



Clean, Green, Ethical (CGE) Management: What Research Do We Really Need?

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Abstract

Industries based on small ruminants are major contributors to world food supply but, in many production systems, reproductive technology is not directly relevant. In addition, there is a general need to embrace the vision for products that are 'clean, green and ethical' (CGE). In the concept of CGE management, the environment of the animal is used to control reproduction rather than technological tools. Nutrition is the primary factor but, rather than feeding ruminants with potential human food, we need to focus on forages with occasional 'smart supplements'. This focus also opens up opportunities – new forages can supply energy and protein whilst improving animal health and welfare, and reducing carbon emissions.

Nutritional inputs must be accurately coordinated with reproductive events to ensure that the metabolic signals are appropriate to the stage of the reproductive process. To control the timing of reproduction, we begin with simply managing the presence of the male but then seek more precision through the greater use of ultrasound.

Finally, genetic improvement should be part of every industry strategy and it is critical in the long-term development of CGE management. Most aspects of CGE management have a strong genetic component, as evidenced by variation among genotypes, and among individuals within genotypes. For example, a combination of nutritional management with genetic improvement in the rate of muscle accumulation can accelerate sexual maturity, potentially leading to simultaneous improvements in meat production, reproductive efficiency and environmental footprint.

For each local situation, we need to introduce the various elements of the CGE package in stages, adapting the process to cover variations in genotype and in geographical and socio-economic environments. Some concepts might need further research and development for local conditions. Ultimately, CGE management is a simple and cost-effective way to improve productivity whilst safeguarding the future of the livestock industries.

Key words :

Background

A prevalent view is that ruminant industries cause rather than solve problems (FAO, 2006) but, to ensure the production of sufficient food for humanity, we need to consider all options, including industries based on ruminant animals (Eisler et al., 2014). The value of ruminants is that they can digest biomass that humans cannot digest and convert it into food that humans can digest. For this and several other reasons, ruminant production systems will be with us for the foreseeable future (Eisler et al., 2014).

Reproduction is obviously essential for milk and meat production, and livestock research has a long history of progress towards manipulation of the reproductive tract, gametes, embryos, and genes.

However, these technologies fail to directly two critical issues:

- i) Need for direct relevance: in Indonesia, most ruminants are managed by smallholders with insufficient resources to participate in complex and expensive technology; smallholders might be interested in genetic improvement but they see such technology as irrelevant for their enterprises, although they could perhaps cope with artificial insemination and ultrasound if it was provided as a service; the reality is that most such smallholders need simple, inexpensive and reliable management tools;
- ii) Need for market vision: there is increasing international pressure for animal products that are 'clean, green

and ethical', or 'CGE' (Martin et al., 2004). 'Clean' involves minimizing the use of chemical intervention (antibiotics, hormones, drugs); 'green' involves minimizing the impact on the environment, particularly the production of methane by rumen fermentation; and 'ethical' focuses on animal welfare. The CGE concept offers smallholders the possibility of marketing into high-price markets in a local context, thus increasing the value of their animal products and perhaps offering opportunities to escape the confines of subsistence farming.

This conference paper develops these two issues. It is based largely on previous publications (Martin and Greeff, 2011; Martin, 2014) but with a focus on relevance to Indonesian production systems.

The Need for Research

To develop fully the CGE concept, we need to continue to search for a deeper understanding of the basic reproductive physiology and behaviour of our livestock species because, in that knowledge, we will find ways to manipulate the environmental factors that affect the reproductive axis, and thus avoid dependency on expensive drugs and technology (Martin, 1995). Investigation of the endogenous systems that control reproduction will allow us to understand responses to internal physiological factors (eg, adiposity) and external environmental factors (eg, nutrition). There is no doubt that the endogenous control systems are complex and difficult to explore, especially if we need to consider interactions among the various environmental factors and genotypes, so we often have to rely on modeling (Blanc et al., 2001; Ferasyi et al., 2016). Nevertheless, we need this information if we are to develop strategies to control animals by manipulating their environment and to direct the power of genetics.

Moreover, most of the current knowledge on ruminant reproduction, published in international journals, has been

derived in the context of developed economies and with genotypes adapted to temperate climatic zones. This phenomenon has been labeled "temperate chauvinism" (Martin, 1995). It is thus important that the dogma in the literature is challenged in tropical and subtropical countries, with local genotypes in their local environment.

Nutrition

When we consider external environmental inputs, we are inevitably confronted with the central role of nutrition, the major limiting resource in all livestock production systems. Forage supplies are often difficult to control and supplements are relatively costly. It is in the interest of farmers to manage these inputs with the highest efficiency, although the issues can be complex (Martin et al., 2008) and can confuse farmers. Nutrition is the core environmental factor in reproduction and is therefore a key management tool, hence the operational term 'focus feeding' (Martin et al., 2004). The ruminant microbiome adapts to the types of feed ingested by the host, so we need to explore local sources of feed (forages, food waste, by-products) to look for locally relevant opportunities for 'focus feeding'.

Predictable timing of reproductive events

It is essential to coordinate nutritional inputs with stages in the reproductive process so that appropriate metabolic signals are used to manage the reproductive system. At the simplest level, farmers control timing by managing the presence of the male and thus the time of fertile mating.

Restrict the timing and duration of births

It is common for the males to be with the females for a very long period (sometimes throughout the year) so that the females have the 'maximum opportunity to conceive'. However, this is short-sighted because it prevents precision in the management of birth, postnatal development and marketing. In fact, the principle of maximizing opportunity to conceive is misguided because the actual gains are small and easily outweighed by the longer-term

benefits of a restricted mating period (Martin, 2014):

- i) Pressure on the genetics of female fertility – a 2-cycle mating period gives the females only two chances to conceive and uncovers any underlying infertility – females that fail this test should be culled;
- ii) Reduced neonatal mortality – a short, concentrated period of births allow intensive management of the birth environment to reduce neonatal mortality; as we shall see below, concentrated births are also compatible with ‘focus feeding’ to improve fecundity and increase the production of colostrum;
- iii) Increased value from ultrasound scanning – if conceptions are limited to one or two cycles, ultrasound scanning also becomes more cost-effective because it will allow accurate segregation of females into groups carrying zero, one or two fetuses; moreover, non-pregnant females can be culled immediately for profit and to improve flock fertility; the segregation of mothers carrying single and multiple fetuses is the first step towards precision management of the birth environment and towards ‘focus feeding’ for colostrum production.

To overcome the insecurity of a decision to restrict the duration of mating, data can be collected on flock fertility. Ultrasound provides these data but the simplest way is to use a harness with marking crayons on the males; changing the color every two weeks allows the detection of mating and thus females that come back into oestrus because they are not pregnant.

Feed males for fertility

Restricting the duration of mating also places pressure on the males, so they need to be managed correctly – adequate numbers, maximum mass of testis, good reproductive anatomy, healthy and fit. To maximize testis mass and therefore sperm production, rams and bucks need to be fed a supplement for 8 weeks before mating (review: Martin GB et

al., 2010). 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. In Indonesia, the options for male goats include katuk leaf powder and palm kernel meal (Ferasyi et al., 2015).

Flush for fecundity – Maximize potential litter size (ovulation rate)

Ovulation rate determines the upper limit of prolificacy, and thus productivity. Ovulation rate is under primary genetic control so it can be improved through selection, but the expression of that genetic potential is greatly influenced by the nutritional regime before mating, especially in sheep (review: Scaramuzzi et al., 2011). This is evident from the correlations between body condition and litter size but, more importantly in the context of ‘focus feeding’, there is also an acute effect – high-quality forages can increase the frequency of twin ovulations by 20-30% (Viñoles et al., 2009). In goats, the evidence for this response is inconclusive, so more research is needed with local genotypes and local forages.

Maximize neonatal survival

High rates of neonatal mortality have obvious consequences for profitability and genetic progress, and also carry a risk of market failure because the problem raises questions about the ethical credentials of the industry. Neonatal mortality is therefore integral to any plan to improve fecundity through genetic selection or ‘focus feeding’. The simplest approach is to better manage birth – provide a calm environment, and shelter, feed and water close to the birth site, allowing more time for the mother at the birth site and therefore better development of the mother-young bond (Nowak, 1996).

Ultrasound for pregnancy diagnosis and for number and age of fetuses

Ultrasound scanning for pregnancy diagnosis is now a routine procedure in small ruminants. Scanning to identify pregnant and no-pregnant females is the

simplest level, but even this information is valuable because it offers: a) an opportunity for re-mating if there has been a disaster; b) culling for improvement of fertility; and c) planning of conditions for birth. The next level of scanning provides the number and approximate age of the fetuses, giving a date for birth within a cycle length and, therefore, reliable options for ‘focus feeding’ during pregnancy and for the management of births (e.g., Gonzalez de Bulnes et al., 1998).

The equipment for ultrasound is expensive and the skills require long-term training, so the technology is beyond the reach of farmers. One possibility is for a veterinary faculty to offer the service for farmers in their region, with the added advantage that the people and machines can then be used for teaching and research.

‘Programming’ the future productivity of the offspring

In the near future, ‘focus feeding’ during pregnancy will be used for ‘fetal programming’ to improve sperm production, ovulation rate, milk production, initiation and development of wool follicles in the skin, muscle fiber formation (review: Martin et al., 2004). Evidence is now gathering that the early conceptus, and even the oocyte, can be ‘programmed’ (Bloomfield et al., 2003; Thompson, 2006; Hernandez et al., 2010; Fleming et al., 2012). To take advantage of this phenomenon, the farmers will need to know precisely the stage of fetal development in their pregnant females, adding value to the use of controlled mating and ultrasound.

Colostrum production and survival of the new-born

Colostrum has nutritional and immunological benefits and it improves the ability of the newborn to recognize its mother, thus contributing to the establishment of the mother-young bond (Goursaud and Nowak, 1999). ‘Focus feeding’ in the last week of gestation can double the amount of colostrum available at birth in sheep (review: Banchemo et al., 2015) and improve neonatal survival in goats (Goodwin and Norton 2004). The

value of ultrasound is again obvious – for animals in good body condition, feeding for colostrum can be limited to mothers predicted to have multiple births, thus avoiding the risk of dystocia caused by excessively large fetuses.

Early mating of young females (management of puberty)

Conservative farmers often delay the mating of young females until they are 18-24 months old. This is a complex problem, with a mix of sociological and biological causes and solutions:

- i) Sociological: a major driver of the decision to delay first mating in young females is the belief by farmers that mating young animals impairs their performance in subsequent years; research shows that this is not that case (Kenyon et al., 2004, 2011, 2014);
- ii) Biological: in young females, first conception is limited by nutrition and growth (live weight, condition score). It is important to focus on ensuring ovulation, conception and neo-natal survival, bringing us back to ‘focus feeding’, ultrasound, birth-site management;
- iii) Genetical: in young sheep, it has been shown that genetic selection can be used to increase growth rate and thus advance the onset of puberty, even if the extra growth is primarily muscle (Rosales et al., 2013ab, 2014). Basically, selecting animals for higher growth potential will positive outcomes for both reproductive efficiency and meat production.

If the females are well fed and their body condition is maintained, there is the potential to increase lifetime reproductive performance (Schoeman et al., 1995; Kenyon et al., 2014). Moreover, by gaining an extra year of production in a 6-year production life, successful early mating could lead to a 16% reduction in methane ‘emissions intensity’ (see below). However, it is important that animals are not culled because they have been handicapped by poor management.

A broader view of the value of nutrition

The concept of 'animal holidays'

A 'holiday' is a non-productive period – for livestock, such 'holidays' include delayed puberty (first conception), extended post-partum anoestrus, embryo mortality, and postnatal mortality. In all of these situations, the consequences are lost production (income to the farmer) and a reduction in the rate of genetic improvement (if the cause is management rather than poor genes). Moreover, non-reproducing females still produce methane, and therefore have a greater environmental impact because they increase 'emissions intensity (kg CH₄ per kg product; see Martin et al., 2009).

Functional nutrition

Most nutritional limitations on reproductive performance (including 'animal holidays') are caused by energy deficiency (Martin et al., 2008). However, we need also to consider the concept of 'nutritional pharmacology' or 'functional nutrition' (Martin et al., 2008, 2009) because, in addition to supplying energy, forage plants can be sources of 'bioactive' secondary compounds (Min et al., 2003; Makkar et al., 2007; Revell et al., 2008; Durmic and Blache, 2012) that can play two very important roles in animal management: a) direct reduction of methane emissions (Durmic et al. 2010; Martin C, et al. 2010); b) reduction in the use of drugs for controlling gastrointestinal helminthic nematodes, thus also alleviating the development of drug resistance, a major threat to industries based on grazing livestock (Kotze et al., 2009; Akkari et al., 2014). For the past 50 years, prevention and treatment of helminth infection has been managed with oral anthelmintic medication, but it is now clear most of these treatments have become ineffective because the helminth worms developed resistance (Besier et al., 2004).

In Indonesia, gastrointestinal nematode infection in sheep and goats is highly prevalent (Beriajaya, 2005), especially in animals raised in traditional farming

systems, and the costs of management deter the farmers from the use of available drugs. As a consequence, there is growing interest in medicinal plants with anthelmintic properties (Athallah, 1995; Razali et al., 2014). The goal of such research is to help the farmers running traditional farming systems to make use of the 'functional nutrition' provided by forage plants close to their farms.

The Genetic Frontiers

Reproductive performance

To date, much of our research has targeted the physiological, behavioural and managerial aspects of CGE management. Clearly, we also need to consider the role of genetics because, as can be seen from much of the above discussion, genotypic factors are a major restraint to the full implementation of the CGE package. Martin and Greeff (2011) outlined evidence of genetic variation (known breed differences or within-breed variation) and heritability for relevant traits, many of which are relevant to Indonesian livestock industries:

- a) Increasing fecundity – Basically, our aim should be to identify animals with the genetic potential to produce multiple ovulations, perhaps with the final outcome of single or twin births being decided by the farmer using focus feeding;
- b) Increasing fertility under the constraint of short mating period;
- c) Increasing colostrum production – There is variation among genotypes (eg, milk breeds versus meat and fibre breeds) in the quantity produced, and variation among individuals in the timing of production, leading to variation in the synchrony of parturition and colostrum supply;
- d) Enhancing mother-young bonding – Neonatal survival seems to vary among genotypes because of variation in the time taken by the mother to recognise its newborn, and the time taken by the newborn to recognise its mother.

Resilience to disease

It is possible to breed for resilience to helminth infestation (Smith et al., 2005; Kemper et al., 2010), but the phenotype is difficult to measure so penetration of the genetics into the national herd will be slow. Research is needed to identify the molecular and cellular components of the immune system so more efficient criteria can be used to select superior animals.

Conclusions

Rather than use exogenous hormones and drugs to control and improve the productivity of small ruminants, we can use the responses of animals to environmental factors, especially nutrition, because the energy it supplies affects most stages of the reproductive process. In addition, we now have forages that can be used to reduce emissions and improve health. The combination of this approach with genetic selection will lead to 'clean, green and ethical' systems for livestock management that are cost-effective and also improve productivity. All we need is a little more research and development in genetics, physiology, nutrition and behaviour, focused on genotypes and environmental conditions that are typical for Indonesia.

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