Guideline 23
June 2010

Guidelines for the Housing of Sheep in Scientific Institutions

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Recommendations

The following recommendations appear in the body of the text.

The Australian Code of Practice for the Care and Use of Animals

1.2.1.1 Institutions using sheep for scientific purposes are responsible for responding effectively to recommendations of the institution's Animal Ethics Committee to ensure that facilities for the housing and care of sheep are appropriate to the maintenance of well-being and health of the sheep.

1.2.2.1 The chief investigator/teacher (person in charge of a research/teaching project) has personal responsibility for all matters related to the welfare of sheep under his or her control, which includes their housing and care. (As per the principle contained in Clause 3.1.1 of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes)

1.2.2.2 The chief investigator/teacher should ensure that the extent of personnel / staff supervision is compatible with the level of competence of each person and the responsibilities they are given in relation to sheep care and management. (As per the principle contained in Clause 3.1.2 of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes)

Aspects of sheep behaviour relevant to housing and handling

1.3.1.1 Sheep should be accommodated so that they have visual and auditory contact with other sheep and preferably with familiar cohorts.

Social structures

1.3.2.1 As the dominant social characteristic of sheep is their flocking behaviour, sheep should not be housed in isolation unless justified for the purposes of the research and with the express permission of the Animal Ethics Committee.

1.3.2.2 Sheep should be handled and housed in stable groups of at least five animals where possible.

Lamb rearing

1.3.3.1 Where possible lambs should be raised with their mothers for normal social and emotional development. They should only be raised without their mothers with the approval of the AEC and, in this situation, they should be raised in groups in an environment that provides some social stimulation.

1.3.3.2

When lambs are to be isolated from con-specifics, they should be with a known handler rather than with a stranger.

Time budgets

1.3.4.1 Sheep should be provided with a well-drained area to rest and ruminate. This should be large enough to enable all sheep in the pen to lie down at once.

Behavioural responses of sheep to fear and distress

1.3.5.1 Sheep should be monitored closely for the subtle changes associated with fear, stress and distress.

1.3.5.2 Handlers should be aware that sheep behave differently in different situations depending on their breed, prior exposure or rearing experience.

Pain-related behaviour

1.3.6.1 Sheep should be monitored closely for the subtle changes associated with pain especially where pain is expected to be associated with procedures.

Summary of behavioural principles

1.3.7.1 For housing sheep, in addition to their normal requirements for food, water, exercise and shelter, particular consideration should be given to:
** their response to isolation and their need for social contact*
** the effect of space allowances and group size on social dynamics*
** their need to establish a maternal bond*
** their need to lie down and ruminate*
** their behavioural responses to pain.*

1.3.7.2 To provide accommodation that meets the species-specific needs of sheep, housing should be provided which allows sheep the opportunity for social interaction, the opportunity to carry out normal behaviours and the opportunity to rest and withdraw from each other.

1.3.7.3 People responsible for the day-to-day care of sheep should be aware of the signs of stress, distress and pain.

1.3.7.4 Sheep should be monitored for the varied behavioural patterns indicative of fear, distress and pain such as lethargy, inappetence, attempts to escape, shivering, agitation, foot-stamping, aggression, persistent bleating, grunting, tooth grinding, changes in ear posture, or changes in facial expression.

1.3.7.5 There may be circumstances where the requirements of experimental procedures will preclude meeting some species-specific needs. Housing in these situations should still meet the physiological and psychological needs of sheep as closely as possible and be expressly approved by an Animal Ethics committee.

Pen design

2.1.1 To meet the social needs of sheep, the walls of pens should be designed to allow sheep to view animal attendants and other sheep in the facility.

2.1.2 Where horizontal bars are used for pen fencing, the gap between the lowest bar and the floor should be wide enough to allow sheep to easily remove their legs from under the bar to avoid injury.

2.1.3 Pen surfaces should be impervious, easily sanitised and resistant to water and corrosive materials (such as animal manure and cleaning solutions). There should be no sharp edges or protrusions which may cause injury. Any paints or glazes should be non-toxic, lead-free, mould resistant and durable. Penning should be free from chemicals harmful to sheep.

2.1.4 Electrical fittings should be situated out of reach of sheep. Ideally electrical fittings should be waterproof to allow for pressure-washing of pens and rooms.

2.1.5 Outdoor pens should have adequate drainage to prevent water and mud buildup.

2.1.6 Outdoor pens should be provided with shelter from sun, wind and rain.

Pen height

2.2.1 As a guide, the walls of pens should be at least 850mm high for adult sheep.

Pen floor area

2.3.1 Group pens should provide enough space for the behavioural needs of the sheep to be met in terms of space to rest, move away from others and express normal species-specific behaviour.

2.3.2 As a guide, a space allowance of at least 1.5m^2 per adult sheep, with a minimum of 2m^2 for a single sheep, should be provided to ensure adequate lying space for all sheep.

2.3.3 As a guide, lactating ewes should be provided with 2.0 m^2 per ewe/lamb unit to ensure appropriate maintenance of air quality, principally microorganism count.

2.3.4 Sufficient space must be provided in pens so that there is a well drained area where all sheep can lie down at once to allow synchronisation of rest periods which encourages rumination.

Floor surface/bedding

2.4.1 Floor surfaces should be non-slip. Ideally surfaces should be abrasive enough to provide even wear on the hooves to minimize the need for hoof trimming while not causing excess wear that may result in discomfort or pain.

2.4.2 Suitable flooring surfaces for sheep in pens include deep litter (for example straw over sand), wooden slats, and galvanized steel panels.

2.4.3 The use of woven steel mesh flooring is not recommended because of the way sheep bear their weight on this surface.

2.4.4 For adequate drainage, solid floors should have a slope of 1:15.

2.4.5 As a guide, when using wooden slats, they should be 60mm wide with a 15mm gap.

2.4.6 As a guide, grating floors for ewes should be built with a web width of 35mm and gap of 15mm and for lambs, a web width of 18mm and gap 9mm.

2.4.7 If using deep litter, it should be managed to keep the surface dry. Management practices include spot cleaning, "top-up" of litter and replacement of litter at regular intervals, up to daily if necessary.

2.4.8 Sheep should not be housed for long periods on hard surfaces.

2.4.9 Sheep housed on wire mesh should be given plastic or rubber mats on which to lie. Ideally such mats should be woven to allow faeces and urine to pass through

2.4.10 Irrespective of the type of flooring, uneven hoof growth may occur and should be managed by regular hoof trimming.

2.4.11 There should be pens available with a thick layer of clean bedding for sheep in the first 2-3 days post surgery and this material should normally be changed daily.

Water supply/troughs

2.5.1 Enough trough space should be provided for all sheep in group pens to feed at once. A minimum of 160mm per sheep is recommended.

2.5.2 Troughs should be high enough to prevent contamination from faeces and bedding and shallow enough so that sheep can maintain eye contact while feeding.

2.5.3 Nipple drinkers, if used, should be placed above head height so that sheep spill less water while drinking.

Pen layout and handling facilities

2.6.1 The design of handling facilities should allow sheep an obstructed view of where they are to move.

2.6.2 As a guide, holding yards should allow one sheep per square metre and up to three sheep per square metre in forcing yards.

Temperature

3.1.1 Extremes of temperature, draughts and humidity should be avoided in housing of sheep.

3.1.2 Facilities with raised floors may be subject to wind chill. Facility design should consider minimizing this with such measures as wind breaks, blinds and barriers around the bottom of the shed. Husbandry procedures such as shearing can also be timed to reduce the possibility of chilling.

3.1.3 Particular care should be taken of recently shorn sheep and young lambs in conditions of extremes of temperature.

3.1.4 As a guide, the indoor temperature should be maintained between 10-24^{0}C, depending on fleece length.

Light

3.2.1 Lighting should be sufficient to allow observation and care of the animals and, unless specifically required for a project, should maintain a circadian rhythm.

Humidity

3.3.1 As a guide, humidity should be maintained between 40-60% to avoid excessively damp conditions.

Air quality

3.4.1 Good ventilation should be provided. Extractor fans should be set to remove 3m^3 air per kg bodyweight per hour to keep ammonia levels down.

Sound

3.5.1 Sudden loud noises should be avoided where possible because of their detrimental effect on resting behaviour.

Shelter

4.1.1 Shelter must be provided for sheep from extremes of weather especially when they are freshly shorn or new-born.

Adequacy of pasture and stocking rate

4.2.1.1 Sheep on pasture should have their fat score assessed regularly by an experienced operator and the quantity of pasture or supplement adjusted accordingly.

Hand feeding and how feed is provided

4.2.2.1 Advice should be sought from an experienced sheep nutritionist when formulating rations for hand-feeding of sheep.

4.2.2.2 When sheep are being hand-fed, they should be monitored regularly and fat scores manually assessed to determine the adequacy of the feeding regime.

4.2.2.3 Sheep may need to be trained to accept hand feeding. This is made easier if some of the sheep in the mob are already experienced.

4.2.2.4 Sheep should be observed during feeding so that any 'shy feeders' are identified and fed separately if necessary.

Water

4.2.3.1 Water (other than mains water) should be tested to ensure it is of adequate quality. If it contains potentially toxic levels of salts or other substances, it should be monitored and managed to minimise any deleterious effects.

4.3.1 Fencing should be adequate to prevent unwanted entry of people or other animals and should be regularly checked and maintained.

4.3.2 A management plan should be implemented for control of vertebrate pests, preferably coordinated with neighbouring properties, to maximise the effect of the control program.

Transport

5.1.1 Where possible, sheep should not be mixed with unfamiliar animals during transport.

5.1.2 Sheep should be rested on feed and water for at least 24 hours following transport prior to any research procedures being carried out unless otherwise justified to an Animal Ethics Committee.

Handling

5.2.1 Where possible, sheep should be moved toward other sheep and away from people and dogs.

5.2.2 When possible, young sheep should be moved through facilities with well-trained, older sheep.

5.2.3 When possible, the same path and direction should be maintained through facilities.

5.2.4 It is recommended that sheds are well lit to encourage sheep movement into and within the shed. Sheep should be moved towards the light from dark areas.

5.2.5 In the design of new facilities with slatted floors, the battens should be aligned across the direction of movement.

Handling of lambs

5.2.1.1 Where possible, sheep that will be subjected to intense handling or invasive experimental procedures should be handled and socialized with humans within the first 3 days of life.

Selection

5.3.1.1 On arrival to a facility, sheep should be treated for internal and external parasites and vaccinated against Clostridial diseases. They should be shorn and have their feet trimmed if necessary.

5.3.1.2 New arrivals should be acclimatised to handling and kept in groups of at least five in the initial period.

5.3.1.3 Any sheep that do not adapt to a feeding regime or handling procedures must be culled from the experimental group.

Management procedures

5.3.2.1 When sheep are brought from outdoor management into housing, changes to temperature and photoperiod should be progressed gradually where possible.

5.3.2.2 Sheep should be monitored for behavioural evidence of failure to adapt to housing or increased handling. If they fail to adapt within 14 days, they should be culled from the research group.

5.3.2.3 If animals are to be moved from holding pens to a laboratory for regular sampling, this procedure should be included in any adaptation schedule.

Experimental procedures

5.4.1 3-6 weeks of daily handling for at least 5-10 minutes (stroking of the head and neck and quiet talking) should be provided prior to commencement of prolonged invasive experimental procedures.

5.4.2 Sheep adaptation schedules should include moving sheep within the facility when this will be required as part of a research protocol.

5.4.3 During training, sheep should be exposed initially to minor treatments and severe treatments should be performed as little as possible.

5.4.4 Sheep should be acclimatised to and maintained in conditions where routines are consistent and sudden events are predictable.

Restraint

5.4.1.1 Use of restraint equipment should be for the minimum time required to achieve research objectives and sheep should be conditioned to the equipment prior to the initiation of the project.

Metabolism crates

5.5.1.1 Sheep should not be housed in metabolism crates unless with the express permission of the Animal Ethics Committee of the institution on the basis of compelling evidence for the need to house sheep in this way. In such cases, sheep should be able to be in visual contact with other sheep.

5.5.1.2 Long-term confinement must be justified and should not exceed 10 weeks. Where possible, sheep should be released from confinement for 3 hours a week, preferably spread over a number of sessions.

5.5.1.3 Sheep should be conditioned to metabolism crates for at least 5 days prior to experimental procedures.

5.5.1.4 Metabolism crates should be designed such that sheep do not need to be tethered.

5.5.1.5 Solid flooring should be provided in the front one third of metabolism crates to provide a more comfortable surface for resting.

Isolation

5.5.2.1 Sheep should not be housed in isolation unless with the express permission of the Animal Ethics Committee of the institution on the basis of compelling

evidence for the need to house sheep in this way. In such cases, where possible, sheep should be able to be in visual contact with other sheep.

5.5.2.2 When isolated, sheep should be given additional attention by an experienced animal technician.

5.5.2.3 The use of mirrors or life-sized images of familiar sheep may lessen the stress of isolation for sheep.

Food and water

5.6.1 Advice should be sought from an experienced sheep nutritionist when formulating rations for sheep.

5.6.2 Where possible, sheep to be used for research should be exposed to a variety of foods early in life, preferably when they are still with their mothers.

5.6.3 Sheep should be introduced gradually to new feeds, preferably in a familiar environment.

5.6.4 Sheep should be provided with adequate long-strand fibre to aid effective rumination.

5.6.5 As a guide, sheep need 4-6L of water daily, preferably available ad libitum. More should be provided to lactating ewes and weaned lambs; and in hot weather.

Restrictions on food and water

5.6.1.1 Prior to surgery, sheep should be fasted for 18-24 hours, depending on diet.

5.6.1.2 Pregnant ewes should be maintained on a highly digestible diet and fasted for 8-12 hours prior to surgery.

5.6.1.3 Water should be withheld from all sheep for 2-3 hours prior to induction of anaesthesia.

Environmental enrichment

5.7.1 To reduce the incidence of oral stereotypies, sheep should be provided with long-strand fibre (eg straw).

Cleaning

5.8.1 Manure slots and gutters should be sized and spaced to prevent hoof or leg injuries.

5.8.2 Care must be taken to avoid contamination of the animals' environment with any cleaning agents or other chemicals.

5.8.3 Mats and deep litter beds should be managed so that their surface is generally dry.

5.8.4 Water bowls should be checked and preferably cleaned daily.

Monitoring

5.9.1 Sheep should be monitored at least once daily so that changes in their condition are detected and appropriate action taken.

5.9.2 Sheep should be closely monitored to detect the subtle changes in behaviour indicative of pain, fear, distress or signs of disease.

Health

5.10.1 A comprehensive health and clinical monitoring program should be put in place in consultation with an experienced sheep veterinarian.

5.10.2 Sheep that do not shed their wool must be shorn at least once a year.

Breeding

5.11.1 Sheep breed in response to short day-length. If lighting is solely or mainly artificial, the period of lighting may have to be regulated to ensure normal reproductive function in ewes and rams.

5.11.2 A clean, dry area must be provided for ewes to give birth.

5.11.3 Research procedures involving recently lambed ewes and/or their lambs should avoid disturbing the sheep in the period when establishment of the maternal bond is occurring, unless expressly approved by the Animal Ethics Committee.

5.11.4 Where possible, lambs should remain with their mothers for at least 15 days after birth for normal weight gain and development of the immune system.

Identification

5.12.1 All sheep should be individually identified to facilitate accurate record keeping.

Records

6.1 Individual records should be kept of sheep that record birth date, sex, breed, source of the sheep and any previous use of the sheep. Records should include all stock movements as well as any signs of ill-health or distress, any veterinary treatments administered (date and nature of treatment) and any mortalities.

6.2 All veterinary treatments, whether medical or husbandry-related, should be recorded. Any procedures carried out (experimental or otherwise) and the outcomes of procedures should also be recorded.

Pen labels

6.1.1 Pen labels should record the number of animals and their identification codes; protocol number; and the name and contact details of the chief investigator and emergency contacts.

Breeding records

6.2.1 Records of breeding stock should be maintained which will allow effective management and monitoring of breeding activities. These should include the source, use and fate of all sheep; details of any disease; fertility, fecundity, morbidity and mortality of all sheep; and the health status of the sheep.

1. General

1.1 Introduction

(i) These guidelines are designed for use by everyone involved in the holding and care of domestic sheep (*Ovis aries*) in scientific institutions. They are not intended to be a complete manual of the husbandry of sheep, nor are they a static document. They will be regularly revised to take account of advances in the understanding of sheep physiology and behaviour, technological advances, and changes in community attitudes and expectations about the welfare of sheep.

(ii) The guidelines are based on principles regarding the care and management of sheep taken from scientific literature. These principles are detailed throughout the document, as are recommendations which are derived from these principles. In some areas, conclusions to be drawn from the available literature are not entirely clear, and in such areas recommendations are extrapolated from information available and practices in sheep care and management current at the time of writing.

(iii) The principles outlined in the document address requirements of the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes* (as outlined below in Section 1.4). The requirements of the Code of Practice include that animals held for scientific purposes should have their species-specific behavioural and physical needs met, whilst at the same time ensuring that the animals can adequately be monitored and are protected from disease, and taking into account the requirements of the research for which the animals are being used.

(iv) Whilst the guidelines focus on the welfare of sheep, it is implicit that conditions that contribute to meeting the physiological and behavioural needs of sheep will also contribute to the quality of scientific outcomes. The guidelines contain many examples of the physiological and behavioural responses of sheep associated with variables in housing and hence the potentially confounding effects of these variables on these animals as research subjects.

(v) The guidelines, in the main, outline requirements for the housing of normal sheep. Where sheep are physically or behaviourally abnormal (for example post-surgery), modifications to housing to meet their needs may be required.

(vi) Sheep are used in a variety of experimental circumstances which will need to be considered when determining the type of housing provided. The kinds of studies in which they are most often used include:

- physiological/ pharmacological/ nutritional studies which may involve the use of surgically instrumented animals;
- studies which require access to individual animals for data collection;
- studies which will require “barrier” housing eg. SPF animals or PC_2;
- studies which require climate control;
- studies which require particular housing needs eg ectoparasite challenge or parasitological work;
- experimental surgical models eg transplantation and orthopaedics; and
- field trials.

(vii) Thus the need for a particular type of housing will be determined by
- the needs of the individual animal in each specific circumstance;
- the kind of access needed to individual animals for data collection or special management;
- requirements for biocontainment; and
- requirements for environmental controls.

(viii) There will also be a need for designated housing for
- pre- and post-operative management;
- conditioning;
- acclimatisation.

1.2 The Australian Code of Practice for the Care and Use of Animals for Scientific Purposes

(i) The *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes (7th Edition)* (NHMRC 2004) specifies responsibilities with respect to the holding of animals for scientific purposes. All personnel involved in the use of sheep in scientific institutions should be familiar with the Code especially section 2 Responsibilities of institutions and their animal ethics committees; section 3 Responsibilities of investigators and teachers; section 4 Acquisition and care of animals in breeding and holding facilities; and section 6 The use of animals in teaching.

1.2.1 Responsibilities of Institutions

Recommendations

1.2.1.1 Institutions using sheep for scientific purposes are responsible for responding effectively to recommendations of the institution's Animal Ethics Committee to ensure that facilities for the housing and care of sheep are appropriate to the maintenance of well-being and health of the sheep.

1.2.2 Responsibilities of Chief Investigators / Teachers

Recommendations

1.2.2.1 The chief investigator/teacher (person in charge of a research/teaching project) has personal responsibility for all matters related to the welfare of sheep under his or her control, which includes their housing and care. (As per the principle contained in Clause 3.1.1 of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes)

1.2.2.2 The chief investigator/teacher should ensure that the extent of personnel / staff supervision is compatible with the level of competence of each person and the responsibilities they are given in relation to sheep care and management. (As

per the principle contained in Clause 3.1.2 of the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes)

1.3 Aspects of sheep behaviour relevant to housing and handling

1.3.1 Background

(i) Sheep are grazing animals, traditionally used for a number of production purposes including fibre, meat and milk. There are many breeds of domesticated sheep, showing a significant variation in some behavioural characteristics. Variations are particularly notable in the intensity of gregariousness and flocking responses, from the highly gregarious Merino to the individualistic Scottish Blackface (Lynch et al 1992).

(ii) Dwyer (2004) suggests that the basic need to defend themselves against predators is a strong factor in determining the behaviour of sheep, even in domesticated breeds. Responses can be divided into those elicited by the immediate presence of a predator and those evolved to minimise chances of detection and capture.

(iii) Sheep may allow a predator to approach to a certain point, before responding. This distance from the sheep is known as the 'flight distance' (Dwyer 2004) and can be used in handling sheep. Sheep in groups frequently bunch together and run in circles, a behaviour which may reduce the risk of predation (Triesman 1975b).

(iv) Sheep have a wide field of vision with a blind area of only 90^0. They have some colour vision, particularly colours with longer wave lengths (dark), and good depth perception (Lynch et al 1992). Sight is a vital part of communication and they continually monitor each other to maintain contact while grazing.

(v) Sheep are able to amplify and pinpoint sound with their ears, because a sound arrives at each ear with a small difference in amplitude. This allows them to process the sound into a directional signal (Gill, undated). They have a wide range of auditory sensitivity, especially in the upper frequency ranges, between 7 and 30kHz (Lynch et al 1992, Wollack 1963).

(vi) Sight and hearing are also critical in enabling ewes to locate their lambs, although Morgan et al (1975) suggested that recognition of the lamb by the ewe is confirmed mainly by smell. Lambs also rely on sight and vocal communication to locate their mothers. Alexander (1977) suggests that visual cues become more important than auditory ones in 2 to 4 week old lambs compared with younger lambs and similarly, Shillito Walser (1978) concluded that as lambs got older, sight became more important than sound in assisting ewes to successfully locate their lambs. In breeds where markings were very similar between individuals, vision and vocalisation appeared to be of equivalent importance for lambs in locating the ewe, but in breeds such as the Jacob, where individuals have distinctively marked coats, lambs appeared to rely more upon vision than vocalisation to identify their mothers (Shillito 1975).

(vii) Vocal communication is thought to be essential in establishing the maternal bond between ewes and lambs (Nowak 1990, 1996). Shillito (1972) reported two distinct

types of bleat produced by ewes, a low pitched bleat described as a "rumble" and a higher pitched sound. Dwyer et al (1998) reported that the low pitched rumble was made almost exclusively by ewes to their lambs, was usually associated with other behaviours such as grooming of the lamb and played a role in the strengthening of the maternal bond. This type of vocalisation was recorded more frequently in primiparous ewes than in multiparous animals and was also more frequent in a less selected breed (Scottish Blackface) compared with a highly selected one (Suffolk). It was considered to be intrinsically influenced by the physiology of the ewe in the early post-partum period and not affected by the vocalisation of the lamb. The higher pitched bleat is used by the ewe to assist in locating her lamb and used by lambs in identifying and locating their dam (Shillito 1975). Shillito Walser et al (1981) found that ewes responded more frequently to recorded voices of their own lambs compared with recordings of unfamiliar lambs, concluding that the ewes recognised their own lambs on voice alone. The addition of a visual stimulus in the form of a model lamb, increased the responsiveness of the ewes to the sound of their own lamb in these experiments. In further investigating the importance of auditory communication, Sèbe et al (2007) found that in the absence of visual and olfactory cues, ewes had developed the ability to identify the bleat of their own lamb between 12 and 24 hours after giving birth and lambs were able to identify the voice of their mothers between 24 and 48 hours post partum.

(viii) Gill (undated) states that sheep have a more sensitive sense of smell than humans. Olfaction is important in social interaction with other sheep, in development of the maternal bond with lambs, in sexual behaviour, and also in location of water and identification of preferred feeds. Chapple & Wodzicka-Tomaszewska (1987) showed that, if one sense is impaired, the other senses are substituted when learning to eat wheat. They concluded that sight, olfaction and hearing are all used in transmission of learning associated with social transmission of feeding behaviour.

(ix) The major problems that will be associated with bringing sheep into a research situation, other than those imposed by the research itself, relate to confinement in housing and the inability of the sheep to fully express their natural behaviour patterns. The lack of space associated with confinement prevents escape from the stresses associated with dominance behaviour (Lynch et al 1992). Sheep adapt best to husbandry systems that provide consistency in routine and in group composition (Fraser 1995).

Recommendations

1.3.1.1 Sheep should be accommodated so that they have visual and auditory contact with other sheep and preferably with familiar cohorts.

1.3.2 Social structures

Principles

(i) The dominant social characteristic of sheep is their flocking behaviour. It aids in finding a mate, finding food, the care of young and evasion of predators (Triesman 1975a). This behaviour can be used to move or control sheep. Individual animals are almost impossible to control as they panic when not in visual contact with other

sheep. It is suggested that a minimum of four or more sheep are necessary before predictable behavioural responses can be expected (Lynch et al 1992).

(ii) Individual sheep can discriminate other individuals within a flock. They have a strong tendency to form associations within breeds, rather than between breeds, probably due to inherited characteristics that allow individuals to discriminate breed identity (Arnold & Pahl 1974). Sheep show preferences for particular faces independent of learning, showing that face-recognition is used as a part of normal daily life (Kendrick 1995). They can remember the faces of con-specifics for up to two years (Kendrick et al 1996). Sheep can distinguish between calm and stressed faces of both sheep and humans, showing a distinct preference for a calm face, even when the stressed face is a familiar one and the calm face is not. Important features used in this distinction are the ear position (flattened against the head), the amount of white showing around the eyes and the degree of pupil dilation (da Costa et al 2004). It takes lambs as long as 1-2 months to recognise their own mother's face (Kendrick 1998) and ewes distinguish their lambs from others almost entirely by smell (Arnold & Pahl 1974, Morgan et al 1975).

(iii) Within a flock, sheep have strong dominance hierarchies and social structures which vary both between and within breeds. Social dominance effects can be very important in situations where there is a high stocking density and dominant animals can control resources at the expense of subordinate animals. Social and behavioural requirements are disturbed if there is not adequate space provided so sheep can maintain a minimum distance between each other; if there is not enough feeding or resting space for all animals; if regrouping is carried out frequently; or if group sizes are very large (Fraser 1995).

(iv) Play behaviour is common in both adult sheep and lambs. Lynch et al (1992) suggest that in adults, it is most common in animals in positive energy balance. They also suggest that it involves the establishment and development of behaviours necessary for social and sexual interactions.

(v) Although the effects of group size on experimental design are yet to be fully explored, it has been suggested that group size is important. Jorgensen et al (2009a) showed that ewes in large groups (36 animals) had an increased variation in resting time; rested and fed less synchronously; and spent less time queuing at the feed barrier than ewes in smaller groups (9 animals). However, they still behaved aggressively, the usual form of aggression being pushing other ewes to displace them from the feed or resting place. This may result in a significant reduction in the ability of lower-ranked animals to feed and rest if resources are limited.

Recommendations

1.3.2.1 As the dominant social characteristic of sheep is their flocking behaviour, sheep should not be housed in isolation unless justified for the purposes of the research and with the express permission of the Animal Ethics Committee.

1.3.2.2 Sheep should be handled and housed in stable groups of at least five animals where possible.

1.3.3 Lamb rearing

Principles

(i) Rearing conditions influence behaviour in sheep. A close maternal bond is important for the normal social and emotional development of sheep. It is very difficult to change behaviours that have been learned from the mother (Gilbert & Kendrick 1999). Lambs raised in a social environment tend to respond by interacting with a stimulus whereas lambs raised in isolation tend to withdraw. However there is no difference between the groups with respect to their adrenocortical response to the stress of a novel environment (Moberg & Wood 1982). Every effort should be made to rear lambs in an environment that provides some social stimulation. This can be provided by rearing them with their peers (Moberg & Wood 1982), however young lambs do form strong social bonds with each other, humans or other animals.

(ii) Lambs reared in artificial conditions can discriminate between their handler and an unknown handler (Boivin et al 1997). They can also associate different handlers with different reinforcement histories (Davis et al 1998). Lambs are less disturbed by isolation from other lambs when in the presence of known handlers than with a stranger. This could help the known handler and increase handling difficulties for a stranger (Boivin et al 1997).

(iii) When solid feed is available, lambs will begin to nibble at it from about 10 days of age. They will consume it as a substantial proportion of their diet by 8 weeks of age (Gill, undated).

Recommendations

1.3.3.1 Where possible lambs should be raised with their mothers for normal social and emotional development. They should only be raised without their mothers with the approval of the AEC and, in this situation, they should be raised in groups in an environment that provides some social stimulation.

1.3.3.2 When lambs are to be isolated from con-specifics, they should be with a known handler rather than with a stranger.

1.3.4 Time budgets

Principles

(i) In the field, sheep normally graze for about 9-11 hours daily. Grazing is generally in cycles interrupted by periods of rest, rumination and idling. It is important to provide rest periods to encourage rumination. The longest periods of grazing are in the early morning and between late afternoon and dusk. Sheep ruminate at irregular times during the day and night, up to about eight times daily. Rumination can occupy about eight hours per day in total (Hulet et al 1975).

(ii) Sheep in an animal house have a daily pattern of behaviour that varies according to the time of day, to the activities of handlers and to the length of time in the animal house. Sheep that have been in the animal house for several months pay more

attention to their surroundings, compared to newly introduced sheep which tend to withdraw and spend more time in a non-alert state (Done-Currie et al 1984).

(iii) It is important to provide a well drained area for sheep to rest and ruminate. They generally lie down to ruminate and the space should be large enough to accommodate all sheep in the pen to lie down at once. Sheep have a strong social motivation to synchronise activities (ie all graze or rest at the same time) and a reduction of synchronization of lying can be regarded as a negative indicator of welfare (Boe et al 2006).

Recommendation

1.3.4.1 Sheep should be provided with a well-drained area to rest and ruminate. This should be large enough to enable all sheep in the pen to lie down at once.

1.3.5 Behavioural responses of sheep to fear, stress and distress

Principles

(i) Signs of fear in sheep vary according to the situation and breed. They include immobilization, attempts to escape a situation, shivering and foot-stamping. Sheep may adopt an 'alarm posture' where they stand immobile, staring forward, with their ears pricked (Lynch 1992). The alarm response in sheep is normally activated by visual stimuli.

(ii) Wemelsfelder & Farish (2004) distinguish fear from timidity, which is the sheep's response to an aversive situation. This is a learned behaviour and manifests as resistance to approach a certain situation or person.

(iii) In some situations sheep may become agitated, when they move back-and-forth, bleat persistently and behave aggressively with head-butting, rearing, stamping and kicking. Situations that commonly provoke this type of behaviour include social isolation, separation of mother and young, mixing with unfamiliar sheep, rough handling, transport and physical restraint (Wemelsfelder & Farish 2004).

(iv) Reefmann et al (2009) examined the ear posture of sheep in situations expected to provoke negative and positive emotions in sheep. They found that a negative emotional state tended to be associated with a large number of changes in ear posture, indicating an increased awareness of the surroundings. In contrast, positive emotional states tended to be associated with passive ear posture ie they hung down loosely. Observations of tail posture in the same situations did not give any clear associations. A raised tail may indicate both strong positive and strong negative emotional states.

(v) Sheep become alert in the presence of humans and will retain visual contact with them unless they turn to flee (Lynch et al 1992). The presence of a human can have a distinct effect on behaviour in that there can be an inhibition of active behaviour such as locomotion and vocalization and also of defaecation. This could be regarded as a reaction to a predator (Romeyer & Bouissou 1992).

(vi) Cockram (2004) points out that care should be taken in interpreting behavioural changes in sheep. Locomotory activity may indicate an attempt to escape (indicating fear), but it may also indicate social motivation and exploration. On the other hand, immobilisation may reflect docility in the absence of fear, or may indicate withdrawal and a high degree of anxiety (Romeyer & Boisseau 1992).

(vii) Dwyer and Bornett (2004) describe several different behaviour patterns that may be associated with chronic stress. Under some conditions, especially those of behavioural restriction and confinement, sheep may be apathetic or show low levels of activity. Hyperactivity, agitation or aggression may be provoked by situations such as rough or pressured handling, high stocking density or confinement, and some disease conditions such as external parasitism. Other disease conditions may be associated with decreased feed intake including lameness, internal or external parasitism and it may also be associated with isolation, restraint or high stocking density. Sheep which are chronically stressed may deviate from group activities. Physiological indicators of stress include decreased immunity which may manifest as a higher incidence of disease or parasitism, and impaired reproduction.

(viii) Dwyer (2004) states that there appears to be a genetic difference between breeds in their responsiveness to stressors which may be modified or potentiated by experience. Thus sheep may behave differently in different situations depending on their prior exposure or rearing experience.

Recommendation

1.3.5.1 Sheep should be monitored closely for the subtle changes associated with fear, stress and distress.

1.3.5.2 Handlers should be aware that sheep behave differently in different situations depending on their breed, prior exposure or rearing experience.

1.3.6 Pain-related behaviour

Principles

(i) As prey animals, sheep may be in serious pain without showing any symptoms. Close observation is needed to detect subtle changes in behaviour such as lethargy, inappetence and a change in facial expression. Severe pain may manifest as rapid, shallow respiration. On handling, they may react violently or otherwise stand rigidly so that the affected region is immobilised. They may occasionally grind their teeth or grunt (Sanford et al 1986) or withdraw from the group with an abnormal stance or lying position (Wemelsfeder & Farish 2004).

(ii) In a study of sheep with footrot, it was found that mild footrot (and presumably mild pain) did not result in levels of cortisol, vasopressin and prolactin significantly different from the levels found in control animals and values changed minimally following treatment and resolution of the problem. Those with severe footrot (and presumably severe, chronic pain) showed decreased cortisol levels and slightly raised vasopressin and prolactin. After treatment and resolution, the levels of cortisol and prolactin did not change, but the levels of vasopressin decreased to a level

significantly lower than that of the control group. Hormone levels should not, therefore, be used in isolation as indicators of chronic pain. They may be useful when used in conjunction with other indicators such as pain sensitivity thresholds which are reduced in sheep with chronic pain (Ley et al 1991).

(iii) Pain scoring systems can be used to evaluate pain in sheep and the need for analgesia. A possible drawback of scoring systems is inconsistency between observers, so it is important that the individuals performing the scoring are familiar with the normal behaviour of the sheep and how this is scored. French et al (2000) have developed a pain scoring system that was shown to be consistent. It requires observation of parameters such as activity, physical appearance, changes in temperament, vocalization, feeding behaviour, physiological changes and appearance of surgery site (if present).

Recommendation

1.3.6.1 Sheep should be monitored closely for the subtle changes associated with pain especially where pain is expected to be associated with procedures.

1.3.7 Summary

Principles

(i) A sheep which is relaxed in its environment is gregarious, it is calm yet vigilant and it is interested in its surroundings.

Recommendation

1.3.7.1 For housing sheep, in addition to their normal requirements for food, water, exercise and shelter, particular consideration should be given to:
** their response to isolation and their need for social contact*
** the effect of space allowances and group size on social dynamics*
** their need to establish a maternal bond*
** their need to lie down and ruminate*
** their behavioural responses to pain.*

1.3.7.2 To provide accommodation that meets the species-specific needs of sheep, housing should be provided which allows sheep the opportunity for social interaction, the opportunity to carry out normal behaviours and the opportunity to rest and withdraw from each other.

1.3.7.3 People responsible for the day-to-day care of sheep should be aware of the signs of stress, distress and pain.

1.3.7.4 Sheep should be monitored for the varied behavioural patterns indicative of fear, distress and pain such as lethargy, inappetence, attempts to escape, shivering, agitation, foot-stamping, aggression, persistent bleating, grunting, tooth grinding, changes in ear posture, or changes in facial expression.

1.3.7.5 There may be circumstances where the requirements of experimental procedures will preclude meeting some species-specific needs. Housing in these situations should still meet the physiological and psychological needs of sheep as closely as possible and be expressly approved by an Animal Ethics Committee.

2. Pens and yards

(i) Depending on the type of study, sheep may be housed indoors or outdoors. Indoor housing may be in small groups in pens, or singly. Outdoor housing may be in pens, yards or paddocks. Indoor housing allows control of the climate, whereas sheep housed outdoors are exposed to extremes of climate, the effects of which must be minimised.

2.1 Pen design

Principles

(i) There should be a large enough gap beneath horizontal bars at floor level to allow sheep to remove limbs easily. Otherwise, they may slide limbs underneath when they lie down, and break them when they attempt to stand (Gilbert & Kendrick 1999).

(ii) Jorgensen et al (2009b) investigated the placement of partitions in different configurations within the resting area of deep pens which allowed 1.5m^2 per ewe. They found that the partitions did not change the resting time of the sheep or the synchrony of resting, however synchrony of resting was achieved in some configurations by some sheep resting in the less attractive activity area of the pen on a concrete floor (the resting area had a wooden floor). The addition of the walls also did not alter the competition for lying space as measured by the displacements of the ewes from the resting area. They concluded that it is probably more important for sheep to have enough resting space and the ability to rest simultaneously, rather than the ability to avoid visual or physical contact with others.

(iii) The Canadian Council on Animal Care (2006) has suggested that surfaces should be impervious, easily sanitised and resistant to water and corrosive materials such as animal manure and cleaning solutions. There should be no sharp edges or protrusions which may cause injury. Any paints or glazes should be non-toxic, lead-free, mould resistant and durable. Penning should be free from harmful chemicals such as wood preservatives.

(iv) The use of water proof electrical fittings allows rooms and pens to be pressure-washed.

(v) Outdoor yards should be situated on a well-drained site with an even slope. If this is not available, a fill of road base is recommended to facilitate draining (Marchant 2004).

Recommendations

2.1.1 To meet the social needs of sheep, the walls of pens should be designed to allow sheep to view animal attendants and other sheep in the facility.

2.1.2 Where horizontal bars are used for pen fencing, the gap between the lowest bar and the floor should be wide enough to allow sheep to easily remove their legs from under the bar to avoid injury.

2.1.3 Pen surfaces should be impervious, easily sanitised and resistant to water and corrosive materials (such as animal manure and cleaning solutions). There should be no sharp edges or protrusions which may cause injury. Any paints or glazes should be non-toxic, lead-free, mould resistant and durable. Penning should be free from chemicals harmful to sheep.

2.1.4 Electrical fittings should be situated out of reach of sheep. Ideally electrical fittings should be waterproof to allow for pressure-washing of pens and rooms.

2.1.5 Outdoor pens should have adequate drainage to prevent water and mud buildup.

2.1.6 Sheep in outdoor pens should be provided with shelter from sun, wind and rain.

2.2 Pen Height

Principles

(i) Commercial yard designs provide heights of around 1m for yards designed for adult sheep although some recommend as low as 850mm. Rail spacings are 120mm at the lower levels and up to 180mm between the top rails in a fence made of steel piping.

(ii) On the basis of the chest dimensions of lambs, it would appear that rail spacings should not exceed the chest width and should be 40-50mm less than the chest depth of any size sheep. Note that chest width is the maximum width of the chest (at 9^{th} to 10^{th} rib) and chest depth is measured vertically from the sternum to the vertebrae (Waghorn et al 1995).

Recommendation

2.2.1 As a guide, the walls of pens should be at least 850mm high for adult sheep.

2.3 Pen Floor area

Principles

(i) Group pens should provide enough space for the behavioural needs of animals to be met in terms of resting space and also allow space for animals to move apart from the group. Increased space allowance tends to be associated with a decrease in the occurrence of interactions and potentially injurious events when groups of sheep are

mixed, as they are able to move away to minimize aggression (Jarvis & Cockram 1995). Partitions may be included to break the space up.

(ii) It is important to provide a well drained area for sheep to rest and ruminate. They generally lie down to ruminate and the space should be large enough to accommodate all sheep in the pen to lie down at once as sheep have a strong social motivation to synchronise activities (eg all graze or rest at the same time). A reduction of synchronization of lying can be regarded as a negative indicator of welfare (Boe et al 2006). Lying behaviour decreases as space allowance is decreased (Jarvis & Cockram 1995, Boe et al 2006). Sheep significantly reduced their lying time when lying space was decreased from 0.75-0.50 m^2 per ewe. Synchronization of lying was also reduced with decreased lying space (Boe et al 2006). A space allowance of greater than $1m^2$ per sheep is required before most of the sheep in a group will lie down at the same time (Kim et al 1994). Lying time is increased in pens which have their longest side away from a corridor as opposed to pens which have their longest side along the corridor (Boe et al 2006).

(iii) Stocking density is a critical factor for lactating ewes and a space allowance of < $2m^2$ may have an adverse effect on health and performance in terms of milk yield, somatic cell count and microorganism counts in the milk and the incidence of subclinical mastitis. If the ewes cannot be allocated adequate room, other factors as ventilation rates must be controlled to influence ambient levels of microorganisms (Sevi et al 1999).

(iv) In designing pens for single housing of sheep, consideration should be given to ensuring that the shape of the pen allows them to move around freely, lie down and engage in species-specific behaviours. Pens should be designed to accommodate the largest animal likely to be kept. It is commonly suggested that the minimum should be 1.5m long by 1.0m wide, however Wolfensohn and Lloyd (1998) recommend 2.1m by 1.05m and Reinhardt and Reinhardt (2002) recommend that for a single sheep, a space of at least $2m^2$ should be provided to allow an adult sheep to turn freely and to take a few steps in one direction.

(v) There have been various recommendations given for space allowances for sheep (values in square metres per animal)

	Group housed /sheep (m^2)	**Ewe and lamb (m^2)**	**Singly housed (m^2)**
Preusse *et al* (1985)	0.8	1.6	
ARMCANZ (1991)	0.9 for < 8 sheep, 0.8 for 9-15 sheep	1.5	0.6 for a lamb, 0.9 for dry ewe or wether, 1.0 pregnant ewe
Adams and McKinley (1995)	1.2		
Kim *et al* 1994	>1.0 needed for all sheep to lie down at once		
Loynes (1983) in Slade and Stubbings (1994)	0.5-0.7 (32kg hogget) Increased on straw by 0.2-0.3. Reduce by 10% if shorn.	1.2-1.7 Increased on straw by 0.2-0.3. Reduce by 10% if shorn.	
Sevi *et al* (1999)		2.0 needed to maintain air quality	
Gilbert and Kendrick (1999)	1.3 for sheep <35kg , 1.9 for sheep >35kg		2.0 for sheep <35kg, 2.8 for sheep >35kg
Reinhardt and Reinhardt (2002)			At least 2.0
RSPCA (2010)	1.8 for ewes <60kg; 2.1 for ewes >60kg; 3.0 for rams	Lambs up to 6 weeks 3.0 for ewes < 60kg; 3.3 if >60kg.	
European ETS 123 / Directive 86/609 (Appendix A)	0.7 for sheep <20kg; 1.0 for sheep 20-35kg; 1.5 for sheep 35-60kg; 1.8 for sheep >60kg. Minimum enclosure size: for sheep <20kg is 1.0; for sheep 20-35kg is 1.5; for sheep 35-60kg is 2.0; and for >60kg is 3.0		

Recommendations

2.3.1 Group pens should provide enough space for the behavioural needs of the sheep to be met in terms of space to rest, move away from others and express normal species-specific behaviour.

2.3.2 As a guide, a space allowance of at least 1.5m^2 per adult sheep, with a minimum of 2m^2 for a single sheep, should be provided to ensure adequate lying space for all sheep.

2.3.3 As a guide, lactating ewes should be provided with at least 2.0 m^2 per ewe/lamb unit to ensure appropriate maintenance of air quality, principally microorganism count.

2.3.4 Sufficient space must be provided in pens so that there is a well drained area where all sheep can lie down at once to allow synchronisation of rest periods which encourages rumination.

2.4 Floor surface/ Bedding

Principles

(i) There is a range of flooring available for indoor housing. Factors which should be considered in selection of materials for floor surfaces include sheep comfort and floor preferences, the potential for slippage when wet and the potential degree of hoof wear for the sheep.

(ii) The ideal floor for sheep should provide adequate traction for the animals and not become slippery for the animals or animal attendants, especially when wet. Slip-resistant grooves or cleats should be incorporated into ramps and other areas where animals are likely to slip. The floor should be effectively drained. A slope of at least 1:15 should be provided for adequate drainage in pens with solid floors (Gilbert & Kendrick 1999).

(iii) The surface should provide a degree of even wear on the hoof that will minimise the amount of hoof trimming required while avoiding excess wear of the hoof which may cause discomfort or pain. It should allow faecal matter to pass through while providing a degree of insulation for the animals, especially while lying down.

(iv) Hardwood wooden slats provide the second largest area of foot-floor contact after solid flooring. Foot wear tends to be poor, so regular hoof paring is necessary. Wood does provide a certain amount of insulation, although sheds can be draughty as wind can still pass through. With age, the slats become worn, gaps will increase, and can trap the feet of lambs. Slade & Stubbings (1994) recommend 60mm slats with a 15mm gap. After a period of time, grease builds up on wood and it becomes slippery, especially when wet. Faecal matter can build up in the grooves over supporting joists. Wooden slats may not be the best choice of flooring in facilities where ewes give birth indoors as they can become very slippery during lamb delivery, making it difficult for both the ewes and the lambs to stand.

(v) There are some systems utilizing concrete slats which would not have the same wear problems as wooden slats, however long-term housing (over 2 years) on concrete results in significant changes in the articular cartilage and bone of knee joints of sheep while not expressing as frank osteoarthritis (Radin et al 1982). Sheep should not be housed for long periods on hard surfaces.

(vi) Sheep will always stand with their weight on the front third of the foot on woven steel mesh flooring. This results in uneven wear on the weight-bearing surface of the hoof resulting in an area of thin hoof at the point of weight-bearing. Over time, heavy sheep will find this type of surface very uncomfortable (Mather pers comm.). Regular foot-paring is recommended to overcome irregular wear on this type of flooring. In a study by Rieger et al (1984b), optimum dimensions of mesh floors for ewes and lambs were derived from the values of sole length and width of the feet of adult sheep and

newborn lambs and from the hoof cleft value. Demands were for adequate self-cleaning of the grating and avoidance of hoof damage. It was found that for ewes, the optimum is a web width of 35mm and gap of 18mm and for lambs the web width is 18mm and gap 9mm. Preusse et al (1985) found that a grate spacing of 10-15mm was too small for ewes, with the grate-gap ratio being too wide.

(vii) Steel welded flooring, marketed as 'pig shed flooring', consists of steel rods with a 10mm gap. It provides better foot/floor contact than woven steel mesh but foot wear would still be uneven as the sheep tend to stand repeatedly in the same position on the foot. It provides reasonable traction and is good for self-cleaning.

(viii) Expanded steel safety flooring provides good traction due to the design of raised sharp edges. However, sheep will always stand with their toes pointed into the gap and develop a 'parrot-beak' effect, with a sensitive worn area just behind the centre of the hoof. Toes must be clipped to prevent this. Depending on the degree of expansion of the steel, sheep with smaller feet or those worn into a parrot beak can get their toes jammed into the hole and, if other sheep push past, de-gloving of the foot will occur (the hoof is pulled off the foot) or lower leg fractures can be sustained. This flooring does have good self-cleaning characteristics.

(ix) Galvanised steel panels that lock together come in varying lengths to fit various situations. The surface has numerous small cleats that are moulded into it to improve traction. Foot-floor area is optimised so hoof wear is reportedly good and even. The flooring is good for self-cleaning but would have faecal build up above joists as for wooden slats.

(x) Rubber matting can be used over other flooring to improve insulation and comfort. Woven rubber has advantages over solid matting as it provides good traction and allows faeces and urine to pass through. Solid rubber mats rapidly become wet and dirty. Unless placed over a mesh surface, the floor underneath will need regular cleaning.

(xi) Moulded plastic tiles have been developed with surface designs to promote traction and self cleaning. Hoof wear and tile wear should be slow and even, but they may be slippery when wet. In a study by Rieger et al (1984a), polyethylene grating flooring proved to be superior to polyvinyl chloride for safe walking and favourable growth and attrition of foot horn.

(xii) There are fewer foot problems on deep litter but it must be managed carefully to avoid dust and respiratory problems. The bedding needs to be replaced at regular intervals, up to daily (Gilbert and Kendrick 1999), to avoid excess soiling which can result in the animals becoming wet or in excess ammonia build up. Attention to spot cleaning and regular topping up can extend the time to replacement up to a month. A solid floor covered with litter may be slippery if the floor underneath is smooth. Litter placed over sand provides a soft area and with concrete underneath is easy to clean. However all litter systems are high maintenance. Deep litter beds should be managed so that their surface is generally dry. Deep litter may contribute to wound contamination in sheep post-operatively and may pose problems with waste disposal and biosecurity.

(xiii) For sheep in post-operative recovery, a thick layer of bedding material such as clean straw placed directly over the floor of the pen may be preferable to deep litter. Regardless of the material used, the bedding for sheep recovering from surgery should normally be replaced daily.

(xiv) In terms of preferences, Gordon & Cockram (1995) showed a clear preference by sheep for lying down on straw compared with wooden slats where slats were 50mm wide wood with 20mm gaps. However the study showed that sheep will also lie down on wooden slats.

(xv) Sheep housed on wire mesh should be given rubber or plastic mats on which to lie. In a study by McGreevy et al (2006) looking at wire mesh flooring, when mats were provided, rams spent significantly less time lying on mesh. They showed a post-inhibitory rebound in mat use when they were returned after removal for a day. Without a mat, rams spent more time lying over the course of a day. This may reflect reluctance to rise from recumbency and stand on the mesh. The benefits of keeping sheep on wire mesh relate to hygiene, however mesh that is easily cleaned may not provide sheep with sufficient support for them to lie comfortably.

(xvi) In a study by Faerevik et al (2005), unshorn ewes preferred a solid wooden floor to rubber mats and tended to prefer an expanded metal floor to straw ie they tended to prefer floors of high thermal conductivity. Shorn ewes preferred wooden floor and straw to expanded metal floor and straw to wood floor. They showed a small preference for wood over rubber which may reflect the fact that rubber mats soon become wet and dirty due to a poor absorption capacity. Thus softness and low thermal conductivity are important for shorn ewes. This finding may be especially important to consider when choosing flooring for post-operative animals which have poor thermal regulation.

(xvi) It is usual for outdoor yards and handling facilities to have earth surfaces. The same principles regarding hard surfaces also apply [see (v) above].

Recommendations

2.4.1 Floor surfaces should be non-slip. Ideally surfaces should be abrasive enough to provide even wear on the hooves to minimize the need for hoof trimming while not causing excess wear that may result in discomfort or pain.

2.4.2 Suitable flooring surfaces for sheep in pens include deep litter (for example straw over sand), wooden slats, and galvanized steel panels.

2.4.3 The use of woven steel mesh flooring is not recommended because of the way sheep bear their weight on this surface.

2.4.4 For adequate drainage, solid floors should have a slope of 1:15.

2.4.5 As a guide, when using wooden slats, they should be 60mm wide with a 15mm gap.

2.4.6 As a guide, grating floors for ewes should be built with a web width of 35mm and gap of 15mm and for lambs, a web width of 18mm and gap 9mm.

2.4.7 If using deep litter, it should be managed to keep the surface dry. Management practices include spot cleaning, "top-up" of litter and replacement of litter at regular intervals, up to daily if necessary.

2.4.8 Sheep should not be housed for long periods on hard surfaces.

2.4.9 Sheep housed on wire mesh should be given plastic or rubber mats on which to lie. Ideally such mats should be woven to allow faeces and urine to pass through

2.4.10 Irrespective of the type of flooring, uneven hoof growth may occur and should be managed by regular hoof trimming.

2.4.11 There should be pens available with a thick layer of clean bedding for sheep in the first 2-3 days post surgery and this material should normally be changed daily.

2.5 Water supply/ troughs

Principles

(i) Ideally, there should be space at the trough for all the sheep in group pens to feed at once. This prevents competition and bullying (Wolfensohn & Lloyd 1998). Arnold & Maller (1974) suggest that sheep do not fight in competition for feed but dominance occurs in leadership to the feed and in competitiveness for a space at the trough. Dominance is not related to body weight but appears to be an individual characteristic of the sheep.

(ii) The rate of disturbance from the trough increases with decreased trough space. As trough space decreases, a greater proportion of sheep stop competing and become non-feeders. Minimum trough space of 160mm per animal is recommended (Arnold & Maller 1974). Slade & Stubbings (1994) recommend 150mm for ewes fed roughage *ad lib.*

(iii) Troughs must be high enough to prevent contamination from faeces and bedding (Wolfensohn & Lloyd 1998). They should be designed to prevent sheep from walking on the feed and to prevent feed from being pulled onto the floor. This minimizes parasite spread and decreases feed wastage, making cleaning easier.

(iv) Reinhardt & Reinhardt (2002) suggest that feed troughs should be shallow enough that the sheep can maintain eye contact with each other while feeding.

(v) Sheep prefer to feed at troughs located in the centre of a yard or pen than at the fenceline. Sheep may find the feed more easily and social facilitation could be enhanced with central troughs. However, the improved feeding behaviour should be

weighed against the ease and efficiency of feeding out and the lesser disturbance to sheep when troughs are incorporated into fencelines (McDonald et al 1990).

(vi) Waghorn et al (1995) provide a guide for the ideal trough heights for various classes of sheep. They state that, for a 30kg sheep to reach feed at the bottom of a trough that is 260mm deep, the top edge must not be higher than 360mm above the floor. For adult sheep (ie over 12 months of age), the height may be up to 460mm above the floor. It is difficult to recommend specific heights for sheep between these two classes due to a poor correlation between the weights and shoulder heights of lambs.

(vii) With floors that are likely to become slippery when wet, consideration should be given to the design of nipples, if used. In this situation, they should be placed so that the sheep need to raise their heads to drink as they spill less water.

Recommendations

2.5.1 Enough trough space should be provided for all sheep in group pens to feed at once. A minimum of 160mm per sheep is recommended.

2.5.2 Troughs should be high enough to prevent contamination from faeces and bedding and shallow enough so that sheep can maintain eye contact while feeding.

2.5.3 Nipple drinkers, if used, should be placed above head height so that sheep spill less water while drinking.

2.6 Pen layout and handling facilities

Principles

(i) In designing handling facilities, consideration should be given to sheep behaviour, the proposed group sizes the facility is to handle and possible utilisation of existing facilities. Facilities should always allow sheep an unobstructed view towards where they are intended to move. Sheep are easiest to move when they have a clear, well-lit path forward, preferably towards familiar sheep. Avoid running races east-west so that sheep do not look into the glare of the sun.

(ii) Handling yards should comprise holding areas (high density and low density), forcing area and race. In holding yards, allow one sheep per square metre, however, in high density areas a space allowance of two sheep per square metre should be allowed to provide enough space while allowing room for gates to swing, and up to three sheep per square metre in forcing pens (Marchant 2004).

(iii) Yard design is critical to smooth and efficient handling of sheep. Curved forcing yards (commonly known as ‘bugles’) are often used to facilitate the flow of sheep into drafting races and working races. Square or triangular pens and forcing yards that have corners where sheep can get ‘stuck’ are best avoided. The race should be narrow enough to prevent animals from turning around; high enough to prevent them from jumping out; and with solid sides to prevent legs and horns from being caught as the

sheep move through. Movement is facilitated when the sheep can see animals ahead of them.

(iv) Specific design elements are detailed by Marchant (2000, 2004) and Barber and Freeman (1993).

Recommendations

2.6.1 The design of handling facilities should allow sheep an obstructed view of where they are to move.

2.6.2 As a guide, holding yards should allow one sheep per square metre and up to three sheep per square metre in forcing yards.

3. Indoor environmental variables

3.1 Temperature

Principles

(i) Sheep with some wool are generally tolerant of a large range of temperatures, however extremes of temperature, draughts and humidity should be avoided. Recently shorn sheep and young lambs are especially susceptible to the effects of extremes of temperature. It is important that the fleece remains dry, so any water leaks should be attended to promptly.

(ii) When the ambient temperature rises above about 30^0C, sheep respond by increasing their respiration rate. Along with this, they show decreased feeding time, decreased active behaviours and an increased plasma cortisol, indicating a degree of stress. They may fall into an energy deficit due to the increased metabolic demands of thermoregulation. It has been recommended that ventilation at a minimum of $66m^3$ per ewe per hour be provided during the warmest periods of the day (Sevi et al 2002).

(iii) The temperature indoors should be between 10-24^0C, depending on fleece length (Wolfensohn & Lloyd 1998). As the environmental temperatures drop, sheep must increase heat production to maintain body temperature. The critical temperature at which this occurs varies with the class of animals from 0^0C in adult sheep in full fleece, to 20-25^0C in newly shorn animals to 30-36^0C in newborn lambs (Adams & McKinley 1995).

(iv) In a study by Faerevik et al (2005), mean lying time on all floors dropped from 65% to 43% for the first 2-3 days after shearing. This gradually rose to normal levels by about 15-16 days post shearing. The drop is more due to thermoregulatory needs than comfort – although heat losses are greater, the metabolic rate is higher and compensates.

Recommendations

3.1.1 Extremes of temperature, draughts and humidity should be avoided in housing of sheep.

3.1.2 Facilities with raised floors may be subject to wind chill. Facility design should consider minimizing this with such measures as wind breaks, blinds and barriers around the bottom of the shed. Husbandry procedures such as shearing can also be timed to reduce the possibility of chilling.

3.1.3 Particular care should be taken of recently shorn sheep and young lambs in conditions of extremes of temperature.

3.1.4 As a guide, the indoor temperature should be maintained between 10-24^{0}C, depending on fleece length.

3.2 Light

(i) Sight is a vital part of communication for sheep and they continually monitor each other to maintain contact. They have some ability to perceive colours, particularly those with longer wave lengths (dark) and have good depth perception (Lynch et al 1992).

Recommendation

3.2.1 Lighting should be sufficient to allow observation and care of the sheep and, unless specifically required for a project, should maintain a circadian rhythm.

3.3 Humidity

Principles

(i) Relative humidity should be low enough to avoid condensation and damp conditions in the building. Humid conditions can predispose to the growth of micro-organisms and may enhance the risk of heat stress (Charles & Stubbings 1992). For most enclosed animal houses, 40-60% is a good rule of thumb (CCAC 2006).

Recommendation

3.3.1 As a guide, humidity should be maintained between 40-60% to avoid excessively damp conditions.

3.4 Air quality

Principles

(i) Good ventilation is important, especially when the sheep are on deep litter where build up of humidity, microorganisms and ammonia may become problems and pre-dispose to respiratory disease and heavy odours.

(ii) Extractor fans should remove 3m^3 air per kg bodyweight per hour to keep ammonia levels down (Wolfensohn & Lloyd 1998). The OH&S standard for ammonia is <25ppm. Once there is a detectable odour, the build up becomes an OH&S issue.

(iii) Draughts may be a problem in open-sided sheds. Blinds allow modification of air flow which should be directed away from the animals.

Recommendation

3.4.1 Good ventilation should be provided. Extractor fans should be set to keep ammonia levels at or below 25ppm.

3.5 Sound

Principles

(i) Sheep have a wide range of auditory sensitivity, especially in the upper frequency ranges, between 7 and 30kHz (Lynch et al 1992, Wollack 1963). Note that frequencies above 20kHz are in the ultrasound range.

(ii) They do best in a peaceful and predictable environment. Sudden noises and disturbances should be avoided where possible as noise is detrimental to resting behaviour (Kim et al 1994).

Recommendation

3.5.1 Sudden loud noises should be avoided where possible because of their detrimental effect on resting behaviour.

4. Paddock housing

4.1 Shelter

Principles

(i) Outdoor sheep require shelter from extremes of weather, which may be provided either by trees, scrub, long grass, stone walls, solid panels fixed to fences or a building. In windy areas, a shelterbelt of trees should be provided. Where a building is used to provide shelter, it should be designed and maintained to provide clean, well-ventilated conditions.

(ii) Freshly shorn sheep and newborn lambs are especially susceptible to the effects of cold and heat stress (ARMCANZ 1991). Sheep commonly seek shade in summer, however not all animals consistently seek the shade. It was shown that the body core temperature did not significantly vary between sheep in the shade and those remaining in the sun for sheep with fleece length of approximately 23-31mm. Animals remaining in the sun tended to lie rather than stand which may have reduced heat production (Johnson 1991).

(iii) Ewes tend not to seek shelter for their lambs in inclement weather, although lambs learn rapidly to take advantage of any shelter provided by the ewe. As the fleece grows, lambs become insensitive to bad weather, but young lambs are very susceptible to heat stress (Hulet et al 1975).

Recommendation

4.1.1 Shelter must be provided for sheep from extremes of weather especially when they are freshly shorn or new-born.

4.2 Nutrition and water

4.2.1 Adequacy of pasture and stocking rate

Principles

(i) The amount and quality of feed available from pasture should be monitored continually and sheep should be excluded from access to toxic plants (ARMCANZ 1991). Animals should be regularly assessed for fat score (see White & Holst 2006) and the quantity of pasture or supplement adjusted accordingly. Pay particular attention to sheep in full wool as these are impossible to assess visually (Gilbert & Kendrick 1999).

(ii) Sheep use their memory of the topography to increase the rate at which they encounter preferred food patches. This allows preferential grazing of pasture and reduces the time they need to spend searching for food and the need to continually sample alternative areas. They can remember preferred sites after only one visit (Edwards et al 1996). When grazing, they tend to follow the same order of site visits but can alter their foraging strategy from topographical memory to pasture sampling in response to variability in distribution of suitable pasture (Hewitson et al 2005).

Recommendation

4.2.1.1 Sheep on pasture should have their fat score assessed regularly by an experienced operator and the quantity of pasture or supplement adjusted accordingly.

4.2.2 Hand feeding and how feed is provided

Principles

(i) Sheep may require handfeeding in times of feed shortage such as drought. The type and quantity of ration provided depends on such factors as the condition and class of stock, quantity and quality of pasture still available and any production targets (Bell & Alcock 2007a).

(ii) Methods of presentation of feed vary according to the type of feed. Large grains such as corn may be trailed on the ground. Trailing is not recommended when feed is cracked or dusty. Meals and fine feeds should be presented in troughs (Bell & Alcock 2007b).

(iii) When sheep are being hand fed, they should be monitored regularly and fat scores manually assessed (see White & Holst 2006) to determine the adequacy of any feeding regime. They should also be observed during feeding so that any ‘shy feeders’ are identified and fed separately if necessary.

Recommendations

4.2.2.1 Advice should be sought from an experienced sheep nutritionist when formulating rations for hand-feeding of sheep.

4.2.2.2 When sheep are being hand-fed, they should be monitored regularly and fat scores manually assessed to determine the adequacy of the feeding regime.

4.2.2.3 Sheep may need to be trained to accept hand feeding. This is made easier if some of the sheep in the mob are already experienced.

4.2.2.4 Sheep should be observed during feeding so that any 'shy feeders' are identified and fed separately if necessary.

4.2.3 Water

Principles

(i) The principal factors affecting water quality are salinity, pH, and toxic elements or compounds including iron, magnesium, arsenic, lead, mercury, selenium, fluorides and algal blooms (especially blue-green algae). Environmental factors affecting water consumption include ambient temperature, drought and pasture quality. Animal factors affecting water consumption are age and condition of stock, breed differences, quality of watering points and watering radius (Markwick 2007).

(ii) Water should be tested to ensure it is of adequate quality. If it contains potentially toxic levels of salts or other substances, it should be monitored and managed to minimise any deleterious effects. Where the water quality cannot be managed, sheep should be moved to another site where adequate good quality water is available (ARMCANZ 1991).

Recommendation

4.2.3.1 Water (other than mains water) should be tested to ensure it is of adequate quality. If it contains potentially toxic levels of salts or other substances, it should be monitored and managed to minimise any deleterious effects.

4.3 Predator control/security

Principles

(i) Lambing ewes are especially vulnerable to predation by dogs, foxes and pigs.

(ii) Sheep kept in urban and semi-urban areas are vulnerable to attacks from humans and from dogs.

Recommendations

4.3.1 Fencing should be adequate to prevent unwanted entry of people or other animals and should be regularly checked and maintained.

4.3.2 A management plan should be implemented for control of vertebrate pests, preferably coordinated with neighbouring properties, to maximise the effect of the control program

5. Care and management

5.1 Transport

Principles

(i) Under the draft mandatory standards for livestock transport (Animal Health Australia 2008) sheep over four months of age must not be deprived of water during transport for more than 48 hours. Lambs under four months of age travelling without their mothers must not be deprived of water for longer than 28 hours. Ewes more than 14 weeks pregnant must not be deprived of water for longer than 24 hours.

(ii) Transport for 20 minutes and mixing of unfamiliar animals both cause an increase in heart rate which may take over 2 hours to return to baseline (Baldock & Sibley 1990). Mixing social groups is likely to be detrimental in terms of the ability of sheep to recover from the effects of transport or handling (Jarvis & Cockram 1995). There is little evidence of habituation to transport and rougher journeys are more stressful than smooth travel (Bradshaw et al 1996).

(iii) After a long journey (eg 15 hours), the immediate priority for sheep is to eat rather than to drink or rest (Cockram et al 1999). Normal metabolism and elimination functions had not been restored by 12-hour access to feed and water following a 15-hour journey (Broom et al 1996).

(iv) A study of the transport of lambs by Knowles et al (1993) showed that blood parameters associated with short-term stress and dehydration returned to normal by 24 hours after transportation for 14 hours. The loss of liveweight, which is primarily associated with loss of gut fill, recovered by 96 hours after transport, but levels of creatine kinase, which indicate physical exertion prior to transport, take up to 144 hours to recover.

(v) Withholding food or water for 48 hours did not cause an increase in plasma cortisol levels in sheep (Parrott et al 1996). However, short-term food and water deprivation are detrimental to lambs (up to at least 5 months of age) and the effects are further exacerbated by transport, possibly due to alterations in ruminal fermentation and blood chemistry (Horton et al 1996).

(vi) Late-gestation pregnant sheep have been transported for 6-7 hours without disrupting their feed and water intake (Chan et al 2000).

Recommendations

5.1.1 Where possible, sheep should not be mixed with unfamiliar animals during transport.

5.1.2 Sheep should be rested on feed and water for at least 24 hours following transport prior to any research procedures being carried out unless otherwise justified to an Animal Ethics Committee.

5.2 Handling

Principles

(i) Handling of sheep must be carried out by trained and competent handlers. They should never be held by the wool as this can cause bruising and skin tears. They tend to have fairly predictable behaviour characteristics in yards that can be used to aid handling. These include:

- Sheep move toward other sheep willingly and away from people and dogs. They move better through a race if they cannot see the operator. They are motivated to move by the sight of other sheep running away and will baulk or step forward when they see sheep moving in the opposite direction.
- They react negatively to loud noises, shouting and barking.
- It is easier to move young sheep through facilities when their first move is with well-trained, older sheep.
- Sheep have good long-term memories, especially of unpleasant experiences. They flow better through facilities if the same path and flow directions are maintained.
- Sheep will move on their own accord from a small area to a large area and will move faster through a long, narrow pen than through a square pen. They will move more willingly toward an open area than a perceived dead end.
- Sheep prefer to move from a dark area towards the light, but avoid contrasts in light, such as, for example, bright light shining through a slatted floor.

(O'Brien 2001, Hutson 1980)

(ii) Some sheep are quite prepared to move readily through a yard system, suggesting that genetic selection for ease of handling could be effective (Hutson 1985). Decoy sheep are a feasible way of encouraging free movement of sheep out of a pen and along a race. Decoys of similar appearance to the sheep being moved are more effective. Mirrors can be used to encourage sheep to enter a shearing shed or where sheep must move towards a dead-end, however they may be hesitant to move past it. Photographs of sheep may be used as decoys, especially if the rump is facing, not the head which indicates aggression. The effect is enhanced if the image is moving, especially towards the exit from the race (Franklin & Hutson 1982).

(iii) Sheep tend to be reluctant to enter dark areas from light areas. Unevenness should be removed from flooring to avoid baulking and lead-up chutes should have solid walls to remove distractions (Blackshaw 1986).

(iv) Hitchcock & Hutson (1979) showed that different light intensities did not have a great effect on sheep movement in races. The effect was restricted to the first sheep in wide races. This sheep was more likely to move, the brighter the intensity, but was unaffected by the direction of change in light intensity. In this study, the lead sheep was neither attracted nor repelled by strong contrasts in light. Once the flock was moving, differences in light intensity or contrast had no effect. Other factors such as a clear view of the path forward may be important in attracting sheep to move forwards.

(v) Sheep prefer to move across the direction of battens in slatted floors regardless of the light intensity below, possibly because they can get better grip with their feet in the spaces between the battens, but their feet will tend to slip when the battens are

aligned longitudinally. However, once moving, the floor type is immaterial. In existing sheds, where it is uneconomic to change batten alignment, the sides below floor level should be covered so that light is excluded from beneath the floor. In the design of new sheds, it is important that battens are aligned so that movement is always across the direction of the battens. This will restrict the vision of sheep through the floor and provide a better grip for their feet (Hutson 1981).

Recommendations

5.2.1 Where possible, sheep should be moved toward other sheep and away from people and dogs.

5.2.2 When possible, young sheep should be moved through facilities with well-trained, older sheep.

5.2.3 When possible, the same path and direction should be maintained through facilities.

5.2.4 It is recommended that sheds are well lit to encourage sheep movement into and within the shed. Sheep should be moved towards the light from dark areas.

5.2.5 In the design of new facilities with slatted floors, the battens should be aligned across the direction of movement.

5.2.1 Handling of lambs

Principles

(i) Handling and feeding of lambs, especially in the first 3 days of life strongly influences their responses to people as they mature (Markowitz et al 1998, Boivin et al 2000). This response can last as late as 3 months of age (Markowitz et al 1998). Gentle handling after this period, even without feed reinforcement, maintains the bond (Boivin et al 2000, 2002). Those handled at later ages show short-term effects but these largely disappear by 25 days, indicating that the most sensitive period for lamb socialization is within 3 days of age. However, lambs raised with the dam do not develop a close relationship with the handler, even if not suckled by the dam (Boivin et al 2002). Gently handling artificially-reared lambs during the days following birth increases their subsequent affinity for their handler if they are later held in isolation (Tallet et al 2005).

(ii) Tallet et al (2009) showed that lambs that received human contact (with or without associated feeding) showed a greater affinity to the caregiver than those that had not received human contact. When placed in an unfamiliar environment, they approached the caregiver more rapidly and spent more time with him. They showed less distress behaviour such as bleating and moving when he was in the pen, and more distress behaviour when he left the pen. Hand-feeding lambs had no greater effect on behaviour than simple handling (holding for 20 seconds, initially three times a day for 5 days and gradually reduced over three weeks). This is possibly because feeding orients lambs to the bottle rather than to the caregiver. Holding lambs elicited a much

greater affinity for the caregiver than no human contact (the stock person was disguised when carrying out management tasks), possibly because the tactile stimulus from holding mimics the social contact normally received from the mother.

(iii) Artificially reared lambs subjected to gentling had higher antibody titres than those reared without gentling. Thus positive handling may enhance humoral responses to antigens in lambs and may be used to reduce lamb morbidity through enhanced immunological responses. After a lamb has socialized with humans, their presence may act as an emotional reassurance which may reduce the stressfulness of management practices involving lamb manipulation, isolation or other fear-inducing situations (Caroprese et al 2006).

Recommendation

5.2.1.1 Where possible, sheep that will be subjected to intense handling or invasive experimental procedures should be handled and socialized with humans within the first 3 days of life.

5.3 Introduction to the facility

5.3.1 Selection

Principles

(i) Unlike most research situations, sheep are not usually purpose-bred. Out-sourced sheep selected for research should be healthy and in good condition (see section 5.10). They should be treated for internal and external parasites on arrival to the facility. In addition, they should be vaccinated against clostridial diseases. Normal husbandry procedures such as foot trimming should be carried out if necessary. Shearing is recommended if sheep are to be housed indoors as it allows them to better acclimatize to the warmer environment.

(ii) On introduction to a research facility, sheep should be introduced gradually to new feed (see section 5.6). Their feed intake should be monitored closely in the initial period and any animals not adapting ('shy feeders') should be culled from the research group.

(iii) If they have been paddock raised and are not accustomed to close handling, they will need to be acclimatised to handling and should not be kept alone or in groups of less than five (see section 1.3.2(i)).

Recommendations

5.3.1.1 On arrival to a facility, sheep should be treated for internal and external parasites and vaccinated against Clostridial diseases. They should be shorn and have their feet trimmed if necessary.

5.3.1.2 New arrivals should be acclimatised to handling and kept in groups of at least five in the initial period.

5.3.1.3 Any sheep that do not adapt to a feeding regime or handling procedures must be culled from the experimental group.

5.3.2 Management procedures

Principles

(i) When bringing outdoor sheep into housing, consideration should be given to changes that are being imposed by the housing regime such as social groupings, diet, and the physical environment including temperature, photoperiod and available space. These should be changed gradually, if possible, to ensure as smooth a transition as possible. Shearing sheep will help them adapt to a warmer environment. During the acclimatization period, they should be isolated from animals already in the facility for health screening, to ensure that they are free from communicable diseases that they may transfer to the main population in the facility (CCAC 2006, Rehbinder et al 2000).

(ii) Dwyer (2004) states that there appears to be a genetic difference between breeds in their responsiveness to stressors which may be modified or potentiated by experience. Thus sheep may behave differently in different situations depending on their prior exposure or rearing experience.

(iii) On introduction to an animal house, sheep have an initial period of withdrawal after which they appear to react more to the stimuli provided by the environment. At this time, the sheep will also have adapted to pens in terms of the ration eaten (Done-Currie et al 1984). Without being handled, animals will usually adapt to the new environment within two weeks, unless they react adversely to a marked change in diet (Pearson & Mellor 1976).

(iv) Sheep still show a small rise in basal heart rate when moved to an almost identical laboratory to that to which they have become adapted, showing that animals which have apparently adapted fully to experimental rooms still remain sensitive to small changes in their conditions (Pearson & Mellor 1976).

(v) Any sheep that do not adapt to housing or increased handling within 14 days should be culled from the research group. More invasive procedures such as surgical protocols may require longer acclimatisation (eg 3-6 weeks), depending on the degree of invasiveness of procedures (Pearson & Mellor 1976).

(vi) During an adaptation period to a new environment, the normal diurnal variation in peripheral cortisol levels is re-established, with substantially higher peak levels during the morning daylight hours than are found in adapted sheep. The time taken for adaptation is variable and the attainment of a stable variation may indicate that adaptation is complete (McNatty & Young 1973).

(vii) A study by Coppinger et al (1991) showed that repeated application of a stressor (restraint and isolation in this case) repeatedly activated the hypothalamic-pituitary-adrenal axis, although the ability of the adrenal gland to secrete cortisol may be reduced upon subsequent application of the stressor. Repeated stresses may reduce

some measures of T-lymphocyte function which are not affected by a single application of a stressor. The conclusion was that not all short-term stressors have an effect on immune function. Sheep showed different hormone responses according to the stressor applied. The physical stress of transport simulation for 60 minutes had a greater effect on cortisol, prolactin and adrenaline release than the other treatments which were 60 minutes of isolation and 60 minutes of standing in water 25cm deep. The only procedure affecting noradrenaline was isolation. Isolation and water treatment did not affect prolactin (Parrott et al 1994).

Recommendations

5.3.2.1 When sheep are brought from outdoor management into housing, changes to temperature and photoperiod should be progressed gradually where possible.

5.3.2.2 Sheep should be monitored for behavioural evidence of failure to adapt to housing or increased handling. If they fail to adapt within 14 days, they should be culled from the research group.

5.3.2.3 If animals are to be moved from holding pens to a laboratory for regular sampling, this procedure should be included in any adaptation schedule.

5.4 Experimental procedures

Principles

(i) Sheep have excellent long-term memories (up to one year) of handling procedures, both when rewarded or unrewarded. Rewarding sheep makes handling significantly easier, however unrewarded learning is also sufficient to improve performance at a later date provided the handling procedure does not have high impact. As the impact of the procedure increases, the long-term effectiveness of the food reward diminishes. Rewards can lead to long-term improvements in handling if procedures of higher impact are performed rarely or interspersed with procedures of lower impact. Trained sheep should be exposed initially to minor handling procedures, and subsequent higher impact procedures should be performed rarely where possible (Hutson 1985).

(ii) Gentled sheep responded less than control animals in terms of flight distance and heart rate response. However, this difference was overcome by five exposures to a handling treatment, regardless of the aversiveness of the treatment (Hargreaves & Hutson 1990a). If animals are to remain unstressed by more prolonged experimental procedures, 3-6 weeks of daily handling (5-10 minutes of stroking of the head and neck and quiet talking to them) are required. There is a close correlation between the disappearance of transient rises in plasma corticoid concentrations and heart rates and the appearance of tame behaviour (Pearson & Mellor 1976).

(iii) In a study by Chan et al (2000), post-surgery recovery of feed and water consumption was shown to be independent of the period of acclimatization (2-7 days). However, after surgery, feed consumption does not return to pre-surgery levels for 2 days and water for 2-4 days which probably relates to the pain and stress of the surgery.

(iv) Greiveldinger et al (2007) showed that, where lambs are able to predict a sudden event due to a light cue, they show weaker startle and cardiac responses and spend more time feeding than control lambs subjected to random appearances of the sudden event. Where sudden events appear regularly, lambs vocalise less and eat more than lambs subjected to random appearances of the same event.

Recommendations

5.4.1 3-6 weeks of daily handling for at least 5-10 minutes (stroking of the head and neck and quiet talking) should be provided prior to commencement of prolonged invasive experimental procedures.

5.4.2 Sheep adaptation schedules should include moving sheep within the facility when this will be required as part of a research protocol.

5.4.3 During training, sheep should be exposed initially to minor treatments and severe treatments should be performed as little as possible.

5.4.4 Sheep should be acclimatised to and maintained in conditions where routines are consistent and sudden events are predictable.

5.4.1 Restraint

Principles

(i) Due to the gregarious nature of sheep, restraint is very stressful for them if it removes them from the flock. Individuals will panic when not in visual contact with other sheep.

(ii) To achieve experimental objectives, it may be necessary to restrict the movement of sheep by the use of equipment such as crushes. Use of restraint equipment for prolonged periods should be avoided unless it is essential to achieve research objectives and restraint devices should not be used for normal housing of sheep. The period of restraint should be the minimum required to achieve research objectives and sheep should be conditioned to the equipment prior to the initiation of the project. Where prolonged restraint is proposed (eg the use of metabolic crates) consideration must be given to the sheep's biological and behavioural needs. (NHMRC 2004, CCAC 2006)

(iii) It is possible, with careful handling, to train sheep to tolerate short periods of restraint and to enter restraining devices voluntarily. They can also be trained to accept single venipuncture, but it is recommended that animals be catheterised for repeated collections (Fisher 2001).

(iv) Tranquillising or anaesthetic agents may aid restraint but they may prolong recovery from the procedure (NHMRC 2004).

Recommendation

5.4.1.1 Use of restraint equipment should be for the minimum time required to achieve research objectives and sheep should be conditioned to the equipment prior to the initiation of the project.

5.5 Single housing

5.5.1 Metabolism crates

Principles

(i) Single housing is stressful for sheep if they are not within sight of a companion animal due to their social needs. In studies using metabolism crates, trial design should allow spelling of animals in pens. A lead time must be allowed for acclimatization to specialized diets. Thermal requirements of sheep may be affected when placed in metabolism crates as they cannot huddle with others to conserve heat. In general, they should not be confined in metabolism crates for longer than seven days without exercise (CCAC 2006).

(ii) Confinement in metabolism crates causes an initial stress response, but maintaining already acclimatised sheep in the crates for up to 14 days after a 5-day adaptation period caused minimal activation of the hypothalamic-pituitary-adrenal axis. There is an initial stress response when lambs are confined in metabolism crates, however they adapt by the fifth day, especially if they have been habituated with humans (Kapp et al 1997). However a study by Bowers et al (1993) showed that 4-month-old lambs, which had been habituated to handling for two months prior to confinement in metabolism crates, showed increased adrenal responsiveness to administration of ACTH and increased thyroxine levels 2 and 9 days after confinement. They also showed an increased motivation for movement when released to a paddock after 9 days' confinement. In this study, basal cortisol levels did not change.

(iii) In a study by Abdel-Rahmann et al (2000), confinement of ewes in metabolism crates without prior adaptation resulted in a decrease in feed intake which was accompanied by a decrease in body weight – this remained significantly low after 21 days. Serum cortisol increased significantly and remained higher than controls until day 14. It was normal after 28 days. Average daily intake and body weight gain significantly decreased following isolation. Non-active behaviours (eating, rumination, resting and sleeping) were significantly decreased after housing in metabolism crates. Active behaviours (eg biting, butting, bleating, pawing, stamping. bar-biting, wool biting) were highly increased in metabolism crates. Additionally, Marsden and Wood-Gush (1986a) showed that diet level and level of disturbance appear to be the most important specific factors in determining overall time spent in abnormal behaviour by individually penned sheep.

(iv) Polydipsia nervosa is occasionally found in sheep kept in close restraint such as metabolism crates. The affected animals drink large amounts of water, especially if it is provided *ad lib*. This results in polyuria and may disturb digestion and absorption of nutrients (Fraser 1995).

Recommendations

5.5.1.1 Sheep should not be housed in metabolism crates unless with the express permission of the Animal Ethics Committee of the institution on the basis of compelling evidence for the need to house sheep in this way. In such cases, sheep should be able to be in visual contact with other sheep.

5.5.1.2 Long-term confinement must be justified and should not exceed 10 weeks. Where possible, sheep should be released from confinement for 3 hours a week, preferably spread over a number of sessions.

5.5.1.3 Sheep should be conditioned to metabolism crates for at least 5 days prior to experimental procedures.

5.5.1.4 Metabolism crates should be designed such that sheep do not need to be tethered.

5.5.1.5 Solid flooring should be provided in the front one third of metabolism crates to provide a more comfortable surface for resting.

5.5.2 Isolation

Principles

(i) Isolation imposes a lack of auditory, olfactory and visual contact with con-specifics. Sheep are particularly sensitive to the stress induced by isolation which has been found to have a greater adrenocortical stress response than handling or restraint (Roussel et al 2004). From the behaviour of the sheep and the abrupt rise in plasma cortisol, isolation may be categorized as emotional stress. Both the peak and duration of the increased cortisol rise progressively higher in each consecutive isolation experiment. This indicates that sheep cannot adapt to an emotional stress like isolation from the flock (Niezgoda et al 1987) even though, behaviourally, they may appear to have habituated (Roussel et al 2004).

(ii) A 30 hour period of isolation increased plasma cortisol. It also reduced drinking, but the usual physiological changes associated with dehydration did not occur. Since sheep normally drink after feeding when plasma osmolality is increased, stress-induced reductions in food intake may indirectly affect fluid balance (Parrott et al 1987).

(iii) Where sheep are isolated from con-specifics, they should be given extra attention from an experienced animal technician. This provides an alternative method of social contact and also aids handling of the animals during experimental procedures (Fraser 1995).

(iv) Da Costa et al (2004) showed that sheep exposed to face images of other sheep during a short period of isolation stress (30 minutes) were less stressed than control sheep. Mirrors or sounds of other animals can also be used for sheep that must be isolated but mirrors are only partially successful (Parrott et al 1988). Anecdotally, the placement of a sheepskin over an object to resemble a sheep may also lessen the stress of isolation for isolated sheep.

Recommendations

5.5.2.1 Sheep must not be housed in isolation unless with the express permission of the Animal Ethics Committee of the institution on the basis of compelling evidence for the need to house sheep in this way. In such cases, where possible, sheep should be able to be in visual contact with other sheep.

5.5.2.2 When isolated, sheep should be given additional attention by an experienced animal technician.

5.5.2.3 The use of mirrors or life-sized images of familiar sheep may lessen the stress of isolation for sheep.

5.6 Food and water

Principles

(i) The daily nutritional requirements of sheep will vary considerably, depending on the age, weight, and physiological state of the animals. Late pregnant and lactating ewes require significantly more feed than dry ewes or wethers. Vitamin and mineral supplements may be necessary, depending on the composition of the diet. Unsuitable rations for sheep housed long-term may result in serious health problems such as urinary calculi, trace element deficiencies or toxicities. Totally housed sheep need to be supplemented with vitamin D.

(ii) Animals generally prefer the physical form of the feeds they can eat faster. Ruminants tend to develop a preference for feeds that will provide a high satiety level rapidly. For a given nutritive value, sensory properties of the feed can stimulate or depress pleasurable (hedonic) feeding behaviour (Baumont 1996).

(iii) Sheep should be gradually introduced to new feeds. This regime needs to be reversed when animals return to the paddock. Some lines of sheep (even within the same breed) accept pelleted feed more readily than others (McDonald et al 1990).

(iv) In preference testing of sheep, it was found that sheep appear to have conservative tastes and are unwilling to eat novel foods. The most attractive foods for sheep are seeds and grains (Hutson & van Mourik 1981). Getting sheep to eat novel foods readily was not easily resolved by management procedures including food restriction and the addition of a known flavour to novel foods. Exposure to foods early in life is perhaps the best way to prepare sheep to readily accept foods later in life, provided one knows which food will be offered (Provenza et al 1994).

(v) Management strategies based on flavour generalization (adding a familiar flavour to food), repeated exposure, and social facilitation (introduction of sheep to novel foods with animals that are experienced at eating the particular diet) will be effective in increasing the acceptance of novel foods (Chapple & Wodzicka-Tomaszewska (1987), Launchbaugh et al 1997). Sheep accept a novel food more quickly when it has a recognized odour or flavour (stimulus generalization). This also operates in feed aversion (Tien et al 1999).

(vi) Offering sheep different foods of similar nutritional value, offering foods of different nutritional value, and offering the same food in different flavours, are all means of enhancing food preference. Offering foods in a variety of flavours and nutrients would enable each individual to select a diet to meet its nutritional needs (Provenza et al 1996, Wang & Provenza 1996).

(vii) Lambs were more neophobic in an unfamiliar location, consuming less of a novel food at an unfamiliar than a familiar location. Lambs at the unfamiliar location did not decrease consumption of a familiar food on day 1. Thus declines in food intake, which often occur when animals are moved to a new location, are most likely caused by a lack of familiar foods and animals' reluctance to consume novel foods. Livestock should be introduced to novel foods in familiar environments to increase food intake in new environments (Burritt & Provenza 1997).

(viii) Lambs can retain dietary preferences learned from their mother for over three years (Gilbert & Kendrick 1999). Lambs ate more of a new food following exposure with their mother as opposed to exposure with a dry ewe or alone. When observing another animal eat without being able to eat concurrently, lambs did not learn to eat novel foods. The greater the delay between observing and performing, the less likely the observer is to demonstrate observational learning (Thorhallsdottir et al 1990).

(ix) Two simple rations for sheep are a 50% mixture of lucerne and wheaten chaff, and a pelleted ration of lucerne chaff (50%), wheat grain (10%), bran (18%), pollard (20%), and crude salt (2%). The addition of salt is important to increase water intake, thus avoiding the development of urinary calculi. These rations have been fed successfully without nutritional deficiencies developing, although the lucerne must be of high quality (Adams & McKinley 1995). A 50kg sheep, housed under experimental conditions, can be adequately maintained on 1kg good quality hay daily. Additional protein should be included in the ration for pregnancy and lactation (Harrison 1987).

(x) Sheep are vulnerable to the effects of copper toxicity (Harrison 1987, Wolfensohn & Lloyd 1998) as their excretory mechanisms are not efficient. When housed indoors and on pelleted feeds, copper requirements are reduced and copper accumulates in the liver, especially if molybdenum is low. Stress can induce a sudden release of liver copper stores which can then trigger a haemolytic crisis resulting in nephrosis and death (Lewis et al 1997). Copper toxicity is especially a problem with some lucerne products. Diets should not contain more than 15 ppm copper on a dry matter basis (CCAC 2006). Avoid copper in mineral supplements and use appropriate lick blocks (high molybdenum/ low copper).

(xi) High levels of phosphorus in a pelleted ration may result in the formation of urinary calculi. This can be avoided by sprinkling the feed with powdered, calcium-rich chalk (Fraser 1995).

(xii) Anecdotally, sheep fed concentrated or pelleted diets for long periods may suffer subclinical acidosis resulting in depression of rumen function and eventually depression of the animal. Addition of meadow hay or poorer quality lucerne to the diet avoids this problem.

(xiii) The type of roughage fed may be important – some pelleted feeds contain short strand fibre whereas hay is a long strand fibre, important for functioning of the digestive tract (Cooper & Jackson 1996). Sheep fed a 'long fibre-free' diet such as some finely milled pelleted concentrates undergo short spells of pseudorumination (regurgitation of a cud which is almost immediately swallowed without being chewed) and no true rumination (regurgitation of a cud which is chewed for about 45 sec) (Campion & Leek 1997).

(xiv) Pseudorumination has been regarded as a form of stereotypy, however it is more likely that it is simply the form rumination-like behaviour takes when insufficient regurgitated fibre is retained in the mouth. Fibre deprived sheep become motivated to ingest even inert fibrous material as a result of a 'fibre appetite' based on a reduced ruminal sensory input, the choice of fibre eaten being driven by ease of ingestion. Provision of long fibre (eg straw) as part of the diet of adult sheep is an important aspect of welfare and health management as it can have a beneficial effect in delaying and reducing wool biting in housed concentrate-fed sheep and providing protection against wool damage (Campion & Leek 1997, Vasseur et al 2006).

(xv) Sheep must have access to an adequate supply of water. Each animal needs between 4-6L of water daily (Wolfensohn & Lloyd 1998). Lactating ewes, weaned lambs and sheep in hot weather have increased needs for water. Dry ewes need up to 4.5L daily and this doubles in early lactation (Slade and Stubbings 1994). High protein and salt-containing diets also increase their need for water. Ideally, water should be available *ad libitum.*

Recommendations

5.6.1 Advice should be sought from an experienced sheep nutritionist when formulating rations for sheep.

5.6.2 Where possible, sheep to be used for research should be exposed to a variety of foods early in life, preferably when they are still with their mothers.

5.6.3 Sheep should be introduced gradually to new feeds, preferably in a familiar environment.

5.6.4 Sheep should be provided with adequate long-strand fibre to aid effective rumination.

5.6.5 As a guide, sheep need 4-6L of water daily, preferably available ad libitum. More should be provided to lactating ewes and weaned lambs; and in hot weather.

5.6.1 Restrictions on food and water

Principles

(i) When sheep are deprived of water, but retain access to feed, their plasma osmolality increases. This reflects the fact that sheep normally drink after feeding and

if water is unavailable, their water balance is disturbed. Deprivation of food and water for 48 hours does not induce marked responses in stress hormones (cortisol, prolactin and vasopressin) even when exposed to extremes of temperature (7^0C and 35^0C) (Parrott et al 1996).

(ii) When fed *ad lib*, sheep activity is mainly diurnal, however restriction of feed to certain times (eg at night) can change their activity patterns to coincide to times when feed is available (Piccione et al 2007).

(iii) Hecker et al (1964) showed that sheep deprived of feed drink little water. This probably maintains the consistency of ruminal contents for optimal functioning. When they are deprived of feed and water for four to eight days, the rate of decrease in rumen fluid volume is greatest during the first two days, while the plasma fluid volume increases during this period. Ruminal fluid volume decreases after the third day when urine volume decreases and osmolarity increases as the sheep becomes dehydrated. Thus, for the first two days of water deprivation, water balance is maintained by drawing water from the rumen and probably the intestinal tract.

(iv) After being deprived of water, sheep will drink an amount of water corresponding with their body weight loss or slightly more. The water consumed is rapidly absorbed from the rumen (Dahlborn & Holtenius 1990).

(v) Prior to surgery, sheep should be fasted for 18 hours (or up to 24 hours if on heavy feed such as pellets or bulky feeds). Care should be taken with pregnant ewes (especially in the last trimester) as they are susceptible to pregnancy toxaemia. They should be fed a highly digestible diet (>90% digestibility) until 8-12 hours prior to anaesthesia. Water should be withheld from all sheep for 2-3 hours prior to induction of anaesthesia. (Ladd *pers comm.*)

Recommendations

5.6.1.1 Prior to surgery, sheep should be fasted for 18-24 hours, depending on diet.

5.6.1.2 Pregnant ewes should be maintained on a highly digestible diet and fasted for 8-12 hours prior to surgery.

5.6.1.3 Water should be withheld from all sheep for 2-3 hours prior to induction of anaesthesia.

5.7 Environmental enrichment

Principles

(i) The development of stereotypies in sheep is frequently related to the interruption of their normal pattern of grazing and the cycle of rest, rumination and idling. Various measures have been tried to provide activity for housed sheep to address issues related to behavioural deprivation. These include feeding twice daily (although this practice is now debatable, see Vasseur *et al* 2006 below); feeding a more complex diet (but more waste is produced); presenting feed in containers that require animals to work for feed; alternative feeds; and the addition of licks.

(ii) Longer term residents are more likely to display stereotypic behaviours such as weaving, wool biting and pen-licking (Done-Currie *et al* 1984). Restricted feeding is more likely to promote the development of stereotypic behaviour in sheep compared with *ad lib* feed access. The provision of increased roughage in the diet can diminish the risks of oral stereotypies developing (Marsden & Wood-Gush 1986). High levels of protein in an energy-restricted diet resulted in an increased incidence of oral stereotypies compared with a lower protein diet of similar energy level, possibly due to the effects of urea on energy metabolism in the liver. Energy restriction also promoted manipulation of bedding material by lambs which was not significantly eliminated by the provision of straw as a bedding material (Yurtman et al 2002).

(iii) Sheep on slats were found to perform a number of redirected oral activities not found in straw-bedded sheep eg bar-biting, slat-chewing, wool biting and repetitive licking. Abnormal oral activities performed by sheep on slats appear to be a substitution for foraging activities such as eating hay or nosing straw performed by the sheep on straw. The type of roughage fed may be important – pelleted feeds contain short strand fibre whereas hay is a long strand fibre, important for functioning of the digestive tract (Cooper & Jackson 1996).

(iv) Wool biting is a behaviour that can develop in housed sheep, in which sheep start to bite and eat the wool of others. It is a redirected behaviour, at least partially initiated by the absence of a natural substrate for grazing and the non-satisfaction of the need for stimulation of the sheep's oral organs by eating and ruminating. Vasseur et al (2006) showed that provision of fibre in the form of straw within 5cm x 5cm metal mesh hay racks had a beneficial effect in delaying and reducing wool-biting in housed concentrate-fed sheep and provided protection against wool damage. Higher feeding frequency (ie twice a day as opposed to once) was associated with more wool biting behaviour, possibly because animals are able to consume all their allocated feed at once, providing them with less oral stimulation than when feed is presented in larger quantities and they return to it several times in the course of a day, however this effect is not consistent.

Recommendation

5.7.1 To reduce the incidence of oral stereotypies, sheep should be provided with long-strand fibre (eg straw).

5.8 Cleaning

Principles

(i) A mature ewe produces about 2.25kg of dung and urine per day. In housed sheep on slats or straw it will build up under slats to a depth of 250-350mm over a 90-day period (Slade and Stubbings 1994).

(ii) Manure can be handled by design elements such as slatted floors, grates, and mechanical scrapers or hydraulic flushing systems to clean floors, gutters or manure channels. Any system must effectively separate the animals from their excreta, and any manure slots and gutters should be sized and spaced to prevent hoof or lower leg injury of animals (CCAC 2006).

(iii) Care must be taken to avoid contamination of the animals' environment with any cleaning agents or other chemicals.

(iv) When deep litter is used, the bedding needs to be replaced at regular intervals, up to daily (Gilbert & Kendrick 1999), to avoid excess soiling which can result in the animals becoming wet or in excess ammonia build up. Attention to spot cleaning and regular topping up can extend the time to replacement of deep litter up to a month.

(iv) Sheep do not like dirty water. Water bowls should be checked daily and cleaned when necessary.

Recommendations

5.8.1 Manure slots and gutters should be sized and spaced to prevent hoof or leg injuries.

5.8.2 Care must be taken to avoid contamination of the animals' environment with any cleaning agents or other chemicals.

5.8.3 Mats and deep litter beds should be managed so that their surface is generally dry.

5.8.4 Water bowls should be checked and preferably cleaned daily.

5.9 Monitoring

Principles

(i) Monitoring should commence at the time of selection of the sheep and continue until the end of use. The frequency of monitoring will depend on the experimental procedures, but must be at least daily, preferably twice a day, and should be such that changes in any animal's condition are detected early. All monitoring should be recorded, not just unusual findings or adverse effects.

(ii) As prey animals, sheep may be in serious pain without showing any symptoms. Close observation is needed to detect subtle changes in behaviour such as lethargy, inappetence and a change in facial expression. Severe pain may manifest as rapid, shallow respiration. On handling, they may react violently or otherwise stand rigidly so that the affected region is immobilised. They may occasionally grind their teeth or grunt (Sanford et al 1986) or withdraw from the group with an abnormal stance or lying position (Wemelsfeder & Farish 2004).

Recommendation

5.9.1 Sheep should be monitored at least once daily so that changes in their condition are detected and appropriate action taken.

5.9.2 Sheep should be closely monitored to detect the subtle changes in behaviour indicative of pain, fear, distress or signs of disease.

5.10 Health

Principles

(i) Sheep may be affected by a variety of diseases of a variety of causes including infectious, parasitic, nutritional or neoplastic. A comprehensive health and clinical monitoring program should be designed and implemented in consultation with an experienced sheep veterinarian. Any signs of disease should be investigated using suitable diagnostic methods (Rehbinder *et al* 2000). The health program should be reviewed regularly (at least once a year).

(ii) It is important to be aware of possible infectious agents as they may affect the outcomes of experiments, even if subclinical. Parameters that may be affected include behaviour, growth rate, relative organ weights, immune responses and tumour development. If present, they are likely to affect biological variability, and some may affect humans. Animal monitoring programs will increase the reliability and reproducibility of research data and decrease the risk of zoonotic infections for researchers and animal technicians (Rehbinder *et al* 2000).

(iii) Sheep that do not shed their wool must be shorn at least once a year to prevent growth of excess wool which can make it difficult for a sheep to rise from lying. It may be helpful to shear sheep housed for research more frequently (eg every 6-8 months) since sheep in full wool require much greater space. Sheep that shed their wool may not shed completely and may need to be shorn.

(iv) Blowfly strike may be a problem in housed sheep, and crutching between shearings may be necessary to control contamination of breech wool with urine and faeces so that the risk of breech strike is minimised. In the absence of adequate control measures, lice infestation may become a problem in housed sheep.

(v) Foot diseases and internal parasites are not generally a problem when sheep are kept on raised slats or wire mesh, but may become a problem when pens with solid floors are not cleaned thoroughly on a daily basis.

(vi) Depending on the flooring system used, hoof trimming may need to be carried out on a regular basis. It is reported that hoofs of Merinos wear differently to those of British breeds and cross-breds which have better conformation.

Recommendations

5.10.1 A comprehensive health and clinical monitoring program should be put in place in consultation with an experienced sheep veterinarian.

5.10.2 Sheep that do not shed their wool must be shorn at least once a year.

5.11 Breeding

Principles

(i) Sheep breed in response to short day-length. If lighting is solely or mainly artificial, the period of lighting may have to be regulated to ensure normal reproductive function in ewes and rams.

(ii) Ewe behaviour at lambing is variable – some ewes remain with the flock while others will seek isolation. Ewes should be allowed to lamb without interference if possible. When assistance is necessary, it must be provided by a competent attendant, using good standards of hygiene and accepted techniques. Housed ewes require a clean, dry area in which to give birth.

(iii) Under paddock conditions, fine-wool Merino ewes separate from their lambs more frequently than British breed ewes such as Dorsets and Romneys or Crossbred ewes, particularly where there are multiple births. Interference, including disturbance by other ewes and lambs, is a factor that contributes to separation in Merinos with twin lambs. However the tendency of Merino ewes to move away from the birth site before the last lamb born is mobile and before the maternal bond with this lamb is fully established is also considered to be a significant factor contributing to mismothering in Merinos. Mismothering is less common in Merinos with single lambs and in the British breeds and Crossbreds, regardless of the number of lambs born. Separation of lambs in these cases is likely to be associated with difficult births and interference (Alexander et al 1983).

(iii) Immediately after birth, the ewe normally grooms the lamb vigorously, starting at the head. The intensity of grooming declines during the first hour, although frequent contact of the ewe's mouth and nose with the lamb continues for several hours. This period of contact is sufficient to allow the ewe to distinguish her own lamb from others, although ewes will readily accept other lambs in the immediate post-partum period, especially if the lamb is still wet (Hulet et al 1975).

(iv) Nowak et al (1987) concluded that Crossbred lambs had developed the ability to discriminate their mothers from other ewes at short distances by 12 hours after birth, while Merino lambs (Nowak et al 1989) had developed this ability by 24 hours after birth. By 3 days of age lambs were able to identify their mothers at longer distances, however ability to identify siblings took up to 7 days to develop. Keller et al (2003) found that olfactory recognition mediates acceptance of the lamb by the ewe at suckling, however visual and auditory cues are involved in ewes recognising their lambs from a distance. This ability developed in multiparous ewes by 6 hours after giving birth, but took up to 24 hours to develop in primiparous ewes. Regardless of maternal experience, olfactory recognition of the lamb was established within 30 minutes after the ewe giving birth.

(v) Disturbance just before or just after parturition may result in failure of bonding between the ewe and lamb as the young must find the teat within 2 hours of birth. Removal of the lamb from the mother may lead to later rejection of the lamb, especially if the lamb is removed for a number of hours (Hulet et al 1975). In the absence of the mother, the lamb can be imprinted with a suitable maternal figure even if that figure is not associated with feeding.

(vi) Maternal experience causes a reduction in ewe withdrawal, aggression and non-cooperation with sucking attempts, without affecting maternal affiliative behaviours such as grooming. Although maternal rejection behaviours are more prevalent amongst inexperienced ewes, individuals with a greater propensity to display caring

or rejecting maternal styles are seen among both primiparous and multiparous ewes. There are both breed and individual consistency in maternal behaviour across parities (Dwyer & Lawrence 2000). Stress during pregnancy may affect some aspects of ewe maternal behaviour. Transport and isolation stress in comparison with isolation stress alone reduced the dam's motivation to stay in contact with her lamb(s). This may be due to increased fear of humans resulting from the more aversive treatment during pregnancy (Roussel et al 2006).

(vii) Light penetrates the pregnant uterus of sheep. In the natural environment, the late gestation sheep foetus is exposed to light-dark transitions at dawn and dusk to a peak of light at midday. This may provide the sheep foetus with circadian and seasonal information or may serve as a sensory stimulus for the development of the visual system (Parraguez et al 1998). These transitions should therefore be replicated in housed sheep for normal foetal development.

(viii) Lambs separated from the ewe at 2 days of age have lower weight gain than those separated later (15 days).They also have a lower antibody titre than controls. The effects on humoral immune response may impact on the efficacy of vaccination programs adopted at the time of separation (Napolitano et al 1995).

(ix) In a study by Roussel et al (2004), lambs stressed prenatally by exposing their dams to treatments of isolation plus the presence of a dog, were heavier at birth than control lambs and there was a trend for this difference to persist up to 25 days of age. Basal cortisol concentrations were higher in the prenatally stressed lambs than the control lambs but no treatment effect on basal cortisol was found at 8 months of age.

(x) Pregnant ewes were found to be less reactive than non-pregnant ewes when confronted with isolation or a surprise effect. This was evident both at 40 days and 140 days, suggesting that this phenomenon is not limited to the last stages of pregnancy. However fear of a human remained constant despite pregnancy (Vierin & Bouissou 2001).

(xi) Note comments on handling of lambs in 5.2.1.

Recommendations

5.11.1 Sheep breed in response to short day-length. If lighting is solely or mainly artificial, the period of lighting may have to be regulated to ensure normal reproductive function in ewes and rams.

5.11.2 A clean, dry area must be provided for ewes to give birth.

5.11.3 Research procedures involving recently lambed ewes and/or their lambs should avoid disturbing the sheep in the period when establishment of the maternal bond is occurring, unless expressly approved by the Animal Ethics Committee.

5.11.4 Where possible, lambs should remain with their mothers for at least 15 days after birth for normal weight gain and development of the immune system.

5.12 Identification

Principles

(i) Ideally, methods used for identification should not be painful, not cause adverse reactions, not be uncomfortable and not likely to catch or tear out. Means of identification include ear tags (which may be electronic) or implanted microchips. Two ear tags may be used in case of one being lost. Temporary identification may be carried out using stock spray markers.

(ii) All sheep born after 1 January 2006 must have a National Livestock Identification Scheme breeder tag which must not be removed until the animal is processed at an abattoir or knackery. These tags identify the property of origin only and do not identify individual animals[1].

Recommendation

5.12.1 All sheep should be individually identified to facilitate accurate record keeping.

6. Records

Recommendations

6.1 Individual records should be kept of sheep that record birth date, sex, breed, source of the sheep and any previous use of the sheep. Records should include all stock movements as well as any signs of ill-health or distress, any veterinary treatments administered (date and nature of treatment) and any mortalities.

6.2 All veterinary treatments, whether medical or husbandry-related, should be recorded. Any procedures carried out (experimental or otherwise) and the outcomes of procedures should also be recorded.

6.1 Pen labels

Recommendation

6.1.1 Pen labels should record the number of animals and their identification codes; protocol number; and the name and contact details of the chief investigator and emergency contacts.

6.2 Breeding records

Recommendation

6.2.1 Records of breeding stock should be maintained which will allow effective management and monitoring of breeding activities. These should include the source, use and fate of all sheep; details of any disease; fertility, fecundity, morbidity and mortality of all sheep; and the health status of the sheep.

[1] Further information regarding the NLIS and sheep is available at http://www.dpi.nsw.gov.au/aboutus/resources/factsheets/primefacts/nlis-sheep-movement

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The information contained in this document is based on knowledge and understanding at the time of writing – June 2010. However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of Industry and Investment NSW or the user's independent adviser.

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