Incorporating farmed goats into sustainable rangeland grazing systems in southern Australia: a review

Ronald B. Hacker^ and Yohannes Alemseged^,^B

^NSW Department of Primary Industries, PMB 19, Trangie, NSW 2823, Australia.
^BCorresponding author. Email: yohannes.alemseged@dpi.nsw.gov.au

Abstract. The recent trend to farming or re-domestication of feral goats poses serious questions for the ecological sustainability of the semiarid and arid rangelands of southern Australia. This paper reviews aspects of the biology and grazing habits of goats, and aspects of the Australian goat industry, relevant to their sustainable management in livestock enterprises. Key factors identified include high fertility and fecundity even under low seasonal rainfall conditions and a generalist feeding strategy. Adverse consequences for rangeland condition can be expected if seasonal or market conditions result in an imbalance between population growth and turnoff, resulting in high grazing pressures. Given the limited control of the reproductive process at the current stage of the development of goat farming, strategies aimed at ensuring continuity of sale of goats (e.g. on-property feed lots or supply chain and market development) will be important in ensuring that imbalances are avoided. Conservative stocking rates and use of seasonal risk management tools are also particularly relevant. The major research and development needs identified by this review, from a resource management perspective, concern the appropriate dry sheep equivalent rating for goat classes based on age, sex and reproductive status, the extent and consequences of heterogeneity of grazing in space, time, and across forage species, and development of means of establishing sustainable stocking rates based on the use of all available forage sources, including browse.

Additional keywords: diet selection, grazing behaviour, growth, reproduction, shrubs.

Received 16 April 2013, accepted 31 October 2013, published online 6 December 2013

Introduction

Feral goats are ubiquitous in the semiarid rangelands of southern Australia. These feral flocks 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.

Feral goats – called ‘bush goats’ by Holst et al. (1976) and today more generally marketed as ‘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 trapping yards or self-mustering facilities at watering points. The majority of goats sold from the Western Division of New South Wales (NSW) are still opportunistically harvested rather than commercially farmed (Pople and Froese 2012).

It is increasingly common, however, for landholders to fence a portion of their property into a ‘goat paddock’ that may be used to hold small goats until they reach a marketable liveweight, or to act as a depot for mustered goat so that larger, more uniform groups can be selected for sale. This represents an intermediate stage in the development of a rangeland goat enterprise.

The final stage of development – a farmed goat enterprise – usually involves retention of selected feral does which are subject to ‘commercial’ standards of management, including infusion of exotic breeds (e.g. the South African Boer goat) to increase productivity. Reproduction, however, is not usually controlled and, therefore, the current practices fail to meet the definition of a managed enterprise. The motivation for development of farmed goat enterprises, particularly for meat production, has been to take advantage of the perceived capacity of goats to thrive in areas in which sheep and cattle perform poorly (e.g. Fletcher 1995), to exploit their browsing habit to control or utilise invasive native scrub (e.g. Harrington 1979; Muir 1995), and to reduce the labour requirements of conventional sheep enterprises under extensive conditions. Nevertheless, few pastoral businesses in Australia’s southern rangelands are currently based solely on a goat enterprise.

Most research on goats in this region has focussed on their capacity to reduce invasive native scrub (e.g. Harrington 1979; Muir 1995; Hacker et al. 2005) or on means to reduce them as a feral pest (e.g. Freudenberger and Hacker 1997; Thompson et al. 2002; Russell et al. 2011). Little attention has been directed to their management as livestock.

This review, necessarily based mainly on non-Australian literature, aims to identify key issues relevant to their use in this changed role, particularly in relation to sustainable management of natural resources, and associated research and development needs.
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 the southern rangelands of Australia. Wilson and Mulham (1980) recorded a kidding rate of 120% by feral does compared with a lambing rate of 57% by Merino ewes in a belah-rosewood community near Ivanhoe in western NSW although the growth rate of kids was lower than that of lambs. Liveweight of kids was only ~60% of that of lambs at weaning and at 1.5 years of age whereas the liveweight of does was ~75% of the liveweight of ewes. Similar relativity between the reproductive performance of feral does and Merino ewes has been recorded in mulga shrub lands in the arid winter-rainfall zone of Western Australia (Fletcher1995). The highest kidding rate recorded by Hacker et al. (2005) in a mulga range type near Tilpa in western NSW was 137% under high seasonal rainfall conditions, and a rate of 125% was recorded under low seasonal rainfall conditions when stocking rate was appropriately adjusted. Atkinson et al. (2007) recorded kidding percentages of 141 and 135% from feral does mated to Boer bucks under ‘managed’ (small paddock) or ‘unmanaged’ (large paddock) conditions, respectively, in a belah-bluebush range type near Wilcannia in western NSW.

The breeding season of goats differs between breeds (Ricordeau 1981). Some, such as the Maradi in Niger, are sexually active throughout the year although the interval between kiddings 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 goats of the Jamnapari breed kidded once a year while 54% of the Black Bengal kidde twice a year. The reported length of gestation also varies between 145 days for the Black Bengal breed (Ali et al. 1973) and 162 days for the Alpine breed of France (Ricordeau 1981). Observations in western NSW suggest a peak of kidding in spring (C. Bright, pers. comm.).

Under extensive conditions in the southern rangelands, management of reproduction is difficult due to the incursion of feral males. Atkinson et al. (2007) found that under ‘managed’ and ‘unmanaged’ conditions in western NSW only 88 and 39% of kids, respectively, were sired by males of the Boer breed to which non-pregnant feral does had been joined, even at a joining ratio (feral does to Boer males) of 20 : 1.

Growth

Birthweight of kids varies with breed and environmental conditions (Morand-Fehr 1981), with males slightly heavier than females. Liveweight gain during the first month is positively related to birthweight and liveweight gain during the first week (Morand-Fehr 1981).

Growth in meat animals is defined as an increase in tissue mass (Owens et al. 1993) and availability of energy is the main limiting factor (Lachica and Aguilera 2005a). AFRC (1998) indicate that the energy requirements for maintenance and growth in castrate males range from 3.7 MJ ME day⁻¹ for kids of 15 kg liveweight to 14.6 MJ ME day⁻¹ for kids of 30 kg liveweight, depending on metabolisability of the diet and liveweight gain (kg day⁻¹). However, Lachica and Aguilera (2005b) have argued that the literature contains limited information on the energy requirement of goats which has largely been inferred by extrapolation of data from other ruminants, ignoring differences in physiological or anatomical features. Molina Alcaide et al. (2000) compared the digestive physiology of sheep and goats and found no difference in digestibility (e.g. dry matter digestibility of 0.634 v. 0.635 for goats and sheep, respectively, when fed Alfalfa hay), degradation rate (22.8 v. 25.6%), or fractional rate of passage of the digesta out of the rumen when medium- or high-digestibility forages were offered. However, when grazing shrub- and tree-dominated vegetation in a semiarid environment goats were able to select forage of higher digestibility and with a lower proportion of unavailable nitrogen (N) than sheep (Molina Alcaide et al. 1997). Sheridan et al. (2003) also found higher digestive efficiencies (for dry matter, crude protein and energy) for goat kids of the Boer breed than for South African Mutton Merino lambs on a low-energy diet but not on a high-energy diet.

The capacity of goats to perform better than other ruminants in harsh environments has been variously attributed to their smaller body size and higher efficiency of 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; see below). 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 southern rangelands. No relevant data are available from Australian investigations but data from South Africa, summarised in Table 1, suggest that, while liveweight gains of goats, both pre- and post-weaning, are sensitive to diet quality (measured as metabolisable energy), the sensitivity appears somewhat muted relative to sheep. The higher liveweight gains of sheep in this table are consistent with the findings of several authors (e.g. Larbi et al. 1993; Kaitho et al. 1998; Mahgoub and Lodge 1998; although see Abidi et al. 2009; for a null finding) and are associated with larger mature liveweight.

Table 1. Liveweight gain (g day⁻¹) of Boer and indigenous (South African) goat kids and South African Mutton Merino (SAMM) lambs in relation to diet quality

<table>
<thead>
<tr>
<th>Diet type and energy level</th>
<th>Boer</th>
<th>Indigenous</th>
<th>SAMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native pasture</td>
<td>90³</td>
<td>56³</td>
<td>n.a.</td>
</tr>
<tr>
<td>Pelleted ration (8.9 MJ ME kg⁻¹ DM)</td>
<td>158³</td>
<td>76³</td>
<td>n.a.</td>
</tr>
<tr>
<td>Pelleted ration (9.9 MJ ME kg⁻¹ DM)</td>
<td>168³</td>
<td>n.a.</td>
<td>220⁵</td>
</tr>
<tr>
<td>Pelleted ration (12.1 MJ ME kg⁻¹ DM)</td>
<td>189⁶</td>
<td>n.a.</td>
<td>306⁶</td>
</tr>
</tbody>
</table>

³Derived from Greyming et al. (2004); pre-weaning growth rates to 12 weeks.
⁵Derived from Sheridan et al. (2003); post-weaning growth rates; averages of 28- and 56-day feeding periods.
Joining Boer males with farmed does of feral origin has the potential to increase meat production in pastoral areas. At ‘Winderie’ in Western Australia first-cross Boer goats had heavier liveweights at weaning than goats of feral origin (Elliott and Woodford 1998) and reached the target market liveweight of 35 kg substantially earlier. Being able to market goats earlier reduces stocking rates over a 12-month period, and provides a greater opportunity for the does to regain condition and conceive again.

Diet selection

Lemus and Brown (2008) present a useful generalised view of the diet preferences of the major livestock species (Fig. 1). While this representation highlights the predominance of browse in the diet of goats, a finding reported by many authors (e.g. Squires 1980; Teague 1989; Bartolome et al. 1998; Ramirez 1999), the literature also reflects considerable variation on this theme and points to goats as highly selective, or ‘fastidious’, grazers while willing to accept a wide variety of forages (Devendra and Burns 1983).

Compared with sheep, in particular, goats are ‘top-down’ grazers selecting readily from the upper layers of the canopy or sward, while sheep are ‘bottom-up’ grazers, selecting preferentially from the ground storey or bottom of the sward (Norton et al. 1990; Du Plessis et al. 2004). This fundamental distinction, if able to be expressed, will largely drive the difference in the selection patterns of the species in a given situation. Norton et al. (1990) concluded that in their study of grazing preferences in tropical grass-legume pastures, goats were more like cattle than sheep as both grazed from the top of the sward downwards, while sheep grazed from the bottom of the sward.

While differences in diet selection between sheep and goats are greater than the difference between breeds of either species (Du Plessis et al. 2004), numerous differences in diet selection between goat breeds have been reported (e.g. Merrill and Taylor 1981; Mellado et al. 2004a; Aharon et al. 2007; Celaya et al. 2010). These may be related to differences in oral morphology, which lead to different selection patterns among plant species without altering the quality of the diet selected (Mellado et al. 2007). Such differences have not been studied in the southern rangelands of Australia but it would be reasonable to expect that they might occur among herds bred or selected for particular production traits without greatly affecting the principles that should guide the management of their grazing.

Other factors reported to have influenced the diet selected by goats include:

• season (e.g. Ricardi and Shimada 1992; Dziba et al. 2003);
• age and body condition (more shrub consumed by adults compared with juveniles in the rainy season, and by goats in lower body condition; Mellado et al. 2004b);
• grazing management system (more shrub consumed under rotational than continuous grazing; Mellado et al. 2004c); and
• reproductive status (more forbs and grasses consumed by pregnant or lactating does, according to nutritional requirements; Mellado et al. 2005).

While a preference for shrubs has generally been found, several exceptions have been reported. Grünwaldt et al. (1994) reported that goats grazing the arid piedmont of Argentina were not primarily browsers, favouring grasses over herbs and shrubs, but had the capacity to maintain diet digestibility under declining range condition resulting from heavy grazing. Guevara et al. (2009) also reported from Argentina that their studies provided ‘no unanimity as to the fact that goats are strictly browsers’. Rafiq et al. (2010) reported, somewhat paradoxically, that the largest component of the diet of free-ranging goats in the Pubbi Hills of Pakistan was the grass, *Cymbopogon jwarancusa*, while pods of the shrub, *Acacia modesta*, were the major component of the diet of sheep under these conditions. In a rosewood-belah community in western NSW, Wilson and Mulham (1980) found that goats browsed trees but did not obtain the majority of their forage from them and were thus competitive with sheep for the herbaceous layer.

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 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 a rosewood-belah community in western NSW. 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.

Role of goats in natural resource management

Goats have long been regarded as a major cause of rangeland degradation since they are often associated with environments that are considered ‘overgrazed’ or ‘degraded’, and with poverty and subsistence production systems in developing countries. A widespread cultural bias against goats has been identified among other livestock producers, bureaucrats and policy makers in developing countries (see Perevolotsky 1991; and authors quoted therein), and to some extent this bias probably prevails in Australia as well. However, the reputation of the goat is by no means well deserved and some authors have highlighted the ecological, as well as economic and social, benefits of goat grazing in landscapes often popularly considered to have been desertified by them (e.g. Perevolotsky 1991; Perevolotsky and Seligman 1998; de Rancourt et al. 2006).

Impact on shrubs

The browsing habit of goats has resulted in frequent attempts to use them for shrub control. Several studies have demonstrated that they can be effective in restricting the increase in shrub cover (particularly of small plants <2 m in height) or limiting regrowth after mechanical clearing or fire (e.g. Du Toit 1972; Radcliffe 1982; Wood 1987; Downing and Evans 1989; Hacker et al. 2005; Hester et al. 2006). Mills et al. (2005) recorded their effectiveness in converting extensive areas of semiarid thicket to open grassland. However, in western NSW, Harrington (1979), in poplar box (Eucalyptus populnea) woodland, and Wilson et al. (1975, 1976) and Wilson and Mulham (1980), in belah (Casuarina cristata)-rosewood (Heterodendrum oleofolium) woodland, have concluded that overall they are not a satisfactory management tool for control of invasive native scrub. This is due to their inability to exert significant grazing pressure on some of the most invasive species such as turpentine (Eremophila sturtii) and budda (Eremophila michellii), which are not preferred by them. Noble et al. (1980) found that goats did not graze the regrowth of mallee (Eucalyptus spp.) and that they had no potential as a management tool for limiting the regrowth of mallee after fire.

Goats can exert heavy grazing pressure on shrub species they prefer, and eliminate them from the community, particularly when heavy grazing is exerted under drought conditions (Wilson et al. 1976; Fletcher 1995; Muir 1995; Hacker et al. 2005). Such grazing can also lead to an increase in non-preferred shrub species and severe impacts on the herbage layer (Sweet and Mphinyane 1986; Muir 1995; Hacker et al. 2005) although at the site of the study of Muir (1995), in a mulga rangeland type in western NSW, excellent regrowth of perennial grasses has been observed by one of the authors (R. B. Hacker) following destocking and favourable weather conditions.

When used for the control of preferred shrub species, continuous grazing is more effective than rotational or non-continuous grazing since constant pressure on the target species appears to be important in determining the level of control achieved (Du Toit 1972; Muir 1995).

Holst et al. (1976) listed common species (both woody and non-woody) in NSW in terms of their preference by goats (Table 2) while recognising that selection of these species can be influenced by the stage of maturity of the plants and that their preference will therefore show seasonal variation.

While reduction in the cover of shrubs may have several advantages in terms of livestock production, it may also result in a considerable reduction in carbon (C) storage (Mills et al. 2005). Alchin et al. (2010) demonstrated the major contribution of woody vegetation and coarse woody debris to total C pools in the northern rangelands of Western Australia but to date no comparable analysis has apparently been conducted for the southern rangelands. Both Alchin et al. (2010) and Hunt et al. (2012) have identified the potential tradeoffs between pastoral production and C sequestration achieved partially through increased cover of woody vegetation in northern Australia. This role of goats in the future may change should pastoralists in the southern rangelands be able to derive economic advantage from C sequestration.

Effects on botanical composition

Despite their reputation as destroyers of vegetation and landscapes, several studies have shown that goats can confer benefits in term of pasture composition and resource condition. In high-rainfall pastures, grazing by goats has been shown to increase the clover content of grass-clover pastures compared with sheep in both New Zealand (Radcliffe et al. 1991) and the UK (Penning et al. 1996), the latter authors suggesting that they could be used as a management tool for this purpose. In

<table>
<thead>
<tr>
<th>Table 2. Preference by goats of some common plant species in western New South Wales (after Holst et al. 1976)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly preferred</td>
</tr>
<tr>
<td>Orange bush (Capparis mitchelli), supplejack (Ventilago viminalis), kurrajong (Brachychiton populneum), gruiue (Ovenia acidula), emu bush (Eremophila longifolia), belah (Casuarina cristata), warrior bush (Apophyllum anomalum), whitewood (Atalaya hemiglaucu), lignum (Muehlenbeckia cunninghamii), blackberry (Rubus spp.), sweet briar (Rosa rubiginosa), lucerne tree (Chamaecytisus proliferus), yellow flower lucerne (Medicago folicata), turnip weed (Brassica tournefortii), sucker leaves of boxes, gums, malleesA</td>
</tr>
<tr>
<td>Moderately preferred</td>
</tr>
<tr>
<td>Punty bush (Senna artemisioides subsp. filifolia), broad- and narrow-leaf hop bush (Dodonea viscosea subsp. spathulata and subsp. angustissima), pine (young) (Callitris spp.), mulga (young) (Acacia aneura), ironwood (Acacia excelsa), yarran (Acacia homalophylla), various other Acacia spp., canegress (Eragrostis australasiae), some box and gum trees</td>
</tr>
<tr>
<td>Eaten occasionally</td>
</tr>
<tr>
<td>Buddha (Eremophila michellii), wilga (Geijera parviflora), mature poplar box (Eucalyptus populneae), horse nettle (Solanum sp.), tall nettle (Urtica sp.), kangaroo thorn (Acacia sp.), galvanized burl (Sclerolaena birchii)</td>
</tr>
</tbody>
</table>

ANote that this assessment, in relation to mallee, is contrary to the findings of Noble et al. (1980).
temperate pastures in the high-rainfall zone of south-eastern Australia, McGregor (2010) found that grazing by Angora goats at the same stocking rate as sheep (animals ha−1) resulted in more subterranean clover in the pasture, less undesirable grasses, and less bare ground, and concluded that Angora goats on sheep farms could be used to speed up establishment of subterranean clover, manipulate pasture composition, reduce soil erosion and reduce weed invasion.

The role of goats in controlling regrowth of shrubs after fire or mechanical clearing in rangelands has been noted above. Most of these studies have not reported in detail the effect on the grass layer but, in South Africa, Du Toit (1972) found that the greater control of regrowth of Acacia karoo by goats compared with sheep was also associated with a marked increase in cover, composition and vigour of the grass sward.

In semiarid thornscrub in Mexico, Baraza and Valiente-Banuet (2008) found that goats were able to disperse viable seed of diverse species, sometimes depositing them in favourable micro-habitats for survival, e.g. under the canopies of perennial plants. This study did not extend to examining the role of this process in rangeland regeneration but the authors called attention to its potential, contrary to the general assumption that goats cause only degradation.

Experiences of some pastoralists in western NSW have also supported the idea that well managed goats have less impact on rangeland condition than sheep, and can facilitate rangeland regeneration, due to their highly flexible diet (K. Francisco, pers. comm.). However, no documentary evidence to this effect is available. Experience in the Western Australian rangelands has also shown that the condition of some habitats (e.g. mulga shrub land) can improve under grazing by goats alone, without competition from other animals (Fletcher 1995; WADAF 2011).

**Stocking rate estimation**

Establishing appropriate stocking rates for new enterprises in which goats are substituted for traditional livestock is obviously fundamental to their sustainability. Species exchange based on the estimated dry sheep equivalent (DSE) rating for various classes of goats (Table 3) will provide a starting point for managing grazing pressure and pasture utilisation. In addition to the relativities described in Table 3, forage consumption will also vary with quality and quantity of feed on offer, water quality and season of year (WADAF 2011). Furthermore, the rate at which sheep can be exchanged for goats in practice will depend heavily on the amount of browse available to goats, with DSE ratings considerably reduced in vegetation types that contain browse that is eaten by goats but not by sheep. Muya et al. (2013) used utilisation-based methods (grazing unit and browsing unit) along with rainfall regime to determine the number of animals that can be stocked in a given area in managing wildlife in Kenya.

**Goat behaviour**

Pastoralists frequently observe that feral goats removed by mustering or trapping are rapidly replaced by new individuals from the surrounding country. Feral goats normally have a high proportion of males in the herd and appear to be highly mobile although their movement is not nomadic. They appear to occupy defined home ranges for considerable periods of time (e.g. Holt and Pickles 1996), albeit ones that are not restricted by normal pastoral infrastructure developed for sheep. When captured they do not exhibit wild behaviour, or appear to fret (Holst et al. 1976), and so are readily domesticated.

Under commercial management, herds of does running as a single species, and with a low proportion of males (~0.05 is considered satisfactory for extensive pastoral situations), are much less mobile and have stable, well defined home ranges, to the extent that the need for internal fencing may be reduced in uniform landscapes (WADAF 2011).

Incursion of feral goats into managed herds may be a serious issue unless fencing is secure. Where managed herds are enclosed by electric fences, feral animals commonly breach the barrier to enter a paddock but receive an electric shock in the process and tend not to challenge it again to leave the paddock. Such paddocks can thus act as feral goat ‘accumulators’ with serious implications for stocking rate and breeding management.

Some observations in western NSW indicate that managed goats do not walk as far from water as sheep unless conditions are dry (C. Bight and A. McLeod, pers. comm.), perhaps reflecting their ability to select from a wider range of forages on offer.

**Incorporating goats into sustainable grazing systems in the southern rangelands of Australia**

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 maintenance or improvement of landscape function (sensu Ludwig et al. 1997) and the maintenance of extant biodiversity at landscape scales. Fundamental to the achievement of these objectives is the matching of forage demand from all herbivores to forage supply with sufficient precision to ensure that utilisation levels are consistent with the resource management objective established for individual management units (see Campbell and Hacker 2000). Despite both anecdotal- and research-based evidence that goats may confer positive benefits in terms of natural resource management, contrary to their popular image, their incorporation into sustainable systems of rangeland use will be dependent on management which satisfies this criterion.

Sustainability of grazing systems (as defined above) is also influenced in practice by the economic conditions prevailing in the industry. The Australian goat industry involves two main supply chains, one for farmed goats and the other for rangeland goats although some movement occurs between them (MLA 2012). At this stage of the industry’s development, these supply chains are not well understood and no economic models are available. Maintaining an adequate supply of meat of appropriate

---

**Table 3. Estimated dry sheep equivalents (DSE) ratings for classes of goats based on forage consumption (adapted from WADAF 2011)**

<table>
<thead>
<tr>
<th>Class</th>
<th>DSE</th>
<th>Liveweight range (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry doe</td>
<td>0.75</td>
<td>30–40</td>
</tr>
<tr>
<td>Breeding doe</td>
<td>1.5</td>
<td>40–60</td>
</tr>
<tr>
<td>Weaver</td>
<td>0.7</td>
<td>20–40</td>
</tr>
<tr>
<td>Entire male</td>
<td>1.5</td>
<td>60–80</td>
</tr>
</tbody>
</table>

^In a herd producing 150% kids.
quality has been identified as the major issue confronting both these sectors of the industry (MLA 2012).

The preceding review suggests that the salient features of goat biology relevant to their management as livestock in the southern rangelands are:

- high fertility and fecundity, even under low seasonal rainfall conditions; and
- a generalist feeding strategy and a marked capacity to select the best available diet from the forage on offer, resulting in a capacity to utilise a greater range of plant species, particularly browse, than those utilised by Merino sheep in current management systems.

It seems likely that these traits would also result in post-weaning liveweight gains of kids that are less sensitive to seasonal variation than is the case for Merino lambs (see Table 1) although few if any field data are available from the southern rangelands to support this suggestion. In any event, low seasonal rainfall conditions will reduce liveweight gains and increase the time to marketable liveweight.

These traits imply:

- the potential for a high rate of population growth, which can be maintained over a wide range of seasonal conditions;
- a potentially reduced selection pressure on individual species of plants but also potentially restricted distribution of grazing if forage demand can be met by utilisation of a wider variety of species; and
- potential for adverse impacts on natural resources should seasonal conditions result in an imbalance between population growth and turnoff.

While the last point applies to all livestock production systems, the capacity of goats to reproduce successfully under a wide range of seasonal conditions makes the issue potentially more serious for goat enterprises than for traditional sheep enterprises. This situation is exacerbated by the limited control over reproduction generally exercised by rangeland goat producers given the current state of development of the industry, and the continuing existence of a substantial population of feral males.

Management strategies to address these issues could include (a) stocking at a lower rate (in terms of DSE) than would be expected for a traditional Merino enterprise (b) use of seasonal risk management tools and (c) establishment of facilities (e.g. feed lots) or collaborative arrangements (e.g. off-property finishing) to ensure that the sale of animals can be maintained under low seasonal rainfall conditions.

Given that continuity of supply of meat of appropriate quality has been identified as a major issue for goat industry development, initiatives that facilitate market development and the operation of integrated supply chains should be beneficial to both the economic and ecological sustainability of the industry.

Research and development needs

The research and development needs relevant to the sustainable management of goats, from a natural resource perspective, include:

- establishment of the appropriate DSE ratings for goat classes based on age, sex and reproductive status;
- clarification of the heterogeneity of grazing – temporally, spatially and among species;
- development of practical means of determining sustainable stocking rates based on all sources of forage on offer, including browse; and
- elucidation of the response of key species, including shrubs, to the interaction of grazing and drought.

Some guidelines (Table 3) already exist in relation to DSE ratings. However, these are considerably higher than those thought appropriate by graziers participating in focus group discussions of goat management in western NSW (S. A. Khairo and R. B. Hacker, unpubl. data), differences relating particularly to the capacity of goats to utilise browse not utilised by Merinos.

Elucidation of the response of key species, including shrubs, to the interaction of drought and grazing is on ongoing issue which is an essential, and still largely incomplete, component of the development of strategies for sustainable grazing in the southern rangelands.

Conclusions

Goats possess physiological and behavioural traits which, taken together, indicate that under commercial management they may pose a threat to natural resource condition in the southern rangelands unless a high standard of management is applied. Their capacity to maintain high reproductive rates under low seasonal rainfall conditions could result in forage demand rapidly exceeding forage supply, with adverse impact on resource condition indicators such as ground cover, unless strategies are established to ensure continuity of the sale of goats. Facilitating continuity of sale (e.g. through on-property feed lots or greater vertical integration within the supply chain) would be enhanced by further development of the goat meat industry. Other management strategies, such as reduced stocking rate relative to traditional enterprises, will also be important in minimising the risk to natural resources but development of demand-side approaches to the sale of goats will be particularly important given that, at the current stage of industry development, the reproductive process is poorly controlled.

Acknowledgements

This review was part of a project jointly funded by the Lower Murray–Darling Catchment Management Authority (now Murray CMA) and the NSW Department of Primary Industries. We are grateful to Dr John Milne and an anonymous referee for constructive comments on the original manuscript.

References


Goats as livestock in Australia’s southern rangelands

The Rangeland Journal


