needs to be a drive to advance the first conception. In addition to increasing the rate of genetic gain by reducing generation interval, early conception will reduce overall methane emissions because females that do not breed continue to produce methane, increasing greenhouse gas production per unit of meat or milk. This magnifies the consequences of delayed puberty and first conception, extended postpartum anoestrus, and offspring mortality. It requires research, development and adoption to overcome farmer scepticism (Kenyon *et al.*, 2004) on factors that delay puberty and cause low fertility in young animals. It is possible that a combination of 'focus feeding' and the 'male effect' is the way forward.

b) Bioactive compounds in forage plants

Some forage plants add value because they provide 'bioactive' substances in addition to energy and protein. The rumen and its microbial community are a key focus of our attention because rumen fermentation is associated with many inefficiencies and production losses, such as methane production and microbial digestion of valuable dietary protein. Moreover, some gut microbes are associated with enteric diseases and rumen disorders such as lactic acidosis and bloat. Antibiotics have been used widely in farm animals because they can control the microbes responsible for these inefficiencies, diseases and disorders, and they act as growth promoters. This practice has already been banned in Europe. Alternative plants, mainly perennial shrubs, are being investigated for their potential to improve rumen function and gut health, reduce methane production, inhibit helminths, reduce ruminal biohydrogenation and lactic acidosis (see Martin *et al.*, 2009).

4) Maximizing offspring survival

A major issue in reproductive efficiency is mother–young interactions, particularly in sheep, because of the very high rates of lamb mortality that were typical for the Australian Merino, with the obvious consequences for economics, genetics and ethics. There is little doubt that, in the future, it will be seen as unethical to promote high birth rates if our management systems cannot

ensure that the new-born can survive and prosper. The use of 'focus feeding' to improve colostrum production has been described above. There is also a great need for better management practices at the time of birth – we need to provide a calm environment, and shelter, feed and water close to the birth site. This will increase the amount of time the mother spends at the birth site and therefore improve the development of the mother-young bond (Nowak, 1996).

5) Genetic selection for fertility, fecundity, behaviour and health

For the past 15 years, we have used genetic selection for temperament to produce two experimental lines: 'calm' and 'nervous'. Early on, this project suggested that calm ewes are better mothers than nervous ewes (Murphy *et al.*, 1994). There is also scope for selection of lamb survival as a trait itself as means of reducing neonatal mortality (see Sawalha *et al.*, 2007). The temperament project extends to other stress-affected aspects of the production process: reproduction, growth rate, immune function, milk yield, meat quality. In all of areas, better temperament is expected to improve productivity while giving our industries an ethical quality (D. Blache, Pers. Comm. 2009).

Because of increasing resistance of parasites to pharmacological treatments, there is also interest in developing parasite-resistant sheep. For example, selection for the resistance to gastro-intestinal nematodes has been quite successful (Karlsson and Greeff, 2006).

Conclusions

Understanding the reproductive responses of animals to environmental factors, such as nutrition, socio-sexual signals and stressors, can help us develop 'natural systems' as replacements for exogenous hormones and drugs for controlling and improving the productivity of our sheep and goats. In addition, we can easily genetically improve our animals (eg, ovulation rate, lamb survival, parasite resistance) to greatly improve many aspects of their productivity. The use of such CGE tools in the management of our animals can be cost-effective and improve profits, at the same time greatly improving the image of our industries in society and the marketplace. All we need is a little more research and development.

References

Banchero, G.E.; Perez Clariget, R.; Bencini, R.; Lindsay, D.R.; Milton, J.T.B. and Martin, G.B. 2006. Endocrine and metabolic factors involved in the effect of nutrition on the production of colostrum in female sheep. Reprod. Nutr. Develop. 46: 447-460.

Blache, D.; Chagas, L.M. and Martin, G.B. 2007. Nutritional inputs into the reproductive neuroendocrine control system – a multidimensional perspective. In: Reproduction in Domestic Ruminants VI. Edited by Juengel, J.I., Murray, J.F. and Smith, M.F. Nottingham University Press, Nottingham, UK. pp. 123-139.

Combrink, G.C. and Schoeman, S.J. 1993. The influence of exercising rams on the lambing performance of a Merino flock. S. Afr. J. Anim. Sci. 23: 24-5.

Delgadillo, J.A.; Flores, J.A.; Véliz, F.G.; Hernández, H.F.; Duarte, G.; Vielma, J.; Poindron, P., Chemineau, P. and Malpaux, B. 2002. Induction of sexual activity of lactating anovulatory female goats using male goats treated only with artificial long days. J. Anim. Sci. 80: 2780-6.

Delgadillo, J.A.; Gelez, H.; Ungerfeld, R.; Hawken, P.A.R. and Martin, G.B. 2009. The 'male effect' in sheep and goats – revisiting the dogmas. Behav. Brain Res. 200, 304-314.

Goodwin, N. and Norton, B.W. 2004. Improving doe nutrition immediately prior to kidding increases kid survival. Anim. Prod. Aust. 25: 233.

Goursaud, A.P. and Nowak, R. 1999. Colostrum mediates the development of mother preference by the new born lamb. Physiol. Behav. 67: 49-56.

Hawken, P.A.R.; Esmaili, T.; Scanlan, V.; Blache, D. and Martin, G.B. 2009. Can audio-visual or visual stimuli from a prospective mate stimulate a reproductive neuroendocrine response in sheep? Animal 3: 690-696.

Karlsson, L.J.E. and Greeff, J.C. 2006. Selection response in faecal worm egg count in the Rylington Merino worm resistant flock. Aust. J. Exp. Agric. 46: 809-811.

Kenyon, P.R.; Morris, S.T.; Perkins, N.R. and West, D.M. 2004. Hogget mating use in New Zealand - a survey. Proc. N.Z. Soc. Anim. Prod. 64: 217–222.

Martin, G.B. 1984. Factors affecting the secretion of luteinizing hormone in the ewe. Biol. Rev. 59: 1-87.

Martin, G.B. 1995. Reproductive research on farm animals for Australia – some long-distance goals. Reprod. Fertil. Dev. 7: 967-82.

Martin, G.B. and Walkden-Brown, S.W. 1995. Nutritional influences on reproduction in mature male sheep and goats. J. Reprod. Fertil. Suppl. 49: 437-449.

Martin, G.B.; Milton, J.T.B.; Davidson, R.H.; Banchero Hunzicker, G.E.; Lindsay, D.R. and Blache, D. 2004. Natural methods of increasing reproductive efficiency in sheep and goats. Anim. Reprod. Sci. 82-83: 231-46.

Martin, G.B. and Kadokawa, H. 2006. «Clean, green and ethical» animal production. Case study: reproductive efficiency in small ruminants. J. Reprod. Develop. 52: 145-152.

Martin, G.B.; Blache, D. and Williams, I.H. 2008. Chapter 10: The costs of reproduction. In: Resource allocation theory applied to farm animals. Edited by Rauw, W.M. CABI Publishing; Oxford, UK. pp. 169-191.

Martin, G.B.; Durmic, Z.; Kenyon, P.R. and Vercoe, P.E. 2009. Landcorp Farming Limited Lecture: 'Clean, green and ethical' animal reproduction: extension to sheep and dairy systems in New Zealand. Proc. N.Z. Soc. Anim. Prod. 69: 140-147.

Murphy, P.M.; Purvis, I.W.; Lindsay, D.R.; Le Neindre, P.; Orgeur, P. and Poindron, P. 1994. Measures of temperament are highly repeatable in Merino sheep and some are related to maternal behaviour. Anim. Prod. Aust. 20, 247-250.

Nowak, R. 1996. Neonatal survival: contributions from behavioural studies in sheep. Appl. Anim. Behav. Sci. 49, 61-72.

Sawalha, R.M.; Conington, J.; Brotherstone, S. and Villanueva, B. 2007. Analyses of lamb survival of Scottish Blackface sheep. Animal 1, 151-157.

Scaramuzzi, R.J. and Martin, G.B. 2008. The importance of interactions among nutrition, seasonality and socio-sexual factors in the development of hormone-free methods for controlling fertility. Reprod. Dom. Anim. 43 Suppl. 2, 129-136.

Ungerfeld, R. 2007. Socio-sexual signalling and gonadal function: Opportunities for reproductive management in domestic ruminants. In: Reproduction in Domestic Ruminants VI. Edited by Juengel, J.I., Murray, J.F. and Smith, M.F. Nottingham University Press, Nottingham, UK. pp. 207-221.

Viñoles, C.; Forsberg, M.; Martin, G.B.; Cajarville, C.; Repetto, J. and Meikle, A. 2005. Short-term nutritional supplementation of ewes in low body condition affects follicle development due to an increase in glucose and metabolic hormones. Reproduction 129, 299-309.

Viñoles, C.; Meikle, A. and Martin, G.B. 2009a. Short-term nutritional treatments grazing legumes or feeding concentrates increase prolificacy in Corriedale ewes. Anim. Reprod. Sci. 113, 82-92.

Viñoles, C.; Gonzalez-Bulnes, A.; Martin, G.B.; Sales, F. and Sale, S. 2009b. Chapter 11: Small Ruminants. In: Practical Atlas of Ruminant and Camelid Reproductive Ultrasonography. Edited by Des Côteaux, L., Gnemmi, G. and Colloto, J. Wiley-Blackwell, Ames, Iowa, USA. In press.