Appendix 8.1

Factors Affecting Growth in Goats: Review of Literature
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Appendix 8.1 - Factors Affecting Growth in Goats: Review of Literature
B.GOA.0109 Final Report - Trial design development to determine expected growth rates of young goats

Background

Farmed goats – called ‘bush goats’ by Holst et al. 1976 – are derived from the rangeland goats that are ubiquitous in the semi-arid scrublands across Australia. These rangeland herds originated as escapees from dairy herds and from Angora flocks disbanded around the turn of the 20th century (Mason 1981). Holst et al. (1976) refer also to deliberate releases by railway gangs, possibly to ensure a future supply of meat, a motivation for release of goats on some islands and in other coastal locations by explorers.

Rangeland goats have been harvested in Australia for export of meat since the early 1950s (Restall, 1982), either by conventional mustering or, increasingly, by use of trap yards or self-mustering facilities on watering points. The majority of goats sold from the Western Division of NSW are still opportunistically harvested rather than farmed commercially (Pople and Froese 2012).

It is, however, reasonably common for landholders to fence a portion of their property into a ‘goat paddock’ that may be used to hold small animals until they reach marketable weight, or to act as a depot for all harvested animals so that larger, more uniform lines can be selected for sale at a higher price and reduced cost per head (e.g. for transport). This represents an intermediate stage of development of the goat enterprise. The final stage of development - a farmed goat enterprise - usually involves retention of a selection of harvested rangeland does which are subject to commercial standards of management, including infusion of exotic breeds (e.g. the South African Boer goat) to improve productivity. The motivation for development of farmed goat enterprises, particularly for meat production, has been to take advantage of the capacity of goats to thrive in areas in which sheep and cattle perform poorly, to exploit their browsing habit to control or utilise invasive native scrub, and to reduce the labour requirements of conventional sheep enterprises under extensive conditions. Moreover, goat enterprises provide flexibility to adjust stocking rate depending on prevailing conditions at the time. Nevertheless, few pastoral businesses in Australia are currently based on only a goat enterprise.

Biological characteristics

Reproduction

The capacity of goats to rear their offspring under challenging tropical conditions where only the most hardy and adapted females are able to perform using a low or medium quality pasture has been identified as a key attribute in improving meat production in the tropics (Devendra and McLeroy 1982; Chemineau et al. 1983). The same capacity is highly relevant to the production and management of farmed goats in Australia. Wilson and Mulham (1980) recorded 120% kidding by rangeland does compared to 57% lambing of Merino ewes in a belah–rosewood community near Ivanhoe in western NSW although the live weight of kids was only 60% that of lambs at weaning and 1.5 years. Similar relativity between the reproductive performances of rangeland does and Merino ewes have been recorded in arid mulga shrublands in the arid winter rainfall zone of Western Australia (Fletcher, 1995). The highest kidding percentage recorded by Hacker et al. (2005) at ‘Laurelvale’ near Tilpa, NSW was 137% under good seasonal conditions, and a rate of 125% was recorded under poor seasonal conditions when stocking rate was appropriately adjusted. Atkinson et al. (2007) recorded kidding percentages of 141% and 135% from rangeland does mated to Boer bucks under ‘managed’ (small paddock) or ‘unmanaged’ (large
paddock) conditions, respectively, in the belah and bluebush country at ‘Bushley’ station near Wilcannia.

The breeding season of goats differ between breeds (Ricordeau 1981). Some such as the Maradi in Niger are sexually active throughout the year although the interval between kidding is nearly a year (Haumesser 1975). Others such as the Angora goat of South Africa have a short breeding season of 94 days between April and July (Pretorius 1973). The interval between kiddings also varies between breeds. Sengar (1976), for example, reported 92% of Jamnapari goats kidded once a year while 54% of the Black Bengal kidded twice a year. The reported length of gestation also varies, between 145 days for the Black Bengal (Ali et al. 1973) and 162 days for the Alpine of France (Ricordeau 1981).

The reproductive seasonality of rangeland does in Australia have not been determined although some observations suggest a peak of kidding in spring (C. Bright, pers. comm. 2011). Management of reproduction is difficult under these extensive conditions due to the incursion of rangeland bucks. Atkinson et al. (2007) found that of kids born to rangeland does under ‘managed’ (small paddock) and ‘unmanaged’ (large paddock) conditions in the Western Division 88% and 39% of kids, respectively, resulted for the Boer bucks joined with tested-empty rangeland does, even at a joining percentage (Boer bucks to rangeland does) of 5%.

**Growth**

Growth in meat animals is defined as an increase in tissue mass and energy availability is the main limiting factor (Lachica and Aguilera 2005). Growth rates along with reproductive efficiency and potential for genetic improvement are key factors to be considered in efficient meat production. The high reproductive performance of goats is however not matched by high growth rates (Naude and Hofmeyr 1981).

Average daily gain (ADG) is used to assess growth rates in most food animal species. Faster growth rates enable animals to achieve market weights in the shortest amount of time using the least amount of input/cost. In goats, as in most livestock species, cost-efficient (optimal) feed conversion and high average daily gain are the primary factors determining efficiency of production.

For Australian rangeland goats, the highest average daily gain reported in literature is 178 g/day (Eady and Rose 1988). McGregor (2005a) in a review of goat growth rates in Australia, reported growth rates of up to 1kg per week in weaned goats which is only 25-30% of the growth rate frequently recorded with lambs under high levels of nutrition. However, it is not clear whether the species were compared under the same conditions.

Goats have the capacity to perform better than other ruminants in harsh environments. This has been attributed to their smaller body size and higher utilisation of ingested nutrients (Silanikove 1997), low metabolic rates (Munn et al. 2012), ability to reduce metabolism (Silanikove 1997), efficient N economy (Muschet al., 2010), efficient use of water (Silanikove, 2000), and their ability to select a relatively high quality diet from the variety of forage available (Ramirez 1999). Goats in comparison to sheep have superior digestive efficiency on low quality feed (McGregor 1982).
The extent to which these traits enable them to maintain growth under poor seasonal conditions is highly relevant to their use as livestock in the Australian rangelands. Their growth rate is less sensitive to quality of diet than sheep and could produce marketable meat where others species struggle.

**Factors affecting growth rate**

**Breed**

Growth rate in goats is mainly dependent on adult size. Adult body weight varies considerably among goat breeds. The mature weight of large breed such as the European dairy breed and Boer goats can exceed 100 kg. Small tropical breeds’ mature weight can be as low as 9-13 kg. Australian rangeland goats have a mid-range mature weight of 45 to 80kg (McGregor, 2005a; Warmington and Kirton 1990). Generally, progeny from large goats have higher growth rates than those of smaller breeds (Dhanda *et al*. 2003). Growth rates vary from around 50 g per day for the small breeds (e.g. Indian Barbari and Indonesian Kambing) to over 200g/day for large breeds (Saanen, Alpine and Boer) (McGregor 1985).

One way of improving growth rates in Australian Rangeland goats may be to crossbreed with larger breeds that display superior growth characteristics. At ‘Winderie’ in Western Australia first cross Boer animals had heavier live weights at weaning than animals of rangeland origin (Eliot and Pearce 1998). First cross Boer goats reached the target sale weight of 35kg substantially earlier than rangeland-origin animals. Eady and Rose (1988) reported that the highest recorded average daily weight gain by growing Australian rangeland goats grazing pasture was 178 g while that of rangeland Anglo-Nubian cross was 225g.

While larger breeds grow faster and attain marketable weight earlier, they may not always be suited to the relatively harsh environmental conditions of the rangelands. Currently, in Australia, cross breeding rangeland goats for faster growth is limited by the lack of access to breeds with superior growth characteristics that are able to perform in rangeland environments. Another issue to consider is the impact of larger animals with a higher DSE rating on the environment.

**Birth Type**

Birth type has been shown to have a significant effect on birth weight and weaning weight with single births usually having higher birth weights than twins and twins having advantage over triplets (e.g. Das and Sendalo 1990). Single and twin born rangeland origin cashmere goats were shown to have significant differences in performance in the pastoral zone of south-west Queensland. Single born kids were significantly heavier at birth (mean 2.94 v 2.50 kg) and at 3 months of age (19.0 v 15.1 kg), and had higher daily weight gain (141 v 105 g/day) compared with twins (Eady and Rose1988). Pym *et al*. (1982) showed that rangeland goats’ birth weight was significantly affected by birth type where single, twin and triplets’ birth weights were 2.97 kg, 2.59 kg and 2.14 kg respectively.

Gebrelul et al. (1994) reported single born Alpine, Nubian and crossbred kids were heavier at weaning and grew faster in the pre-weaning period than multiple born kids. In Creole kids, daily weight gain (between 10 and 30 days of age) varied from 95 g for single kids to less than 70 g for twins (Alexandre *et al*. 1999).
The impact of birth type on growth rate may have limited commercial bearing. The higher growth rate of single born kids could be more than offset by the higher number of goats produced in multiple births. Furthermore there is no evidence the initial advantage will persist to maturity.

**Dam age**

Dam age and parity has been shown to influence the growth of progeny rangeland goats in Australia. Pym et al. (1982) reported early growth of kids born to maiden does was slow; however, any early weight disadvantage was overcome by 5 months of age (Table 1).

The relationship has also been demonstrated in other goat breeds. Inyangala et al. (1990) and Gebrelul et al. (1994) demonstrated that parity and dam age were significant sources of variation for growth rate of goats. Similarly, Ikwuegbu et al. (1995) showed that the rate of gain and body weight up to weaning was affected by dam age, parity and birth type in studies on African Dwarf goats under village conditions. Results of Osinowo et al. (1992) also showed that pre-weaning ADG was significantly affected by parity.

<table>
<thead>
<tr>
<th>Dam age</th>
<th>Birth Type</th>
<th>Rearing Type</th>
<th>Weaning wt (Kg)</th>
<th>ADG (g)</th>
<th>5 –mt wt (kg)</th>
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<td>150</td>
<td>26.1</td>
</tr>
</tbody>
</table>

Table 1: Effect of dam age and birth type on weaning weight, average daily growth (ADG) and 5 month weight (5-mth wt), in Australian Rangeland Goats (reproduced from Pym et al., 1982).

**Birth weight**

Growth during the first month is mainly dependent on the birth weight and weight gain during the first week (Morand-Fehr 1981). A growth rate study involving rangeland and Anglo-Nubians cross kids’ showed that those with the higher birth weights grew faster (Bajhau and Kennedy 1990). In this study, birth weight had an effect on growth that was more than twice the effect of milk consumption and more than ten times the effect of breed. Similarly Madibela et al. (2002), working on Tswana goats concluded that birth weight was positively correlated with growth rate.
Birth weight of kids varies with breeds and environmental conditions (Morand-Fehr, 1981). Greyling et al. (2004) indicated that birth weight of kids is not affected by nutrition but subsequent growth rate is significantly affected by the nutritional regime. However, Bajhau and Kennedy (1990) argued that maternal nutrition influenced the postpartum growth of rangeland kids.

Hence, birth weight appears to be an important factor influencing the crucial postpartum growth to weaning. It is currently unclear to what degree maternal nutrition can influence this relationship in rangeland goats. Investigation may have an impact on management recommendations for rangeland doe nutrition in late pregnancy.

**Age**

Young goats tend to grow faster than older goats. Generally, goats will grow slowly after weaning for several years until mature size is reach. Seasonal conditions heavily influence the actual growth pattern (McGregor 2005a). Pre-weaning growth of kids is invariably faster than post-weaning growth, even when adequate high-quality feed is available after weaning and weaning is gradual (Mavrogenis 1983). Weaning frequently coincides with a period where growth rates begin to decrease (between 3 and 4 month of age) (Morand-Fehr 1981). Dhanda et al. (1999) observed in kid goats a significant decrease in average daily gains as their age increased. In Australian Rangeland goat kids, high growth rates were observed in the pre-weaning period followed by post-weaning depression (Allan and Holst 1989).

**Sex/Castrates**

Pym et al. (1982) reported that the birth weight of Australian Rangeland Goats was significantly affected by sex and the difference was also significant at weaning (19.6 cf 16.5 kg) and at 5 months (28.6 cf 22.9). Eady and Rose (1988) showed significant differences in performance of male and female progeny of rangeland origin cashmere goats. Male kids were significantly heavier at birth (mean 2.74 v 2.54 kg) and 3 months of age (17.55 v 15.22 kg) compared with female kids. Male kids having a higher birth weight compared with female goats has also been reported in other breeds (Karua and Banda 1990; Osinowo et al. 1992). Sex has been shown to have a significant effect on weaning weight and pre-weaning ADG of Alpine, Nubian and crossbred single-born or multiple-born kids (Gebrelul et al.1994).

Allan and Holst (1989) compared the growth rates of intact male and female domesticated rangeland goats. Intact male and female liveweight gain ranged from about 150 g/day to 175 g/day and 135 to 145 g/day, respectively from 30 to 180 days of age. The liveweight observed in female kids was significantly less than males from birth to 180 days of age.
Ash and Norton (1984) fed male and female rangeland origin cashmere goats rations with different protein content. The males grew significantly faster compared with the females although, their intakes were similar indicating that males have a higher efficiency of feed utilisation and growth rate changed according to the level of protein in the ration. Male growth rate was 48% higher on the low protein ration; this difference was reduced to only 11% on the high protein ration. In Damascus goats, it has also been shown that male feed efficiency is greater than females and this difference is greatest at low protein intakes (Louca and Hancock 1977).

Male and female goats have been shown to have different dressing percentages. The difference between the sexes appears to vary according to slaughter weights (Allan and Holst, 1989; Saxena et al. 1974). Allan and Holst (1989) showed when slaughtered at 20kg liveweight, male kids had a lower carcase dressing percentage (44.4%) compared with females (46.3%). However, when kids were slaughtered at 26kg liveweight, males had the higher dressing percentage (45.3%) compared with females (43.6%).

Castration in farm animals is a management procedure used to reduce aggression and sexual activity, allow for ease of handling and improve meat quality. Allan and Holst (1989) found kids castrated at 29 days of age had growth rates that were intermediate between intact males and females (Figure 1).

Louca et al. (1977) has shown that intact Damascus male goats grew faster and use feed more efficiently than castrates until the age of about 9 months. From birth to 100 days of age, an intact male ADG was 18.2% greater than the castrated males. From 101 to 206 days, the ADG of intact males was only 10.4% higher than the castrated males. After reaching 9 months of age, the intact goats exhibited strong...
sexual activity and their growth ceased completely, while the castrated goats continued to grow.

Castration has been shown to reduce the magnitude of seasonal changes in body mass associated with annual cycles in voluntary feed intake exhibited by intact males. It has been suggested that intact bucks’ voluntary intake is directly limited by high testosterone concentrations during the breeding season and growth rate and testosterone concentration are negatively correlated (Walkden-Brown *et al.* 1997).

Male goats grow faster than females mainly due to their higher birth weight and ability to convert feed more efficiently. Intact males generally grow faster than castrated males until the onset of sexual maturity, when the advantage is reduced or lost. Knowing the age or weight when sexual maturity occurs and start having impact on growth rate might have important implication for the management and marketing of rangeland goats. Running males and females separately may also reduce the impact of male sexual activity on growth rate and could be investigated.

**Nutrition**

Nutrition is the most important environmental factor influencing growth both before and after birth. In Australia, fastest growth rates have generally been recorded in suckling kids; when grazing spring pastures and when highly digestible diets are provided (McGregor 2005a). Deprivation of energy is the most common nutritional impost on a growing animal and has the greatest implications for growth rate. The effects will generally be more severe and long-lasting the earlier the deficiency occurs (Widdowson and Lister 1991). Goats can lose live weight at rates of up to 1kg per week, due to poor nutrition (McGregor 2005a). Compensatory growth following a period of weight loss has been shown in Australian Cashmere and Angora goats. However, compensatory growth recorded in Australian goats has not occurred to the extent exhibited in cattle and sheep (McGregor 2005a).

The mean energy requirement for growth of Australian goats, derived from four experiments involving Angora, Cashmere and rangeland goats, was 39.8 kJ ME/g of growth and rations containing at least 10MJ ME/kg are therefore recommended for maximum growth of kids (McGregor 2005b). McGregor (1984) suggested that low energy intake was a major limitation to rapid growth rates, following studies that related rates of growth in Angora goats to their maintenance requirements.

Norton and Ash (1985) showed that cashmere (rangeland origin) does fed rations in the last month of pregnancy produced kids that were significantly (29%) heavier than other kids at weaning and (23%) at 10 months of age. The major determinate of this response was energy rather than protein.

McGregor (2005b) suggested that kids require 16% crude protein for maximum performance and diets with crude protein levels greater than this result in substantial losses of nitrogen caused by rumen degradation. Johnson and Rowe (1984) reported responses in growth rate to increasing levels of protein and for young growing goats (growing from 14 to 30 kg), the protein requirement was approximately 15% (on a dry matter basis). However, Norton (1982) cautioned that the variability in the Australian rangeland goat population, due to their broad genetic base may cause difficulty in precisely describing their nutritional requirements. Johnson and Rowe (1984) further reported liveweight gain was greater in wether weaners (progeny of unselected rangeland does and cashmere bucks) fed a diet
with supplementary protein compared to a basal diet with a similar concentration of metabolisable energy.

McGregor (1984b) showed that roughage intake influenced total feed intake and growth rate in 6 month old rangeland/angora kids. Chopped hay was supplemented at three levels (0, 13% of intake and \textit{ad libitum}) to a basal ration of grain. The 13% hay treatment increased total dry matter intake from 479 to 753 g/d and liveweight gain from 10 to 54 g/d. The goats fed \textit{ad libitum} hay consumed 26.9% of their diet as hay; this resulted in non-significant increases in total food intake and liveweight gain compared to the basal ration of grain.

\section*{Season}

Australian studies have noted a seasonal deterioration in goat growth rate unrelated to decline in pasture condition. Eliot and Pearce (1999) reported low growth rate from March through June/July, followed by a significant increase in growth rate from July to August in rangeland and rangeland x Boer goats. It was observed that feed was not limiting and the changes in growth rate did not correspond with rainfall events. Ash and Norton (1987a) also noted that low growth rates, in cashmere weaned goats grazing tropical pasture, could have possibly been associated with a seasonal decline in appetite.

Walkden-Brown \textit{et al.} (1994a) examined the influence of season and diet quality on the voluntary feed intake (VFI) and growth of three-year-old Cashmere bucks (unselected line of domesticated feral goats). VFI was greatest during spring and summer and lowest during autumn. The changes in VFI appeared circannual with high intakes during spring on two occasions during the 16 month long trial. Buck liveweight changed in a cycle similar to VFI, as liveweight was closely associated with digestible energy intake. Bucks lost weight throughout autumn and their maximum growth rates occurred between mid-winter and mid-spring. Liveweight peaked in mid to late summer and was lowest during late autumn or early winter. Bucks also exhibit a seasonal reproductive cycle, which peaks during autumn and early winter (Walkden-Brown \textit{et al.}1994b). Growth cycles were not driven by prevailing nutrition, but other factors, most likely photo period drive the response, mediated by both steroid dependent and independent mechanisms (Walkden-Brown \textit{et al.}1997).

Body mass and testicular size declined 15-20\% and 29\% over autumn, respectively (Walkden-Brown \textit{et al.} 1997a) when bucks were at pasture. This degree of seasonal change was higher than the decline (7.6\% and 7.8\% of their liveweight on low and high quality diets, respectively) recorded in housed bucks fed unrestricted fixed diets (Walken-Brown \textit{et al.} 1994). Walkden-brown \textit{et al.} (1997) suggested that the difference may be due to the increased energy costs at pasture and/or a compounding of the effects of seasonal change in feed quality and photoperiod.

Ash and Norton (1987) suggested the quality of feed on offer may need to be improved to compensate for the decrease in intake. However, Walkden-Brown \textit{et al.} (1994a) found that diet quality did not alter the magnitude of seasonal liveweight decline, although, diet quality did influence growth rates during the period of maximum growth (between mid-winter and mid-spring). At this time, bucks fed the high quality diet had superior growth rates compared with bucks fed low quality diets.

There is a need to quantify the impact of this phenomenon in young rangeland goats. It potentially has implication for enterprise management and marketing decisions.
The experiments will address this issue to some degree by monitoring growth rate with and without supplementation, which will allow for judgements about non-nutritional environmental effect.

**Weaning**

Growth rate can be effectively divided into two periods: pre-weaning and post-weaning ADG. A high pre-weaning ADG reflects the genetic potential of the growing animal and the mothering ability of the doe (Luginbuhl 1998). In production systems where kids are sold at weaning, pre-weaning ADG is an important production trait while post-weaning ADG becomes important where kids are sold as yearlings or as older animals.

Weaning is a critical phase of kid management and if not handled appropriately may cause severe weaning shock. Kids experience stress, growth retardation and even weight loss during weaning (Lu and Potchoiba 1988). Replacing milk with solid feed during weaning always causes a shock in young animals and the magnitude of this shock and the degree to which it impacts on growth depends on the age and/or weight of the kid (Morand-Fehr 1981; Economides 1986).

There is limited information on the impact of weaning age and weight on post-weaning performance of rangeland goats in rangeland production systems. However, studies in other breeds of goats have shown varying range of responses when age and weight of weaning are varied.

Teh et al. (1984) found weaning shock to be more severe for kids weaned at 4 and 6 weeks compared with kids weaned at 8 and 10 weeks of age. They further stated that kids weaned at 4 weeks showed stunted growth for three consecutive weeks while those weaned at 6 weeks were stunted for only two weeks before recovery and both exhibited similar weight gain after five months. Owen and DePaiva (1980) found body weight at 16 weeks was significantly higher in kids weaned at 8 and 10 weeks of age than those weaned at 4 and 6 weeks of age. However, Hoon et al. (2011) reported no difference in body weight between weaning and unweaned kids after 10 months. Moreover, they reported non-weaning had no adverse effect on the reproductive performance of does.

Age alone is not a sufficient criterion for weaning however. In fact, in many instances weight is a better indicator than age (Ndlovu and Simela 1996). Studies suggest that the liveweight rather than age at weaning is more related to the shock magnitude. Morand-Fehr (1981) reported that the impact of weaning on the growth of Alpine female kids can be reduced by allowing goats to reach a higher liveweight before weaning. Their study showed kids weaned at 7 and 8.5 kg resulted in ADG reduction of 120 g and 44 g respectively, while weaning kids at 10 kg had a negligible impact on growth. King (1991) reported that it can take up to five months before kids regain their weaning mass under South African natural 'Veld' conditions and early weaning may result in high mortality rate. Furthermore weaning by weight is considered as a low risk program because it prevents unhealthy or undernourished kids from being weaned too early. According to Ndlovu and Simela (1996) weaning can take place when birth weight is tripled, provided that the birth weight is near or greater than the average for the particular breed.

In addition to age and weight factors such as sex, breed of goats or physical form of diet can affect the outcome of weaning. Males may be more susceptible to weaning shock than females (Morand-Fehr 1981) and Nubian kids were more sensitive to
weaning shock than Alpine kids (Teh et al. 1984). The types and amounts of feed that young goats can eat is also affected by the physiological changes that a young goat's digestive system goes through with age. These changes affect the types and amounts of feed that young goats can eat, and thereby their nutritional requirements. Pre and post-weaning management should therefore be geared to minimise growth shock or setbacks during the adjustment periods.

**Water Quality**

McGregor (2004) reviewed water quality requirements for goats and suggested clear differences between breeds of goats in their ability to resist dehydration based on genetics and environmental history. Silanikove (1985) found that desert goats were more resistant to dehydration than temperate breeds and had lower water consumption, evaporative and urinary losses and suggested that the kidneys of desert goats have greater ability to reabsorb water. Dunson (1974) found that the relative kidney medullary thickness (RMT), largely responsible for higher water reabsorption, to be greater in rangeland goats than in sheep in Australia.

Studies showed that goats are accepting of saline water McGregor (2004). It is reported goats can drink saline water with levels up to 9,500 mg/l total dissolved solids (TDS) and maintain food intake. Goats can live on sea water and once adapted to saline water are able to tolerate higher levels of salt than sheep (Abou Hussien et al. 1994); although the time required for goats to adapt to saline water is unknown. However, the relationship between the growth of Australian goats and water salinity and production impact has not been investigated (McGregor 2004). Measuring water quality used by goats in Australia and relating results to productivity would positively contribute to goat management.

**Genetic improvement**

For the Australian rangeland goat, two main genetic approaches to improve meat production have been documented (Holst et al. 1982). The first approach is within-herd selection for improved growth rate to slaughter age. A heritability estimate of liveweight at five months of 0.35 (+/- 0.15), suggests a worthwhile response to selection for growth rate (Holst and Pym 1977). The adoption of within-herd selection for growth is limited by the necessity for accurate correction factors for age, birth and rearing type and dam age (Holst et al. 1982). The second genetic improvement option is crossbreeding with a breed that has a superior performance (Holst et al. 1982). Cross breeding, the mating of animals from two breeds that have complementary traits, is a good tool to enhance the offspring’s economic value (Dhanda 2001). Holst and Pym (1977) demonstrated growth rate gains can be achieved via crossbreeding. First cross Anglo Nubian x rangeland goats were 3kg heavier than their rangeland parents at five months of age. The progeny of the first cross animals joined to Anglo Nubians were 4kg heavier compared with rangeland goats. Mills et al. (2000) comparing rangeland x rangeland progeny and Boer x rangeland progeny, found that the Boer cross progeny were significantly heavier at birth (3.05 vs 2.51 kg) and from 1.5 to 16.5 months of age than rangeland kids. The Boer cross wether carcases were 15% heavier than the rangeland wethers. The results of the ‘Winderie’ trial described above also demonstrated the benefits of cross-breeding (Eliot and Pearce 1988).
In Australia, a limitation to the crossbreed approach is that the breeds possibly superior to the feral goat in growth and meat characteristics are few and may have characteristics undesirable in rangeland environments (Holst et al. 1982). Holst and Pym (1977) recommended any breeding objective to improve the genetic potential of rangeland goats as a meat goat breed should make sure to maintain their fecundity and to avoid dystocia. Generally although genetic progress is possible, care should be taken not to compromise other traits, such as the hardiness and suitability to arid and semi-arid environments of the rangeland goat, while making gains in growth rate.

**Diet selection**

Lemus and Brown (2008) present a useful generalised view of the diet preferences of the major livestock species (Fig. 2). While this representation highlights the predominance of browse in the diet of goats, findings reported by many authors (e.g. Squires 1980; Teague 1989; Bartolome et al. 1998; Ramirez 1999; Devendra and Burns 1983), also reflects considerable variation on this theme and points to goats as highly selective, or ‘fastidious’, grazers willing to accept a wide variety of forages.

Goats have a notable capacity to select a diet with the highest nutrient concentration (Alexandre and Mandonnet, 2005). Morand-Fehr (1981) noted that, whether on range, pasture or at the trough, goats seem to be very careful in choosing among plant species, varieties or morphological fractions and that, while selective feeding behaviour exists in other ruminants, it seems particularly well developed in goats. Lemus and Brown (2008) noted the capacity of goats to select plants when they are at their most nutritious stage. Merchant and Riach (1994), studying cashmere goats on sown pasture, observed that all classes of goats (females, castrates and kids) selected green leafy material of high digestibility. Wilson et al. (1975) found that in a rosewood-belah community in western NSW, the N content of the diet of goats was generally higher than those of sheep or cattle, while digestibility values were comparable among the species. In contrast, Squires (1980) found that sheep selected diets higher in both N and digestibility than either goats or cattle in poplar box woodland, also in western NSW, probably because they made better use of the short herbage layer that was present for much of the study while cattle, and particularly goats, consumed more browse.
Several authors have observed that goats are flexible grazers and continually adapt their grazing behaviour to changing herbage conditions (Teague 1989; Grünwaldt *et al.* 1994; McGregor 2010). More specifically, Dziba *et al.* (2003) observed that goats selected species that offered the highest rate of nutrient intake. This well-developed capacity for selective grazing is probably an important component of their ability to maintain body condition and production under a wider range of seasonal conditions than is feasible for sheep or cattle.

**Grazing management**

The biological characteristics of goats, and producer experience in the Western Division of NSW, indicate that some aspects of their grazing management will differ from that of traditional Merinos. A characteristic noted for goats is a tendency to walk shorter distances from water. This may be due to the greater diet selectivity of goats compared to Merinos. While rangeland goat herds move long distances, producers have observed that domesticated does, in the absence of bucks, tend to stay within relatively small area. Thus while the greater dietary selection available to goats has potential to reduce grazing pressure on some key species (Alemseged *et al.* unpub. data), under poor seasonal conditions the hardiness of goats will enable them to ‘hang on’ longer, and exert greater grazing pressure than Merinos unless stocking rate is reduced. These characteristics suggest that management of goats would benefit from smaller paddocks and/or more frequent access to water than traditionally used for Merinos. This would allow more efficient use of the landscape and to provide the flexibility to implement strategic pasture-spelling grazing practices.

Regardless of the species of livestock involved, sustainable grazing systems seek to maintain or, where necessary, improve the condition of rangeland resources. This implies at least the preservation or improvement of landscape function (*sensu* Ludwig *et al.* 1997) and the maintenance of biodiversity at landscape scales. Fundamental to the achievement of these objectives is the matching of forage demand to forage supply to ensure ‘safe’ utilisation levels of key species (Campbell and Hacker 2000).

Published estimates of the DSE rating of various goat classes, based on forage consumption (WADAF 2011), are given in Table 3. However, producers in the Western Division of New South Wales anecdotally considered that the appropriate ratings were considerably less that these figures. Entire males and breeding does were rated as only 1 DSE in open country and in shrubby country, where goats are normally run; they were rated as only 0.7 DSE due to their utilisation of browse. Moreover, Munn *et al.* (2012) indicated the level of daily energy use of goats was less than half that measured in domestic Merino sheep grazed at the same location and under comparable environmental conditions.
Table 3. Dry sheep equivalent for classes of goats (adapted from WADAF, 2011)

<table>
<thead>
<tr>
<th>Class</th>
<th>Dry Sheep Equivalents</th>
<th>Weight range (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 dry doe</td>
<td>0.75</td>
<td>30-40</td>
</tr>
<tr>
<td>1 breeding doe*</td>
<td>1.5</td>
<td>40-60</td>
</tr>
<tr>
<td>1 weaner</td>
<td>0.7</td>
<td>20-40</td>
</tr>
<tr>
<td>1 buck</td>
<td>1.5</td>
<td>60-80</td>
</tr>
</tbody>
</table>

* In a herd producing 150% kids

Although goats have the potential to impose heavy grazing pressure if mismanaged (Wilson et al. 1984), there is also considerable evidence of beneficial effects of well-managed goats on botanical composition of pastures (McGregor 2010). In temperate, high rainfall pastures they have been credited with promoting an increase in clover content (McGregor 2010) and their tendency to avoid legumes has also been noted by producers in the Western Division of NSW (Alemseged et al. unpub. data).

Reference


Appendix 8.1 - Factors Affecting Growth in Goats: Review of Literature

B.GOA.0109 Final Report - Trial design development to determine expected growth rates of young goats


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