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Current knowledge of the environmental influences on Australian cashmere production and quality

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Abstract
Goat fibre production is affected to a similar extent by genetic and environmental influences. Environmental influences include bio-geophysical factors (photoperiod, climate-herbage system and soil-plant trace nutrient composition), country of origin, nutrition factors (live weight, growth patterns) and management factors (farm, herd age and sex structure). Nutrition and management influences discussed include rate of stocking, energy nutrition, live weight change, parturition and management during shearing. The nutritional variation within and among years is the most important climatic factor influencing cashmere production, fibre diameter and fibre curvature (crimp). With productive cashmere goats, large responses to energy supplementation have been measured with optimum nutritional management. The effects and importance of management and hygiene during fibre harvesting (shearing) in producing quality fibre are emphasised.

1. Introduction
Cashmere fibre production is affected to a similar extent by genetic and environmental influences. As the heritabilities for most of the important production traits of cashmere goats are of the magnitude 0.2 to 0.4, most of the remaining variation (0.6 to 0.8) is caused by environmental factors along with the interaction of genetic and environmental influences. This review briefly summarises these important environmental influences and updates my most recent review of the subject (McGregor 1998) by including outcomes of recent research in Australia.

Bio-geophysical factors (photoperiod, climate-herbage system and soil-plant trace nutrient composition), nutrition factors and management factors are all important environmental influences upon cashmere production. Nutrition and management influences discussed include rate of stocking, supplementary feeding of energy and protein, live weight, parturition and management during shearing. Farm of origin and age of goat also influence cashmere production. This review discusses environmental influences on cashmere production primarily using examples from research in the Australian environment but many principles will be relevant in other production systems.

2. Bio-physical influences on cashmere fibre production
2.1. Photoperiod
The variation in day length between seasons affects the growth of cashmere (McDonald et al., 1987) with fibre growth being lowest in midwinter and highest in midsummer. Nagorcka (1979)
considered the photoperiod response in Merino sheep to be a modification of the “archaic pattern of shedding” seen in unimproved breeds such as Wiltshire Horn sheep and dairy goats and this comment is relevant to cashmere goats. The variation in day length (natural photoperiod) is related to latitude.

Cashmere typically grows from about midsummer when cashmere fibre growing secondary follicles become active until late autumn or early winter when follicle activity ceases (Holst et al., 1982, McDonald et al., 1987). Unlike Merino sheep or Angora goats, which have continuously growing commercial fibres, most cashmere goats grow their commercial fleece in only about half a year. However, cashmere breeders in many countries are selecting goats for increased production and continuously growing cashmere fibres and some Australian breeders have reported some success. For some Australian cashmere goats, shearing is necessary every six months in order to harvest cashmere with commercially acceptable length.

In Australian cashmere goats, it has been reported that cashmere growth rate declines linearly from summer to midwinter (McGregor, 1988, Klören et al., 1993). There are reports of cashmere goats which began growing their cashmere in late spring (McGregor, 1988, McGregor 1998) and of cashmere growth in late winter following the shearing of their entire fleece in midwinter (McGregor, 1988, Klören and Norton, 1993). McDonald and Hoey (1987) demonstrated that alternate exposure to continuous light and natural light for various cycles has the potential to increase cashmere production. Such a practice has significant logistical problems and is currently uneconomic in Australia.

2.2. Climate-herbage system

Because nutritional variation both within and among years is the most important environmental factor influencing wool growth of sheep (Black and Reis, 1979) experiments have been undertaken in Australia to assess the influence of nutrition on cashmere production. In Australia, the majority of farmed goat grazing occurs on grasslands, either improved or native, which exhibit very seasonal patterns of pasture growth (growing seasons commonly of 5 to 8 months). Mean annual rainfall in these regions called the “wheat-sheep zone” varies from 400 to 750 mm. Usually growing seasons extend from mid autumn to late spring although in northern parts of the wheat-sheep zone summer rainfall predominates. The hot summers and autumns are characterised by declining quantities and qualities of mature dead pasture residues. It has been known for many years that these pasture residues are deficient in both energy and nitrogen resulting in loss of live weight and declining fibre production of sheep grazing such pastures (Donald and Allden, 1959). Cashmere production in other countries occurs in neo-arctic regions, continental regions and desert regions where winters are very cold with snow and gales, while summers can be very hot and dry. In some Western countries, where cashmere production has been introduced, cashmere goats are grazed in temperate climatic conditions.

Figure 1 shows the typical pattern of live weight change of goats grazing annual pastures in the “wheat-sheep zone” near Melbourne, Victoria (37°54'S., mean annual rainfall 520 mm, McGregor 1998). In three successive years these animals experienced live weight loss during summer and
autumn for periods of 5, 7 and 4 months, resulting in loss of live weight equivalent to 14%, 21% and 20% of the previous maxima respectively. These periods of live weight loss are normal as there are no or few browse plants available as alternative feed sources. In this environment ad libitum nutrition usually occurs in spring for about 2 to 3 months, when cashmere growth does not occur on most goats. Maintenance of live weight is rarely observed. In some years a temperate pattern occurs with summer rainfall, but such rainfall is usually ineffectual in producing any or sustained pasture germination and growth. Small live weight gains are sometimes measured but any short term summer pasture growth is usually followed by wilting and a return to live weight loss as leached dry pasture residues remain.

2.3. Soil-plant trace nutrient composition

Deficiencies in trace mineral nutrition cause loss of production and health in fibre producing animals. With increasing research, formulation of mineral requirements for goats is becoming less of an extrapolation of sheep and cattle work (Haenlein, 1992). Effects of mineral deficiencies on fibre goats are known to be large in practice but the requirements have not been clearly established for maintenance or production. In the wheat-sheep and temperate environments of southern Australia deficiencies have been reported for Se, Cu, Co and I (McGregor, 1990). Kids born during late winter and spring in areas of high winter rainfall may exhibit goitre, lack of vigour and fleece development problems.

In any region where cashmere goats are produced, it is essential to maintain adequate trace mineral nutrition of the goats by overcoming any identified deficiencies by either nutritional management, such as applying trace mineral with other fertiliser for pasture, provision of specific nutritional supplements or provision of mineralised urea blocks, or by the direct treatment of all susceptible animals by injection or oral drenching of suitable medicines.

3. Country of cashmere origin

Raw cashmere from different countries of origin has different properties. Cashmere from China, Iran and Australia has different fibre diameter, crimp frequency, crimp form, fibre curvature and resistance to compression (softness) (McGregor 2000, 2003, 2004, 2007) Table 1 provides some regressions between these parameters indicating the size of responses.
For some origins, cashmere crimp form was primarily of uniplanar sinusoidal form (Australia, China), while for other origins the crimp form was primarily three dimensional helical form (Iran) (McGregor 2007) and may represent cashmere from different breeds of goat. If cashmere buyers rely on subjective appraisal of cashmere crimp (curvature) to determine cashmere fibre diameter, they will be misled by differences in the fibre crimp form and frequency differences between cashmere from different origins. Cashmere from origins with uniplanar crimp of low frequency (low fibre curvature) has lower resistance to compression and will be assessed as handling softer than both cashmere of similar crimp frequency but with three dimensional crimp, and cashmere with higher crimp frequency.

Table 1. Regression constants, correlation coefficient and probability (P) for relationships between cashmere fibre crimp frequency (crimps/cm) and cashmere fibre curvature (degree/mm) and origin of cashmere (from McGregor 2007)

<table>
<thead>
<tr>
<th>Dependant variate</th>
<th>Fitted parameters</th>
<th>Estimate</th>
<th>se</th>
<th>RSD</th>
<th>R</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crimp frequency</td>
<td>Constant (Origin reference Australia)</td>
<td>3.15</td>
<td>0.17</td>
<td>0.99</td>
<td>0.32</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Origin China</td>
<td>0.79</td>
<td>0.25</td>
<td></td>
<td></td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td></td>
<td>Origin Iran</td>
<td>0.67</td>
<td>0.29</td>
<td></td>
<td></td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Crimp frequency</td>
<td>Constant Fibre curvature</td>
<td>0.133</td>
<td>0.448</td>
<td>0.79</td>
<td>0.66</td>
<td>NS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0639</td>
<td>0.0082</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Fibre curvature</td>
<td>Constant (Origin reference Australia)</td>
<td>69.2</td>
<td>11.1</td>
<td>6.58</td>
<td>0.79</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Origin China</td>
<td>4.57</td>
<td>2.14</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Origin Iran</td>
<td>12.1</td>
<td>2.17</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>Crimp frequency</td>
<td>4.10</td>
<td>2.14</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
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<tr>
<td></td>
<td>Mean fibre diameter</td>
<td>-2.16</td>
<td>0.59</td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

4. Nutrition and management influences

4.1. Influence of rate of stocking on fibre production

The rate of stocking of pasture is the single most important management decision which influences the productivity and economic viability of fibre producing farms in Australia. The determination of the optimum rate of stocking is complex and depends on several different criteria which may conflict (Morley, 1981). These include maximum production per unit area or labour, stability of pasture, minimum stress on livestock, soil conservation, stock health and appearance of livestock. White and Morley (1977) estimated the optimum rate of stocking of wool producing sheep based on studies of either: i) profit maximisation over a number of years; or ii) risk avoidance, as indicated by the lowest gross margin or bank balance recorded over a long period. Their study indicated that the optimum rate of stocking was not very much less than that which gave the maximum profit.

Stocking rate experiments have been conducted throughout Australia with sheep and few are now being undertaken as the important issues have been clarified and the cost of conducting properly replicated stocking rate experiments is very high. There have been no properly replicated stocking rate experiments conducted in Australia with cashmere goats but one
replicated experiment with Angora goats has been completed in the “wheat-sheep zone” (McGregor 1985, 1987). As the grazing environment for this experiment was very similar to that provided to most cashmere goats in Australia, the findings are considered relevant to cashmere goat producers.

As the rate of stocking of Angora goats increased, the availability of pasture decreased, pasture composition changed, pasture structure changed and the exposure of the soil did not change. The effects of rate of stocking on mohair fibre characterises were large and commercially significant. The effects of grazing Angora goats with Merino sheep were also studied. The intake and diet selection of Angora goats was different to that of Merino sheep (Gurung et al., 1994). Increasing rate of stocking when Angora goats grazed with Merino sheep produced complementary effects at moderate levels of stocking, when Merino sheep were more productive than sheep grazed alone at the same rate of stocking, or produced competitive effects at higher rates of stocking, where sheep were more productive but goats less productive compared to sheep or to goats grazed alone at similar high rates of stocking.

The limiting factor in these grazing studies was the effect of increasing the rate of stocking on the rate of mortality and the level of gastrointestinal parasitism in Angora goats. At higher rates of stocking the mortality of Angora goats from post shearing hypothermia was twice that of lower rates of stocking (McGregor and Butler 2008). Angora goats ingested more infective trichostrongyloid larvae than did sheep (Jallow et al., 1994). The heavier trichostrongyloid burdens of goats compared with sheep, when grazed together, are due in part to greater rates of infection consequent on different grazing patterns as well as greater susceptibility to infection.

The research concluded that mohair producers need to graze Angoras at rates of stocking no greater than that recommended for sheep and to minimise both gastrointestinal parasitism and post shearing weather stress, rate of stocking should be no higher than 7.5 dry sheep equivalents/ha (a dry sheep equivalent being the feed required to maintain a 45 kg castrated sheep).

4.2. Influence of energy nutrition on cashmere growth and fibre diameter

The impact of nutrition on cashmere growth has been covered in detail elsewhere in this conference (McGregor 2008). Briefly, in appropriately designed larger experiments, nutritional manipulation significantly affected cashmere production and quality. Three experiments conducted over five entire cashmere growing seasons (November to July) have clearly indicated benefits in cashmere production ranging from 11 to 15%, 67% and 88% (McGregor 1988, 1992, McGregor and Umar 2000). This research showed that goats which had small live weight gains during summer achieved near maximal levels of cashmere growth. If goats grazed pastures that enabled live weight gain over summer, there was no benefit from the provision of supplementary feed. However if goats consumed poor quality dry summer pasture deficient in protein and energy cashmere growth and fibre diameter were increased by the provision of energy supplements, type of supplementary feed and level of feeding of supplementary feed.

4.3 Influence of nutrition on cashmere fibre crimp and curvature

In Australian goats, cashmere fibre crimp (curvature) is dependent on nutrition of the goat (McGregor 2003). Goats fed to lose weight grow cashmere with significantly increased fibre curvature compared with goats fed to gain weight (61 vs 47 °/mm) but total fibre curvature
(fibre curvature x fibre length) was not affected by nutrition treatment (McGregor 2003). The responses of six different treatment groups are illustrated in Figure 2.

Figure 2. The relationships between clean cashmere production, cashmere fibre length (FL), cashmere mean fibre diameter (MFD) and cashmere fibre curvature in Australian cashmere goats. Data points are means for different nutrition treatments (from McGregor 2003)

Fibre curvature in cashmere is clearly associated with mean fibre diameter and cashmere fibre length. Practices that alter live weight, cashmere production, mean fibre diameter and fibre length have the potential to significantly alter cashmere fibre curvature. Changes in cashmere fibre curvature are relative to the starting point. Goats that lost weight grew cashmere with significantly increased fibre curvature compared with goats fed to gain weight. Conversely, goats fed to gain weight grew cashmere with significantly lower cashmere fibre curvature than goats fed to lose weight.

These results showed that cashmere fibre crimping is a function of time and not of fibre length, so that the wavelength varies along the fibre according to the rate of growth.

4.4. Affects of farm, age of goat and sex

Farm of origin and age of goat have commercially significant affects on cashmere production and fleece attributes in Australian (McGregor and Butler 2008b). The differences between
farms for clean cashmere weight, mean fibre diameter, cashmere staple length and other attributes of cashmere were much larger than the effects of age and sex (e.g. Figure 3). Farm and age accounted for 42 to 67% of the variation in clean cashmere production, mean fibre diameter, fibre curvature, staple length and clean washing yield. Sex of the goats had only a minor effect on the staple length of cashmere. The response to age of clean cashmere weight, mean fibre diameter and the inverse of fibre curvature are very similar. Generally cashmere production and mean fibre diameter increased with age. There were large differences in cashmere staple length from different farms with means ranging from 7 to 12 cm. Between 1 and 2 years of age the staple length of cashmere demonstrated a constant proportional increase. At ages older than 2 years, staple length either declined or increased by less than 1 cm with age depending on the farm of origin. This study demonstrates that a better understanding of on-farm factors that influence cashmere production would enable all producers to optimise their production systems.

Figure 3. The influence of age and farm on predicted cashmere mean fibre diameter. Individual symbols represent backtransformed means of farm X age combinations. Lines represent different farms (from McGregor and Butler 2008b).

In a study using raw Liaoning cashmere, there was a significant difference between each age and sex group in cashmere fibre curvature (bucks 52; does 65; kid bucks 78°/mm, McGregor et al. 1991, McGregor 2003). The finer and shorter Liaoning cashmere, grown by light weight lactating adult does and light weight kid bucks, had significantly greater fibre curvature than the coarser and longer cashmere grown by the relatively well fed heavier bucks.

4.5. Live weight manipulation
In a study over 3 years, three live weight measurements (mean live weight, the gain in live weight and the loss of live weight during the cashmere growing period), together accounted for 77% of the variation in cashmere growth of cashmere goats grazing annual temperate pastures (McGregor, 1992). Cashmere production for groups of goats was on average, greatest in the heaviest goats who gained live weight and least in the lightest goats that lost live weight. These increases in cashmere production were associated with increases in cashmere fibre diameter.
These data illustrate principles applicable to the management of flocks of grazing cashmere goats. McGregor and Umar (2000) also reported an association between the weight of cashmere produced and the change in live weight achieved during a nine-week period when goats were fed a basal diet of forage deficient in energy and protein. Supplementary feeding various types and amounts of grain resulted in an additional 13.6 g of cashmere being grown for every 1 g/d increase in live weight, accounting for 72% of the variation in cashmere production. The length:diameter ratio of cashmere grown during the entire growing period was increased by supplementary feeding, grain type and feeding level and increased linearly as feeding level and live weight change increased, accounting for 80% of the variation in the length:diameter ratio.

In these studies the increase in cashmere growth has been in part due to increases in cashmere fibre diameter and potential changes in other cashmere attributes such as staple length that were not measured. The separate effects of a range of cashmere parameters on cashmere production has been recently quantified with Australian cashmere goats monitored on 11 farms (McGregor and Butler 2008c). Once variations due to farm, cashmere mean fibre diameter and other attributes were accounted for neither age or sex were statistically significant, indicating that fleece metrics and live weight were the drivers in affecting cashmere production. The outcome was that a 10 kg increase in the live weight of a cashmere goat at the start of the cashmere growing season resulted in a 5% increase in clean cashmere weight. Thus the impact of increasing live weight from 20 to 50 kg on cashmere production would be an increase in cashmere production of 15% excluding any impact of increasing fibre diameter. This implies that there are some animal size effects on cashmere production that are not mediated through fleece metrics or recent patterns of live weight change. The range in effect of a 5 kg increase in live weight during the cashmere growing season on clean cashmere production differed from about -10% to about +10%, depending on farm. These responses to live weight indicate that cashmere growers can increase productivity per head by increasing the live weight of goats, which is usually achieved by improved nutrition and herd health over the lifetime of their animals.

5. Other management requirements for quality fibre production

5.1. Influence of pregnancy and lactation on cashmere production

In Australia it is a widespread practice to avoid kidding in the cashmere growing period (summer to mid winter). It is a common experience that does which kid prior to shearing in mid winter will either prematurely moult their fleece or grow a lighter fleece. Producers have been advised to kid after shearing in August-September. This will coincide with autumn mating and the natural peak in ovulation rate that occurs at this time of the year. Klören and Norton (1993) have indicated that kidding in December and March can delay the initiation of cashmere follicles and kidding in July can prematurely end follicle growth. This contrasts with evidence from pregnant Merino ewes (Williams and Butt, 1989) and pregnant Angora does (McGregor 1995) that fibre growth will be maintained when sufficient energy is supplied to maintain maternal live weight.
5.2. Harvesting (shearing) management

For high quality cashmere it is critical that contamination of fleeces with impurities be eliminated. Harvesting and shearing hygiene standards have been developed to minimise contamination with vegetable matter, coloured fibres, synthetic fibres and rubbish. Practices include: the thorough sweeping or preferably the vacuuming of facilities before, during and after harvesting; harvesting white coloured animals first and darker coloured animals last; proper skirting of fleeces prior to packing, to remove fibres stained by urine, short kempy fibres, fribs and cotted edges; elimination of the use of coloured markers to identify animals; collection of all synthetic twine used on the farm; behavioural changes for staff such as the banning of smoking near harvesting. It is essential to adequately package fibre for dispatch to marketing agencies in strong, contaminant free packs.

6. Conclusions

Cashmere production and quality are responsive to a range of environmental factors, some of which can be manipulated by cashmere producers. Manipulation of energy nutrition and live weight of goats offer the greatest potential to increase production of cashmere and these are associated with changes in qualitative attributes of cashmere. Management during fibre harvesting is critical in maximising both fibre quality and financial returns.

References


