6. Marketing of Sheep and Sheepmeat

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Learning objectives

At the end of this topic you should be able to:

• Have an understanding of the different components of the pre-slaughter period for sheep.
• Discuss sheep management practices in relation to impacts on food safety, animal welfare, meat quality, meat yield, environmental contamination, and biosecurity.
• Demonstrate an understanding of the optimal management of sheep during the pre-slaughter period.
• Access and utilise recent research and extension material describing effective pre-slaughter management.

Key terms and concepts

Time off food and water, faecal and urine contamination, stress

6.1 Introduction

In the past, most Australian lamb has been consumed domestically. Exports of Australian lamb have now risen to over 45% of production (Chapter 2) which has created more price stability in the market. More than 70% of Australian mutton production is exported which has increased the value of surplus sheep sales which now make a significant contribution to the profitability of all sheep enterprises.

Live sheep export is focused on the Middle Eastern markets with an increasing emphasis on animal welfare, product quality, younger sheep and market specifications. A small number of live sheep are exported for breeding to other sheep producing nations.

Recent developments in the marketing of sheep meat include:-

• Value based marketing systems that reward producers for meeting target specifications. The proportion of lambs sold direct to abattoirs has increased from 5% in 1990-91 to approximately 50% in 2003-04 (MLA, 2005).

• Payment systems are still predominantly based on carcase weight and sometimes fat depth. Genetic improvements in leanness and muscling have facilitated the likely implementation of systems to pay on saleable meat yield and value in the future.

• Some producers now have clear relationships with partners in the supply chain and a commitment to supplying a quality product to specifications. The need to accurately assess and describe the live animal and the carcase has become increasingly important to the success of these relationships. Meat companies are developing their own recognised quality brands to differentiate their product in the market place.

• Quality assurance and trace-back systems minimise the risk of supplying a level of quality that does not meet customer requirements.
The pre-slaughter period includes the total time required to move sheep from the paddock to the slaughter floor of an abattoir in preparation for slaughter. The individual components and the lengths of these components vary according to practical and commercial considerations. However included within the list of individual time components of the pre-slaughter period are: mustering, consignment assembly, farm curfew, transport, saleyards, and lairage.

Key issues influenced by sheep management during the pre-slaughter period are food safety, animal welfare, meat yield, meat eating quality, environmental contamination, and biosecurity. Such issues influence both the quantity and quality of meat harvested from sheep and potentially, public perception about the sheep meat industry. Quantifying the effects of pre-slaughter management in relation to these key issues allows a better understanding of how to optimise pre-slaughter management.

Sheep meat markets demand a product that is safe, healthy and consistent in supply and quality. Competition from other protein products is fierce. Lamb has now positioned itself as a versatile, tender and flavoursome product that is well recognised on restaurant menus around the world.

### 6.2 Components of the pre–slaughter period

**Mustering**
Mustering represents the start of the pre-slaughter period. The intensity and speed of mustering can affect muscle glycogen concentration and meat quality.

**Consignment assembly**
To achieve the best price a consignment will usually need to meet certain specifications stipulated by the buyer. These specifications often are in relation to sheep live weight, fat score, age and breed. Carcase weight and fat score specifications are often referred to as a “grid”. Assembling a consignment will usually involve further exercise after mustering in the process of weighing, conditions scoring and drafting sheep to identify the animals that meet the specification required. Sheep may also be crutched at this time if they have excessive faecal contamination (dags) in the breech area.

**Table 6.1:** The different components of the pre-slaughter period. Source: Jacob, (2007).

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mustering</td>
<td>Movement of a mob of sheep from their grazing location to a yard in readiness for consignment.</td>
</tr>
<tr>
<td>Consignment assembly</td>
<td>Selection of sheep from a mob to meet the specifications of the buyer.</td>
</tr>
<tr>
<td>Farm curfew</td>
<td>Holding sheep in a confined space on farm prior to transport.</td>
</tr>
<tr>
<td>Transport</td>
<td>Movement from the property of origin to an abattoir or a saleyard, usually on road transport but can include rail and ferry transport in some parts of Australia.</td>
</tr>
<tr>
<td>Saleyards</td>
<td>A yard where sheep are held for the purpose of public display and subsequent sale by auction.</td>
</tr>
<tr>
<td>Lairage</td>
<td>A confined yard at an abattoir where sheep are held immediately prior to slaughter.</td>
</tr>
</tbody>
</table>

**Farm curfew**
Farm curfew may begin immediately after the consignment has been assembled or be delayed for a short period of time to coincide more closely with transport. Generally farm curfew involves confinement in a small yard, often in a shearing shed, at a high stocking density with both feed and water being withheld. The purpose of withholding feed and water during farm curfew is to reduce the volume of the contents of the gastrointestinal tract and the urinary bladder prior to transport. The length of the farm curfew period will often be determined by recommendations from the
transport contractor and or processor. Recommendations can be flexible and may depend on the feeding system under which the livestock have been run. For example one processor recommends that animals grazing lush pasture be fasted for 12 hours and animals grazing dry feed be fasted for 4-6 hours before loading onto transport Meat and Livestock Australia have a standard recommendation of 12 hours (Anonymous, 2005)

**Transport**

Transport from farm to abattoir generally involves road transport under Australian conditions. Rail transport is still used in some parts of Australia, notably Queensland, but is not as common as in the past. On some routes in Australia, notably from Kangaroo Island to the mainland in South Australia and from Tasmania to Victoria, transport will include a short sea voyage whereby a truck carrying livestock is shipped on a vehicle ferry.

The length of transport will vary according to a number of factors including the distance from farm to abattoir, the need to collect other consignments on neighbouring farms to fill a truck, and the time of arrival in relation to the opening time of the lairage. Lairage yards may be closed during the night so if a truck arrives after closing time, the livestock will be kept on the truck until the lairage opens the following morning. When this occurs the period of confinement on the truck will be longer than the travelling time.

Both food and water are withheld during the transport period. Many studies have demonstrated that transport elicits a physiological stress response in travelling livestock, namely an increase in the serum concentrations of adrenaline, noradrenaline and cortisol. Motion sickness, fasting, mixing, high stocking density, maintaining balance, noise, temperature extremes, and water deprivation (Gregory, 1996) are factors during transport that contribute to a stress response.

However this hormonal response to transport tends to occur mainly at the beginning of the journey and livestock become acclimatised to transport. Short journeys may therefore be just as stressful as long journeys. Fell and Shutt (1996) showed that the cortisol response of lambs to transport depended on the nature of the transport. Thirty minutes of stop-start transport gave significantly higher salivary cortisol levels than 1 hour of steady highway transport. Age of the animal breed may also be important for the magnitude of the stress response to transport.

**Figure 6.1** Different components of the pre-slaughter period with estimates of the range in time period for each component. Source: Jacob, (2007).

#### Saleyards

Displaying sheep at a sale yard prior to sale by auction remains a popular way of marketing slaughter sheep. This involves further exercise associated with unloading and reloading on to transport, stress, and potential for further soiling of the skin and fleece.
Lairage
Holding livestock in abattoir lairage yards prior to slaughter has a number of purposes. To rest animals after transport, to further reduce the volume of contents in the gastrointestinal tract before slaughter, to facilitate a continuous supply of animals to the slaughter floor throughout a working day, and to allow resorting of animals into lines consistent with the markets available to the meat processor.

In Australia food is withheld but water is made available during abattoir lairage unless the lairage period is planned to extend beyond 24 hours. In this event the animals should be released to holding yards where food and water can be supplied.

Lairage yards are often covered and designed to keep the animals as clean as possible. Floors vary from solid earth or concrete to wooden slats or metal mesh. Lairage yards in the case of sheep are often raised to facilitate removal of manure. Stocking densities are high and yards may be large. Group sizes in abattoir lairage tend to be smaller for cattle than for sheep. Lairage yard specifications depend on AQIS regulation when the abattoir is licensed to sell meat for export.

6.3 Food safety

Slaughter hygiene is important for the safety of consumers of sheep meat as well as for product keeping qualities. Organisms of main concern are Escherichia coli (E. coli) and Salmonella spp.

In the case of E. coli there is both generic strains and specific strains particularly enterohaemorrhagic Shiga toxin (STEC) producing E. coli strains O157:H7, O26 and O111.

Principles relating to carcase hygiene
Carcase contamination with enteric bacteria of livestock that are potentially pathogenic to the public relates to several principles. (Gill 2004).

1. Enteric pathogens found on meat are mainly associated with faecal matter that is deposited on the carcase during the slaughter process.
2. Such matter will be more prevalent on carcases from animals that are visibly dirty at the time of slaughter than on carcases that are clean.
3. It can be more difficult to eviscerate and dress carcases hygienically when animals have liquid diarrhoea. Diarrhoea is more likely to cause contamination of the body surface, and it can introduce hazards during evisceration.
4. Animals carrying dust, dags or clinker in their coats or fleece are more difficult to dress hygienically than animals with clean hides or pelts. This is a concern with cattle kept in some feedlots.
5. Truck, holding pen and stunning pen walls and floors that are wet and dirty are more likely to cause body surface contamination than walls and floors which are dry and clean. Such body surface contamination could introduce risks of transfer of soiling to the carcase during hide or pelt removal.
6. It can be more difficult to remove the pelt of a sheep or lamb carcase hygienically that is in long wool in comparison with a shorn fleece. The importance of this effect depends on breed, and on the ways in which roll-back of the fleece is controlled at individual abattoirs.

Production factors
For sheep, Hadley et al (1997) showed that increased fleece length was associated with increased soiling of live animals. Biss and Hathaway (1994) found that the carcases of shorn lambs had lower total aerobic plate counts of viable microorganisms (TVC) after dressing than “woolly” lambs. However, crutching did not reduce the numbers of bacteria on the carcase (Roberts 1980).

Additional information in relation to the influence of production factors is presented in the following sections on specific hazards and indicator organisms.

Effect of farm curfew
There are 2 aspects to consider in relation the influence of farm curfew on carcase contamination. The first is soiling of the hide or fleece during production curfew and transport. The second is the accelerated growth of some microbial hazards and hygiene contaminants in the gut due to feed withdrawal. This increased gut content contamination may result in carcase contamination via further hide/pelt faecal contamination during transit to slaughter or by ingesta spillage during carcase dressing procedures.
Withholding sheep from feed or feeding after starvation can result in a $10^3$ to $10^6$ fold increase in the level of *Salmonella* in the rumen and faeces of sheep (Grau *et al.*, 1969). Grau and Smith, (1974) showed that the level of *Salmonella* shed by sheep increased with holding time at the abattoir. In heavily contaminated pens the levels increased by about 1-log unit per day. The rate of contamination of the fleece also increased rapidly, after three days nearly all of the animals were contaminated. In less heavily contaminated pens the levels increased more slowly and fewer hides became contaminated (~20%). Contamination of carcasses with *Salmonella* followed a similar pattern, with the number of positive carcasses increasing with holding time prior to slaughter. Serotypes isolated included Adelaide, Havana, Meleagridis, Oranienburg and Derby. It was concluded that the fleece was the primary source of contamination of carcasses. *Salmonella* was also isolated more often after evisceration (Grau 1979) inferring this to be a major point of carcass contamination.

**Figure 6.2** The effect of fasting on bacterial populations in the gut
adapted from Gregory *et al* (2000).

Contamination from saleyards/lairage
Recent studies have demonstrated substantial capacity for cross contamination of microbial hazards between animals' hides at saleyards and at the abattoir. Pathogens can survive on hides, in faeces and on lairage materials for longer than 1 week such that pathogens can be carried over from one batch to another and/or from one day to the next (Small *et al* 2003). Although this is considered to be a greater issue for cattle than sheep some studies have shown potential for cross contamination between different consignments of sheep in abattoir lairage.

Summary of food safety issues
The management of sheep during the pre-slaughter period is important for carcase hygiene although slaughter floor practice remains crucial to a successful outcome. There are many factors and the interaction between factors makes the prediction of carcase contamination in any particular consignment complex and difficult. However some important factors are:

- Wool length- short better than long
- Hide cleanliness- the cleaner the better
- Food curfew- up to 24 hours beneficial, but longer than 48 hours may be detrimental
- Trucks, saleyards and abattoir lairage yards need to be kept clean
6.4 Animal welfare

Welfare considerations during the pre-slaughter period

Livestock are potentially confronted with many stressors during the pre-slaughter period. These include feed and water deprivation, exposure to unfamiliar environments; transport; increased human contact and handling; dogs, changes in the social structure (i.e. through separation and mixing); exposure to physical trauma, and exposure to sudden changes in climatic conditions (Ferguson et al 2001). Water deprivation is possibly the most important stressor that is a regular part of the pre-slaughter period.

Paradoxically the motivation for curfew on farm prior has in part been for animal welfare reasons. The anecdotal reports from livestock transporters are that cattle and sheep tend to travel better following pre-transport curfews and this is supported by the National Model code of practice for the transport of livestock. However there is a paucity of scientific data to support the anecdotal views from livestock transporters that pre-transport curfews facilitate improvements in the capacity of cattle and sheep to cope with transport. The application of pre-transport curfews will result in less excreta in trucks but it is not clear whether this reduces the amount of slippage and losses in balance during the journey.


<table>
<thead>
<tr>
<th>Blood Parameter</th>
<th>Indicator</th>
<th>Response to Food Deprivation or Food + Water Deprivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Carbohydrate metabolism</td>
<td>Decrease (may show slight increase initially up to 24 h)</td>
</tr>
<tr>
<td>NEFA</td>
<td>Lipolysis</td>
<td>Increase</td>
</tr>
<tr>
<td>Urea Nitrogen</td>
<td>Protein catabolism</td>
<td>Increase</td>
</tr>
<tr>
<td>Total protein</td>
<td>Haemoconcentration/dehydration</td>
<td>Increase</td>
</tr>
<tr>
<td>Albumin</td>
<td>&quot;</td>
<td>Increase</td>
</tr>
<tr>
<td>Haematocrit or PCV</td>
<td>&quot; &amp; HPA activation (fear)</td>
<td>Increase</td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>&quot;</td>
<td>Increase</td>
</tr>
<tr>
<td>Osmolality</td>
<td>&quot;</td>
<td>Increase</td>
</tr>
<tr>
<td>Cortisol</td>
<td>HPA activation (fear)</td>
<td>Minimal change</td>
</tr>
<tr>
<td>PCO₂</td>
<td>Blood-acid base balance</td>
<td>Decrease</td>
</tr>
</tbody>
</table>

*Response during food and water deprivation. Food deprivation alone may only result in minimal changes to these parameters. HPA Hypothalamic-pituitary-adrenal axis WBC-White blood cell count.

National model codes of practice for the welfare of animals

The welfare of livestock during curfew in Australia falls under the jurisdiction of a range of regulations and codes of practice. Whilst administration and supporting legislation for livestock welfare are state based, the basis for most state codes is the National Model Codes of Practice (NMCOP). NMCOP are written by the Primary Industry Ministerial Council (PIMC) with advice from the Primary Industry Standing Committee (PISC). Each state has representation on PISC, hence an input into the content of NMCOP. The aim of this national system is to promote uniformity between the state codes whilst keeping the authority for prosecution of regulations within state legislation.

Disparities between recommendations and implementation of recommendations between states have led to plans to change NMCOP from the current format into an auditable standards based system of “Australian Standards and Guidelines for the Welfare of Animals”. This change is expected to be implemented by 2010 under the auspices of Animal Health Australia. NMCOP contain recommendations in relation to rest, time off feed, time off water and stress minimisation. For the time off feed and water recommendations, ranges and maximum times are specified for component (on farm, transport, saleyard, lairage) and composite (total time) curfew periods. Although time period recommendations are clearly documented, a clearer interpretation of time
periods relevant within the context of a pathway to slaughter is necessary, to enable comparison between recommended and actual time periods.

For dry sheep the maximum permissible time off water is 36 hours while for lambs less than 6 months of age 20 hours is recommended. There are provisions for longer times for extended transport. The maximum allowable time off feed for the curfew + transport period for sheep is 32 hours. However the total time off feed for the entire farm to slaughter path is not stated. Curfew can be reinstated after a rest period prior to reloading, after a rest period within an extended transport period, or towards the end of a lairage period prior to slaughter. Recommendations in relation to stress minimisation include refer to facility design, use of electric prodders and the muzzling of dogs used to move livestock.

Table 6.3 National model codes of practice for the welfare of animals relevant to pre-slaughter management of livestock.

<table>
<thead>
<tr>
<th>Short title</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock at slaughtering establishments SCARM 79</td>
<td>2001</td>
</tr>
<tr>
<td>Land transport of cattle SCARM 77</td>
<td>2002</td>
</tr>
<tr>
<td>Land transport of sheep Draft</td>
<td>2004</td>
</tr>
<tr>
<td>Land transport of goats (proposed)</td>
<td></td>
</tr>
<tr>
<td>Animals at saleyards SCARM 31</td>
<td>1992</td>
</tr>
</tbody>
</table>

Table 6.4 State codes of practice for the welfare of animals relevant to pre-slaughter management of livestock.

<table>
<thead>
<tr>
<th>Title</th>
<th>Publish Date</th>
<th>Jurisdiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code of practice for the transport of cattle in Western Australia</td>
<td>March 2003</td>
<td>Western Australia</td>
</tr>
<tr>
<td>Code of practice for the transport of sheep in Western Australia</td>
<td>March 2003</td>
<td>Western Australia</td>
</tr>
<tr>
<td>Code of accepted farming practice for the welfare of cattle</td>
<td>October 2001</td>
<td>Victoria</td>
</tr>
<tr>
<td>Code of accepted farming practice for the welfare of animals at saleyards (Vic)</td>
<td>August 2001</td>
<td>Victoria</td>
</tr>
</tbody>
</table>

Table 6.5 Animal welfare legislation within each state.

<table>
<thead>
<tr>
<th>State</th>
<th>Name of Legislation</th>
<th>Principal Animal Welfare</th>
<th>Department administering Animal Welfare legislation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Capital</td>
<td>Prevention of Cruelty to Animals Act 1979</td>
<td></td>
<td>Primary Industries</td>
</tr>
<tr>
<td>New South Wales</td>
<td>Prevention of Cruelty to Animals Act 1979</td>
<td></td>
<td>Community Development, Sport and Cultural Affairs</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>Animal Welfare Act 2000 (25)</td>
<td></td>
<td>Primary Industries and Fisheries</td>
</tr>
<tr>
<td>Queensland</td>
<td>Animal Care and Protection Act 2001</td>
<td></td>
<td>Environment and Heritage</td>
</tr>
<tr>
<td>South Australia</td>
<td>Prevention of Cruelty to Animals Act 1985</td>
<td></td>
<td>Primary Industries, Water and Environment</td>
</tr>
<tr>
<td>Tasmania</td>
<td>Animal Welfare Act 1993</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Victoria</td>
<td>Prevention of Cruelty to Animals Act 1986</td>
<td></td>
<td>Primary Industries</td>
</tr>
<tr>
<td>Western Australia</td>
<td>Animal Welfare Act 2002</td>
<td></td>
<td>Local Government and Regional Development</td>
</tr>
<tr>
<td>Commonwealth</td>
<td>Australian Meat and Live-stock Industry Act 1997</td>
<td></td>
<td>Agriculture, Fisheries and Forestry</td>
</tr>
</tbody>
</table>
Table 6.6 Government committees involved with NMCOP.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Membership</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIMC</td>
<td>Primary Industries Ministerial Council (Australian/State/Territory and New Zealand government ministers responsible for agriculture, food, fibre, forestry, fisheries and aquaculture industries/production and rural adjustment policy)</td>
<td>Peak government forum for consultation, coordination and, where appropriate, integration of action by governments on primary industries issues. Meets twice per year.</td>
</tr>
<tr>
<td>PISC</td>
<td>Primary Industries Standing Committee Departmental Heads/CEOs of relevant Australian/ State/ Territory and New Zealand government agencies, New Guinea is an observer</td>
<td>Supports PIMC</td>
</tr>
<tr>
<td>AWWG</td>
<td>Animal welfare working group</td>
<td>Committee responsible to PISC</td>
</tr>
<tr>
<td>LGRDWA</td>
<td>Department of Local Government and Regional Development Government of Western Australia</td>
<td>Administers Animal Welfare Act 2002 and Regulations (WA).</td>
</tr>
<tr>
<td>Safemeat</td>
<td>Committee with Industry and government members Secretariat located in Australian Government Department of Agriculture, Fisheries and Forestry, Edmund Barton Building, Canberra</td>
<td>Safe Meat, to ensure that red meat products achieve the highest standards of safety and hygiene from farm to consumer and to provide strategic direction and policy advice to the red meat industry.</td>
</tr>
</tbody>
</table>

Figure 6.3 Relationships between government committees, NMCOP and the livestock industry.

Use of NMCOP
An important function of NMCOP is to form the basis for legal argument about livestock management practices hence prosecution of offenders by the appropriate government agency when necessary. However a code breach is likely to be prosecuted only when accompanied by an adverse welfare outcome. Monitoring compliance with NMCOP is not routine and to date prosecutions for breaches of NMCOP recommendations have been an uncommon event.
NMCOP also have the function of being a point of reference for industry bodies as well as government agencies. Some industry bodies provide their members with literature that include animal welfare information. For example “Is it fit to load? A guide to the selection of animals fit to transport in WA” is supported by a range of bodies including the Livestock Transporters Association, Pastoralists and Graziers Association and Western Australian Farmers Federation. Several quality assurance programs such as Truckcare, Flockcare, and Cattlecare also have an animal welfare component. All of these activities refer to or draw on the NMCOP as the basis for animal welfare recommendations.

**Summary of sheep welfare**
Sheep welfare is an important consideration during all phases of the pre-slaughter period. National model codes of practice contain the minimum requirements to ensure the welfare of livestock during this period. Further research is planned to determine the effects of feed and water deprivation on the travelling welfare of livestock.

### 6.5 Meat quality and yield

Both meat quality and yield can be affected by management during the pre-slaughter period.

**Liveweight loss**
Liveweight loss is particularly relevant for estimating the value of livestock when they are sold live rather than “over the hooks” as carcases. Livestock valuers may impose a curfew period before weighing animals for valuation purposes to reduce liveweight variability due to gut fill. Liveweight loss occurs due to a reduction in the weight of the gastrointestinal tract (gut fill) as well as carcase weight loss. Over a 48 hour pre-slaughter period losses in live weight of up to 15% can occur depending on conditions. Meat and Livestock Australia recommend the following benchmarks (Anonymous, 2005) for estimating the effect of time off feed on dressing percentage: 1% after 4 hours off feed, 2% after 12 hours off feed, and 4% after 24 hours off feed.

**Carcase weight loss**
Carcase weight loss influences the value of the meat harvested although the impact of a change in carcase weight will depend on how the sheep have been traded. When sold over “the hooks” the producer will bear the cost of carcase weight loss rather than the processor and vice versa when the sheep have been sold as live animals.

Thompson et al (1987) found a curvilinear relationship between carcase weight loss and feed deprivation time. They found no extra loss due to stress associated with transport apart from that due to feed and water deprivation.

*Figure 6.4 The effect of fasting on carcase weight loss adapted from Thompson et al (1987).*

Carcase weight loss can be due partly to tissue mobilisation to satisfy the energy requirements of the animal but dehydration is also important. Dehydration causes a loss of fluid from muscle tissue which decreases muscle weight, muscle volume, carcase weight, condition score as estimated by
GR tissue depth, and dressing percentage (Jacob et al., 2005). After a 48 hour period of water deprivation, carcase weight loss due to dehydration may be in the order of 2-3% for lambs.

One study at 2 commercial abattoirs estimated that about 50% of lambs are dehydrated at the time of slaughter. This study associated dehydration at the time of slaughter with a number of factors including: long farm curfew times, lamb age-sucker lambs were more susceptible than carry over lambs, time of the year- lambs slaughtered in winter were more susceptible to dehydration than lambs slaughtered in summer, and location, lambs in cool locations were more susceptible than lambs in warm locations. A conclusion from this study was that lambs may fail to drink in lairage even when water is made available and this may be the cause of dehydration at the time of slaughter.

Bruising in sheep is not as prominent and issue as it is for cattle. Pulling sheep by the wool is considered to be the major cause of bruises. Dog bites can also reduce carcase weight by causing a bruise that has to be trimmed after slaughter.

**Meat quality**

Meat quality is defined as the traits which are; (a) appealing to the eye when the consumer views the meat prior to purchasing and (b) appealing to the palate when the consumer eats the meat. Thus meat colour is a visual quality trait which the consumer uses to judge the quality and important palatability traits are tenderness, juiciness, chewiness and flavour. The main meat quality defect that may manifest as a result of stress between farm and slaughter is “dark-cutting” high ultimate pH meat. Dark-cutting meat is a direct consequence of low muscle glycogen levels at slaughter. Dark-cutting meat is dark and therefore less acceptable to the consumer, with variable tenderness, reduced shelf-life and bland flavour. Stress and exercise during the curfew period can reduce muscle glycogen concentration and possibly hydration status at the time of slaughter. Prevention of stress and exercise during the pre-slaughter period therefore has a major role to play for the eating quality and retail appearance of red meat.

However the effects of stress and exercise on muscle glycogen concentration hence meat eating quality is likely to be related to the nature rather than the length of the curfew period. Fasting alone does not cause glycogen mobilisation in muscle tissue. Exercise is the most potent cause of muscle glycogen mobilisation although this must be anaerobic (sustained sprinting) in nature. Evidence suggests that fasting may actually improve tenderness through activation of calpain enzyme systems that breakdown myofibrilla proteins. Slaughtering on arrival may also cause meat to have a high ultimate pH (pHu) without causing a reduction in muscle glycogen concentration. Although the reasons for this are not fully understood it seems that there is a need for rest following transport. A lairage period of 1 day is currently considered optimal for lamb meat quality (Young et al., 2006).

Finishing diets fed should contain sufficient metabolisable energy to maximise muscle glycogen concentration prior to consignment for slaughter. However more research is required to determine the effect of diet type on the rate of muscle glycogen turnover and the susceptibility to glycogen loss due to stress during transport. Water loading strategies, such as feeding high concentrations of salt or the osmoregulatory compound betaine, prior to the pre-slaughter period do not improve hydration status at the time of slaughter and may increase urine production during transport. Finding methods to increase water intake in lairage is an important area for future research to reduce the incidence of dehydration at the time of slaughter.

**6.6 Biosecurity**

Large distances can be covered when transporting livestock from farm to slaughter. Furthermore transport vehicles may visit several properties in the process of assembling a load on their way to the final destination at an abattoir. This poses the risk of livestock transport acting as a conduit for the spread of noxious plants, animals and parasites. The primary biosecurity risk is weed dispersal although sheep are considered to be less of a risk than cattle in this regard due to higher mastication rates and preferential digestive processes. Studies show that hard seeds survive passage through ruminant digestive tracts better than soft seeds and all continue to be excreted several days after consumption. Some WONS (weeds of national significance) are potential biosecurity risks during livestock transport. Studies have shown that their seeds can survive passage through cattle, and can be successfully spread by attachment to skin and hides of animals. Little is known about the effect of curfew on seed survival, however since peak seed
excretion occurs for 2 – 4 days after ingestion, curfews of less than 48 hours are likely to be ineffective in preventing dispersion.

A range of animal pathogens can potentially be transmitted between different consignments when transporting live sheep. These include specific enteric pathogens such as *Mycobacterium paratuberculosis* (the cause of Ovine Johnes Disease) and helminth parasites (*Ostertagia* spp, *Trichostrongylus* spp, *Haemonchus contortus*). Other pathogens, such as the causative organism of footrot (*Dichelobacter nodosus*), may not be derived from faecal material but can simply survive in organic material on trucks and represent a risk to sheep loaded subsequent to an infected load. Similar to weed seeds, animal disease pathogen excretion is not likely to be affected by the length of the curfew time. Expression of helminth eggs is not affected by short-term fasting, which is of insufficient duration to affect the animal’s immune system. From a biosecurity perspective there is thought to be little if any benefit in a curfew extended curfew on farm prior to transport.

### 6.7 Environmental contamination

Manure spillage is the principle environmental risk associated with livestock transport, especially in wet weather. Manure is offensive and highly polluting – even at low mass quantities. Very large mass loads of contaminants are associated with a single B-double vehicle load of animals (equivalent to sewage from a town of 250 persons). While it is unlikely that the entire manure load will be spilled (although this can not be discounted in wet weather), environmental risks include contamination of transport routes and environs with soluble organic matter, suspended solids, nutrients (nitrogen and phosphorus) and micro-organisms. On drying, this may generate contaminated dusts. In wet weather, it will generate contaminated runoff and wheel and slipstream sprays.

From an environmental protection viewpoint, the greatest environmental benefit is achieved by reducing the manure load excreted during transport, when it is at highest risk of escaping to the environment. The literature suggests that very significant reductions in manure load (50% or more) and contaminant mass are achieved by a 24 hour curfew off feed for cattle. Curfews shorter than 24 hours may also be beneficial, but data are lacking, whereas longer curfews (up to 48 hour) have little additional benefit in reducing manure output. Curfew also appears to improve manure consistency, making it less susceptible to spillage. There are no equivalent studies for sheep or goats.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Live weight (kg)</th>
<th>Ave. no. in B-double</th>
<th>Mass of manure (kg/ head/day)</th>
<th>Contaminant (kg/truck/6 h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>450</td>
<td>65</td>
<td>6.8</td>
<td>440</td>
</tr>
<tr>
<td>Sheep</td>
<td>40</td>
<td>650</td>
<td>0.4</td>
<td>260</td>
</tr>
</tbody>
</table>

The beneficial impact of curfew is reduced for long-haul (greater than 8 hours) transport pathways when animals may need water and feed during travel to address animal welfare concerns.

### 6.8 Optimal management of the pre-slaughter period

In trying to optimise the pre-slaughter management of sheep there is potential for conflict between the competing key issues of food safety, animal welfare, meat quality, meat yield, environmental contamination, and biosecurity. However there is sufficient commonality evident between the recommendations for each issue to reach a compromise in terms of feed and water deprivation periods. In particular extended curfew times beyond 24 hours can not be justified on the scientific information available for the issues such as environmental contamination, for which a curfew period has value.

A summary of the recommendations from each discipline segment is shown in Table 8. The maximum time off feed is recommended at typically around 48 hours to comply with food safety, meat quality and welfare recommendations. Importantly any period of reduction in total time off
feed below 48 hours would deliver very significant gains in carcase weight and lean meat yield. Accordingly the curfew period should sufficient to allow faecal expulsion to maintain ‘clean’ livestock after transport. It is likely that this curfew period might typically be less than 24 hours.

Table 6.8 The recommended time period (hours) off feed or water to maximise each of the discipline segments.

<table>
<thead>
<tr>
<th>Discipline Segment</th>
<th>Feed Curfew</th>
<th>Total time off feed</th>
<th>Water recommendation when not in transport</th>
<th>Total time off water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food safety</td>
<td>≤24h (enough to ensure clean hides/pelts)</td>
<td>≤48h (minimise pathogen over growth)</td>
<td>Available</td>
<td>NA&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Environmental</td>
<td>≤24h (minimise faecal prodn.)</td>
<td>NA</td>
<td>Available</td>
<td>NA</td>
</tr>
<tr>
<td>Biosecurity</td>
<td>≥48-72h (minimise seed loss in faeces)</td>
<td>NA</td>
<td>Available</td>
<td>NA</td>
</tr>
<tr>
<td>Meat quality</td>
<td>NA</td>
<td>cattle ≤ 36h sheep ≤ 48h (minimise dark cutting)</td>
<td>Available</td>
<td>Manage hydration index (urine specific gravity)</td>
</tr>
<tr>
<td>Carcase loss</td>
<td>NA</td>
<td>cattle ≤ 24h sheep ≤ 12h (carcase shrink after this time)</td>
<td>Available</td>
<td>Manage hydration index (urine specific gravity)</td>
</tr>
<tr>
<td>Welfare</td>
<td>Unknown (effects on transport stress not known)</td>
<td>cattle ≤ 48h sheep ≤ 48h</td>
<td>Available</td>
<td>adult cattle ≤ 36&lt;sup&gt;b&lt;/sup&gt; adult sheep ≤ 36 young sheep ≤ 20</td>
</tr>
</tbody>
</table>

<sup>a</sup>NA – no recommendation since not relevant; <sup>b</sup>Adult cattle or sheep defined as dry and > 6 months of age. Young sheep defined as lamb < 6 months of age. Recommendations same as NMCOP including special cases for extension.

Readings

The following readings are provided on e-reserve


Chapter 29 of the International Sheep and Wool Handbook provides a good coverage of this topic.
References


Mulcahy, P., 1998. 'Livestock Transport Farmnote.' Western Australian Department of Agriculture.


Phillips, A., 1997. 'Electrolyte and sugar supplements for slaughter cattle transported long distances.' In Final Report, Alice Springs, Northern Territory Department of Primary Industry and Fisheries, Meat Research Corporation.


