CHAPTER 6: ANIMAL TRANSPORT AND BEHAVIOUR

It is important to look at the process of transporting animals, as many animals are injured or even die during transport. Also, many carcasses destined for slaughter are bruised, and this represents a huge loss to the livestock industries.

In beef, losses from bruising and losses through death and serious injury of railed cattle are very costly.

Losses from bruising in beef cattle from pasture to slaughter in Australia have been estimated at $42 million per annum (Eldridge et al., 1988).

This chapter will examine the transport of cattle, pigs, sheep and very briefly, deer, under the following headings:

1. Treatment of animals before transport

2. Loading and unloading facilities

3. Transport and adjusting to a new environment

4. Recommendations

The process of transport involves all these factors and all are important to the well-being of the animal as well as to the quality of the slaughtered carcass.

TREATMENT OF ANIMALS BEFORE TRANSPORT

1. Animals are usually handled intensively before transport. They are grouped together, often in unfamiliar groups ready for loading onto a truck. It has been shown that mixing of strange animals will cause restlessness and agonistic encounters leading to bruising (Pearson and Kilgour, 1980). Mixing of unfamiliar animals at any stage results in an increase in agonistic behaviour, poorer welfare and poorer meat quality (Knowles, 1999). Once the social organisation has been established, fighting diminishes. If sheep, cattle and pigs can be grouped together for two or three days before transporting so that they become familiar with each other, the stress of transporting will be much less.

2. Horns account for about half of all bruising in horned cattle (Mieschke et al., 1974), so cattlemen should dehorn calves or breed polled animals. Hornless animals in a mixed group bruise more than those transported separately, whereas bruising is the same for all horned animals (Wythes, 1981).

3. If animals are familiarised with the yards and handling procedures when young, the potential stress will be reduced.

4. Groups of animals should be about the same size for transportation.

5. One of the key factors is the handling by the stockman. If the animals are handled quietly and gently, the stress will be reduced.

6. The design of yards to improve the flow of sheep and cattle is important.

The use of dogs in herding sheep often causes the animals to stand alert as a primary response, often accompanied by a covert increase in heart rate (Baldock et al., 1990).

Drafting prior to transport is more stressful than dipping and drenching, and is represented by a significant increase in plasma cortisol levels (Hargreaves et al., 1990).

The use of a crush can often cause a greater stress response than drafting or penning. The release of red blood cells from the spleen is a common response to handling distress in red deer (Carragher et al., 1997).

Pigs that have had handling experience tend to move through loading facilities more quickly than pigs that have had little handling (Abbott et al., 1994b).

Pigs with previous handling experience have improved carcass quality, as they are not as adversely affected by pre-slaughter handling in lairage (Abbott et al., 1997a).

Pigs with previous handling experience show paler meat, due to enhanced postmortem glycogen breakdown, but, importantly, this is not accompanied by a higher incidence of pale, soft, exudative (PSE) meat (Generink N.A. et al., 1998).

LOADING AND UNLOADING FACILITIES

This is a critical area in the process of transport. Poorly designed loading ramps, over-use of force and lack of understanding of animal behaviour all contribute to both physical damage and stress.

There is a difference in design for chutes used only for unloading trucks to those which are used for both loading and unloading (Grandin, 1980). If at all possible, it is better to have a type of chute for loading and another for unloading. A chute used for unloading any type of livestock should be wide and straight to provide a clear, unimpeded path. In packing plants a wide unloading chute (2.4 m wide) is recommended by Grandin (1978). This type of chute must never be used to load livestock.

A chute used for loading only, should have high solid sides to prevent animals from seeing out, and a narrow curved single-file chute is the most efficient. If the chute is going to be used for loading and unloading, care must be taken not to curve it too sharply. If the chute has too sharp a curve the animals will often baulk and refuse to leave the truck because the chute appears to be a dead end (Grandin, 1978). Either a curve or a 15-degree bend is recommended to prevent the cattle from seeing the truck until they are part way up the ramp. Observations (Grandin, 1980) indicate that the most efficient chutes had solid fences and an inside radius of 3.5–5 m. A radius tighter than 3.5 m is likely to cause baulking problems when the cattle are unloaded. The inside width should be about 70 cm for mature cattle so they are unable to turn around in the chute. If it is used exclusively for loading calves, the inside width can be 50–60 cm. The sides of the chute should be at least 1.5 m high for cattle, but if Brahmans are being loaded, or if the cattle are wild, the sides should be raised to 1.8 m high (Grandin, 1978).

Cattle and pigs prefer to walk up steps rather than inclines, and chutes suitable for both species should

have steps with a 10 cm rise and a 30 cm tread width (Grandin, 1978).

A common problem in poorly designed loading chutes is bunching and jamming of livestock at the junction between the single file ramp and the crowding pen. Bruises are prevented if this transition is smooth and gradual (Grandin, 1978).

Where a wide variety of trucks is going to be used, adjustable chutes are ideal, as they can be raised and lowered to load or unload the bottom or top deck (Grandin, 1978).

Straight raceways cause animals to baulk, because they perceive the truck as a dead end (Grigor et al., 1998a).

There are conflicting data to suggest that loading animals from darkened to illuminated areas reduces stress or increases efficiency (Grigor et al., 1998a).

Initially after loading, urination and defecation is very frequent but declines as transport begins (Fraser, 1980).

During rail transit, cattle rarely alter their position. They align their bodies at right angles to the direction of travel (Fraser, 1980).

In horses, transport by road over short and long distances is found to suppress feeding behaviour, elevate heart rate and lead to unnatural body postures causing weight loss and fatigue (Warren et al., 1995).

Overloading and underloading of trucks increases bruising (Grandin, 1995c).

TRANSPORT AND ADJUSTING TO A NEW ENVIRONMENT

The actual transporting of an animal is probably one of the most traumatic periods of its life. It leaves the security of a known environment and is subjected to motion, changes in temperature, ventilation, noise levels, smells and changes in group size and density. Short transportation periods cause rises in sheep plasma cortisol of moderate to high levels (66 ng/ml) compared to minimal disturbance levels (36 ng/ml). Long transportation periods and a new environment cause complex changes in corticosteroid levels in both directions, which may extend over some months (Pearson and Kilgour, 1980).

Transport can cause various problems apart from physical bruising and damage, including:

1. transit erythema—red skin due to urine soakage;
2. transit tetany—metabolic upset caused by lack of food and water. The animals lie down and coma results. It is common in cows, ewes and ponies;
3. transit or shipping fever—usually a bacterial infection (Pasteurellosis) in fatigued animals, and particularly affects cattle;
4. fatigue and exposure.

BEHAVIOUR OF ANIMALS DURING TRANSPORT AND ON ARRIVAL AT NEW ENVIRONMENT

SHEEP

The effects of different modes of transport on the behaviours of sheep has been reviewed by Kilgour (1976).

1. ***Road transport***. Following completion of a road journey, lambs grazed briefly (2–3 hours) and spent the next 23 hours resting, then returned to their field. Where animals have not been able to lie down, resting takes precedence over feeding or arrival (Ewbank, 1975).

2. ***Air transport***. Little is known of the effects of flight on sheep or lambs, but one study suggests that unshorn sheep in two-tiered crates suffered some ventilation problems while the plane was not in flight (Allsup, 1975).

3. ***Sea transport.*** The main problems seem to be in the handling of the sheep. Sheep must be conditioned to eat pellets before boarding the ship; hand-fed sheep that are used to this type of feed do not have this problem. Ship hygiene and Salmonella losses, poor ventilation with high temperatures and humidity, fluctuating and changing diets can all cause problems.

4. ***Rail transport.*** On a long rail trip, adult Merino sheep seldom lie down in railway trucks, even on a five-day journey. When rested after travelling for two to four days without water or food, no preference for either was shown, but after five days there was a preference for water. In the rest pens, only 0.4 kg of lucerne hay per sheep was eaten in 24 hours; so if the regulation four one-hour rests were given, very little food would be taken (Sutton and Heever, 1968).

During long transportation where a lairage period is allowed, sheep require sufficient time to drink before a subsequent journey is undertaken (Jackson et al., 1999).

If feed is provided during a break from transport, and sheep are not provided with sufficient drinking time, dehydration can result due to consumption of large amounts of dry feed (Jackson et al., 1999).

Sheep require a lairage of more than 8 hours to gain any real benefit (Knowles, 1998).

The behaviour of sheep generally is little changed under conditions of poor welfare, such as injury or overcrowding (Knowles, 1998). Thus sheep seem to be particularly tolerant of transportation compared with other farm animal species.

During transportation of sheep by road, they ate less, ruminated less and lay down less (Ewbank et al., 1990).

Sheep will ruminate while being transported and if they are transported at low enough densities, they will lie down and be able to rest to some extent. However, they do not lie down as much as they would in a static pen at a similar stocking density (Knowles, 1998).

Driving conditions play a role in the behaviour of sheep during road transport. The rougher the journey,

the more likely is bruising and the greater is the increase in cortisol levels (Ruiz-de-la-Torre, 2001).

After a trip lasting 24 hours, slaughter lambs did not return to normal drinking patterns until 14 hours into recovery; normal eating patterns were not resumed until 16 hours later and even after 24 hours of recovery, the lambs were not standing as much as prior to transport (Knowles, 1998).

Sheep that are to be transported by sea on journeys of less than 8 hours should be fasted of water and food (18 hours prior to departure) to reduce the incidence of death or sickness. On longer journeys, the sheep should be fed 2–3 hours prior to the start of the journey (Shupe, 1985).

Ewes introduced to a new flock show minimal grazing and increased vocalising and walking. The newly introduced sheep tend to remain at the edge of the flock (Baldock et al., 1990).

Exposure to a familiar feed (e.g., hay) will increase the food and water consumption (up to 4.9 times) of sheep transported to a new environment (Hall et al., 1993).

CATTLE

1. ***Road transport***. If cattle are allowed to settle down at the beginning of a journey they will travel without difficulty. Several studies take the lowering of the head as a sign that cattle have settled, and this may occur as soon as 30 minutes after travel commences. It has been noted that weaned calves hold their heads high in the early stages of road travel and, where this was not possible, they tend to lie down and be trampled on by others (Kilgour and Mullord, 1973). They also tend to bunch their heads to the centre during road travel and avoid contact with pen walls. They swayed as a group, avoiding the side rails of the truck. During fast, flat land travel with corners, their bodies tended to be side on to travel, but when hilly roads were encountered, they moved in line with the direction of travel. When calves were released to pasture after 25 hours of penned conditions, the prime need was for exercise, with grazing next, and water only a third consideration (Kilgour and Mullord, 1973).

(The most common orientation for cattle is perpendicular or parallel to the direction of travel. These positions may be chosen to improve security and balance on a moving vehicle (Tarrant, 1990).

There is little difference seen between responses of bulls and steers to transport (Knowles, 1999).

At the beginning of a journey, cattle are generally anxious and restless and defecate and urinate frequently (Knowles, 1999).

Cattle do not readily lie down while being transported and this forced standing causes them to become physically tired during transport in a way that is not seen in pigs and sheep (Knowles, 1999).

Loss of balance is a major determinant in injuries in transported cattle. In a study by Tarrant, 1990, it was found that one-third of events where cattle were floored during transport were caused by loss of balance during cornering.

Knowles et al. (1999) also found that when one or more animals lay down (on a 31-hour journey), it became more difficult for the others to remain standing and several animals lost their footing and fell down.

The space allowance for animals during transport can significantly influence carcass weight, level of bruising and welfare of the animals (Eldridge et al., 1988).

It is recommended (Eldridge et al., 1988) that for cattle 350–400 kg live weight, a space allowance within 10% of 1.16 sq m per animal is satisfactory.

Animals on a double-decked vehicle drank less often than those on a single-decked vehicle (Knowles et al., 1999).

2. ***Air transport.*** Hereford cattle were flown from Gatwick (UK) to Shanghai. During the flight the animals browsed at hay and, although water was offered, they did not attempt to drink. There was an increase in the number lying down as the journey went on, and animals appeared unconcerned during the whole flight (Jackson, 1979). The longer the flight continued, the more cattle lay down (Jackson, 1974).

3. ***Sea transport.*** There is a lack of information on the behaviour of cattle during sea transport. Shipping fever can be brought on by a cascade of events initiated by stress (Tarrant et al., 1993).

4. ***Rail transport.*** Cattle are restless in railway trucks for up to five hours after starting their journey. They show muscular trembling, butting of other animals, considerable movement, defecation and urination (Bisschop, 1961). An average of 10% rested at any one time on the journey. The behaviour of Angus and Hereford calves was monitored while travelling in a rail car for a 57-hour journey (Friend et al., 1981). Calves commenced eating and drinking immediately after being loaded. Up to 75% of the calves could lie down while the car was not in motion (14.4 hours of the trip) and they stood at high speeds (80 km/hr) but continued to eat, drink and move about. Self and mutual grooming commonly occurred while travelling up to 40 km/hr, and they ate and drank readily. They were also adept at maintaining their balance and conducting 'normal' activities even when the ride was very rough.

Cattle off-loaded in rest kraals during rail transport showed a preference for either food or water; and after a marked urge to walk around, ate and drank for 40 to 100 minutes, and then lay down (Sutton et al., 1967).

Long-distance road or rail transport can cause an elevation of meat pH, which can be reversed by resting and feeding the animals for two days or longer after the end of a long journey (Tarrant et al., 1993).

Road and rail transport at low and high space densities significantly increases bruising, reduces carcass weight and impacts on the welfare of the animals (Eldridge et al., 1988).

Liveweight decreased with increased travelling time (more than 31 hours). Plasma osmolarity and urea concentration increased, suggesting dehydration (Knowles et al., 1999).

PIGS

It has been shown that pigs subjected to simulated transport for 30 minutes had a rise in heart rate to 150 beats/minute compared with a resting control level of 100 beats/minute. As pigs became familiar with the experimental situation by repeated exposure, the increase in heart rate in response to transport simulation was reduced. There was no significant change in heart rate (Stephens and Rader, 1982). It seems that pigs do get used to transport stress.

1. ***Road transport***. During the whole journey pigs should have light, even if only dim, to facilitate orientation and social contact. Water should be provided at intervals during stops (Van Putten, 1977). The driver's skill is important and as long as lorries are well ventilated and the pigs do not suffer from heat stress, pigs tend not to be restless.

2. ***Air transport.*** A number of short air journeys (1.5–2.5 hours) have been monitored when breeding pigs were exported. Boars in particular are subject to heat stress, and it is also important to transport these animals in familiar social groups to reduce agonistic behaviour (Jackson, 1979). Pigs are reasonably good travellers by air, provided they are not over-fed prior to embarkation. On occasions they need spraying with water to reduce temperatures and when mortality does occur it is usually the result of overcrowding (Scott 1978).

Recommendations for air transport of pigs include: avoid the use of tranquillisers; pre-mix pigs in constant groups one week before shipping to reduce fighting; provide an adequate water supply; keep a dim light on during the entire flight; control dust; avoid heat stress; and instruct the receiving party to avoid post-transport losses by taking jet-lag into account (Lambooij et al., 1993).

3. ***Rail transport.*** Pigs that travelled from England to France and thence to Italy over seven days were only restless when hungry or thirsty. The movement of the train appeared to have little effect, except when violent shunting was being carried out. Huddling occurred on a very few occasions when it became cold at the pig's level, but most of the time the pigs wandered around the pen in apparent contentment. The behaviour in all the pens tended to be synchronised, even though the pens were well separated (Jackson, 1979).

Transport does induce stress in pigs. Climatic conditions, loading density, duration of transport, cold draughts, heat stress, social stress, vibrations and noise all affect the condition of the pigs during transport (Lambooij et al., 1993).

Small rises from the normal pig body temperature of 39–42 degrees proved fatal (Lambooij et al., 1993), so adequate ventilation on transport vehicles and the weather of the day must be taken into consideration.

Pigs try to stay in contact with one another in stressful conditions and this can be seen in huddling behaviour during transport. Pigs in a stressful situation are calmed by the presence of their pen mates (Lambooij et al., 1993).

The transport of pre-pubertal pigs often leads to hypothermia after 30 minutes of travel (Parrott, 1998).

Fasting and transport over various distances in pigs showed no detrimental effects on meat quality. The meat of the animals showed an increase in tenderness with no reduction in juiciness (Becker et al., 1988).

HORSES

1. ***Road transport.*** It has been shown that rear-facing transport provides horses with the physical and psychological security and comfort that is wanting in conventional, forward-facing transport. Once en route, the horse sees objects slipping harmlessly away from it, rather than threateningly towards it. During the rear-facing transit, the horse's rump is at the trailer bulkhead area, rather than the fragile head, and any emergency stop will be received on the rump (Cregier, 1980, 1981).

Rear-facing transport is less stressful than forward-facing, as indicated by the horses having a lower mean HR. The horses rested their rumps on the bulkhead and carried their heads in a lower, more natural position (Warren et al., 1996).

2. ***Air transport.*** Horses are usually accommodated in moveable padded crates, the sides and floor of which are covered with coconut matting, and the front and rear are thickly padded. Some horses are frightened by the engine noise at take-off or landing and are inclined to rear. Adequate restraint is necessary; panic-stricken horses have had to be destroyed during turbulence on an aeroplane, while strapped-in horses were less restless and at the most, spent time stamping their feet incessantly throughout the entire flight (Judge, 1969). Horses should be loaded so that they face either fore or aft, so that they can flex the joints of their hindquarters at take-off (Scott, 1978).

3. ***Sea transport.*** Flooring of the carrying crates should be of antislip material and each box should be provided with a strong head-stall with ropes attached on either side and suitable provision for slinging horses, if necessary. If horses have been fed and watered within one hour of starting the voyage, they need no provisions for a further 12 hours. Horses must not be carried if there are reasonable grounds, at the time of sailing, to expect adverse weather conditions that might lead to suffering (Scott, 1978).

The entrance to the transport vehicle should be wide, well-lit and uncomplicated, to take into account the natural fear a horse has of confinement and eyesight restrictions (Houpt, et al., 1993).

Water and feed intakes during transit and after arrival are critical to maintain normal body functions and this has been recognised as a problem, in particular, for racehorses (Mars et al., 1991).

Compared to experienced horses that load easily and stand normally, naive yearlings are reluctant to enter a vehicle via a ramp and consequently often have higher heart rates (Warren et al., 1995).

DEER

It is suggested that deer be transported in a darkened box or closed vehicle to prevent panic. During transport it is better if deer stand up, as lying down can result in bruising, fractured ribs or broken bones. When deer are about to be released from the boxes, they should be put into the paddock with the release door facing the farthest fence of the paddock so if the deer are frightened they have plenty of space to run without damaging themselves. The farmer should stand well back and out of sight after the door is open. The deer will explore if allowed to be undisturbed for several days (Anderson, 1978).

Deer prefer to orient themselves parallel to and facing the direction of travel, avoiding diagonal orientations (Jago et al., 1997).

Stocking density of deer should be around 0.42 sq m per animal so that the deer can remain in contact with others to help maintain balance around corners (Jago et al., 1997).

On longer trips it is suggested by Jago et al. (1997) that stocking densities should be lowered to allow deer to lie down.

The distance travelled has no effect on agonistic behaviour. When in groups, large animals initiated agonistic behaviour that was usually directed at the smaller members of the group (Jago et al., 1997).

Road surface influences the behaviour of deer during transport but increased distance of travel has no additional effect on behaviour or ultimate pH (Jago et al., 1997).

Bruising due to stress during transport accounts for an average economic loss of 26.9% of the carcass value (Selwyn and Hathaway, 1990).

Pre-slaughter handling (including transport) results in an increase in creatine kinase (CK), aspartate aminotransferase (AST), glucose, cortisol, lactate and a decrease in magnesium (Jago et al., 1997).

Transportation plus prolonged lairage in an unfamiliar environment has minimal effect on venison quality (Grigor et al., 1997b).

RECOMMENDATIONS

From the discussion of transport and associated problems involved, it is apparent that certain management procedures would make the whole process easier both for man and his animals. Recommendations include:

1. Familiarising animals with yards and yard-handling.

2. Grouping animals well before transport so social groups become established and the rate of agonistic activity is lessened.

3. Grouping animals of similar age, size and sex.

4. Dehorning calves or breeding polled cattle will improve welfare during transport and marketing.

5. Appropriate design for animal yards. It is recommended that pens are long and narrow so that animals enter through one end and leave through the other (Grandin, 1990b).

6. Appropriate design for transport vehicles.

7. Appropriate design for loading and unloading facilities. The maximum recommended angle for adjustable ramps for cattle, pigs and sheep is 25 degrees (Grandin, 1990b).

8. Adequate attention must be paid to the transport environment (temperature, ventilation, humidity, food, water, etc.).

9. Adequate rest periods must be allowed.

10. Proper handling by the handlers.

Model Codes of Practice now cover most aspects of animal welfare in Australia, including road and rail transport of livestock. Similar recommendations exist in Europe for the transport of farm animals.

Handlers must treat horses and cattle correctly to prevent memory traces associated with fear developing in the amygdala. This can determine how an animal reacts to future fearful or negative experiences (Grandin, 1999a).

Cattle that are quietly handled have smaller flight zones and are easier to manage in the future than cattle that have been roughly handled (Grandin, 1999a).

Indoor housing pens should have even, diffuse lighting that minimises shadows. Cattle, pigs and sheep have a tendency to move more easily from a dimly illuminated area to a more brightly illuminated area (Grandin, 1990b).

Deer-loading facilities should be wide enough for group movement but narrow enough to stop the animals from turning around (Grigor et al., 1998a).

Cattle should be transported by rail and road at a medium density to minimise weight loss and bruising (Eldridge et al., 1988).

A lairage period of 24 hours should be provided for recovery after a 14–31 hour journey (Knowles et al., 1999).

REFERENCES

Abbott, T.A., Hunter, E.J. 1994b. The effect of routine handling on the ease of moving and loading pigs. Applied Animal Behaviour Science 41, 269–79.

Abbott, T.A. Hunter, E.J., Guise, H.J., Penny, R.H.C., 1997a. The effect of experience of handling on pigs' willingness to move. Applied Animal Science Behaviour 54, 371–75.

Allsup, T.N. 1975. Transport by air. In: Transport of farm animals. U.F.A.W. Symp. 13–22.

Anderson, R. 1978. Gold on Four Feet. Publ. by R. Anderson and Assoc. Pty. Ltd. 2/8 The Ridgeway, Ivanhoe, Vic., Australia. p.73.

Baldock, N.M., Sibly, R.M, 1990. Effects of handling and transportation on the heart rate and behaviour of sheep. Applied Animal Behaviour Science 28, 15–39.

Baldock, N.M., Sibly, R.M. 1990. Effects of handling and transportation on the heart rate and behaviour of sheep. Applied Animal Behaviour Science 28, 15–39.

Becker, B.A., Mayes, H.F., Hahn, G.L., Nienaber, J.A. 1988. Effects of fasting and transportation on various physiological parameters and meat quality of slaughter hogs. Journal of Animal Science 67, 334–41.

Bisschop, J.H.R. 1961. Transportation of animals by rail. 1. The behaviour of cattle during transportation by rail. Sth. Afr. Vet. Med. Assoc. 32: 235–68.

Bureau of Agricultural Economics, 1981. Livestock Marketing in Australia. An Economic Evaluation. Industry Monograph No. 1. Aust. Govt. Publishing Service, Canberra.

Carragher, J.F., Ingram, J.R., Matthews, L.R. 1997. Effects of yarding and handling procedures on stress responses of red deer stags (***Cervus elaphus***). Applied Animal Behaviour Science 51, 143–58.

Cregier, S.E. 1980/1981. Alleviating road transit stress on horses. Anim. Regul. Stud. 3: 223–27.

Eldridge, G.A, Winfield, C.G. 1988. The behaviour and bruising of cattle during transport at different space allowances. Australian Journal of Experimental Agriculture 28, 695–98.

Ewbank, R. 1975. The transport of animals by road. U.F.A.W. Symp. p.3–9.

Ewbank, R., Kent, J.E. 1990. The behaviour of road-transported sheep. J. Ap. An. Behav. Sci. 26, p.294.

FRASER, A.F. 1980. Farm Animal Behaviour, 2nd edn, p.52.

Friend, T.H., Irwin, M.R., Sharp, A.J., Ashby, B.H., Thompson, G.B. and Bailey, W.A. 1981. Behaviour and weight loss of feeder calves in a railcar modified for feeding and watering in transit. Int. J. Stud. Anim. Prob. 2: 129–37.

Geverink, N.A., Kappers, A. van de Burgwal, J. A., Lambooij, E., Blokhuis, H.J., Wiegant, V.M., 1998. Effects of Regular Moving and Handling on the Behaviour and Physiological Responses of Pigs to Preslaughter Treatment and Consequences for Subsequent Meat Quality. Journal of Animal Science 76, 2080–85.

Grandin, T. 1990b. Design of loading facilities and holding pens. Applied Animal Behaviour Science, volume 28 187–201.

Grandin, T. 1995c. Bruise levels on fed and non-fed cattle. Proceedings Livestock Conservation Institute, 193–201.

Grandin, T. 1999a. Accimate, Don't Agitate: Cattle and Horses with excitable temperaments must be introduced gradually to new experiences, Beef, 14–16 (www.grandin.com/references) .

Grandin, T. 1978. Transport from the animal's point of view. American Soc. of Agric. Engineers. Paper No. 78–6013.

Grandin, T. 1980. Observations of cattle behaviour applied to the design of cattle-handling facilities. Appl. Anim. Ethol. 6: 19–31.

Grigor, P.N., Goddard, P.J., Littlewood, C.A., Deakin, D.W., 1998a. Pre-transport loading of farmed deer: Effects of previous overnight housing environment, vehicle illumination and shape of loading race. The Veterinary Record 142, 265–68.

Grigor, P.N., Goddard, P.L., MacDonald, A.J., Brown, S.N., Fawcett, A.R., Deakin, D.W., Warriss, P.D., 1997b. Effects of the duration of lairage following transportation on the behaviour and physiology of farmed red deer. The Veterinary Record 140, 8–12.

Hall, S.G., Schmidt, B., Broom, D.M., 1993. Feeding behaviour and the intake of food and water by sheep after a period of deprivation lasting 14 hours, Animal Science 64, 105–10.

Hargreaves, A.L., Hutson, G.D., 1990. The stress response in sheep during routine handling procedures. Applied Animal Behaviour Science 26, 83–90.

Houpt, K.A., Lieb, S. 1993. Horse handling and transport in Livestock Handling and Transport, ed T. Grandin, CAB International, UK.

Jackson, W.T., 1974. Air transportation of Hereford cattle to the People's Republic of China, Veterinary Record 94, 209–11.

Jackson, R.E., Cockram, M.S., Goddard, P.J., Doherty, O.M., McGlip, I.M. and Warren, N.K., 1999. The effects of 24-hr water deprivation when associated with some aspects of transportation on the behaviour and blood chemistry of sheep. J. An. Welfare 8, 229–41.

Jackson, W.T. 1979. Behavioural observations on farm animals in transit. Appl. Anim. Ethol. 5: 291 abs.

Jago, J.G., Harcourt, R.G., Matthews, L.R., 1997. The effect of road type and distance transported on behaviour, physiology and carcass quality of farmed red deer (***Cervus elaphus***). Applied Animal Behavior Science 51, 129–41.

Judge, N.G. 1969. Transport in horses. Aust. Vet. J. 45: 465–69.

Kilgour, R. 1976. Sheep behaviour: Its importance in farming systems, handling, transport and pre-slaughter treatment. Proc. Sheep Assembly and Transport Workshop. West. Aust. Dept. of Agric., Perth, Oct. 1976.

Kilgour, R. and Mullord, M. 1973. Transport of calves by road. N.Z. Vet. J. 21: 7–10.

Knowles, T.G., Warriss, P. D., Brown, S.N., Edwards, J. E., 1999. Effects on cattle of transportation by road for up to 31 hours. Veterinary Record 145, 575–82.

Knowles, T.G., 1998. A review of road transport of slaughter sheep. The Vet. Record 143, 212–19.

Knowles, T.G., 1999. A review of the road transport of cattle. The Vet. Record 144, 197–201.

Lambooji, E., van Putten, G. 1993. Transport of Pigs in

Livestock Handling and Transport, ed T. Grandin, CAB International, UK.
Mars, L.A., Kiesling, H.E., Ross, T.T., Armstrong, J.B. and Murray, L. 1991. Water acceptance and intake in horses under shipping stress. Proceedings of 12th Equine Nutrition and Physiology Symposium. University of Calgary, Alberta, Canada, 249–50.
Meischke, H.R.C., Ramsay, W.R. and Shaw, F.D. 1974. The effect of horns on bruising in cattle. Aust. Vet. J. 50: 432–34.
Parrott, R.F., 1998. Effects of transport and indomethacin on telemetered body temperature and release of cortisol and prolactin in pre-pubertal pigs. Research in Veterinary Science 64, 51–55.
Pearson, A.J. and Kilgour, R. 1980. The transport of stock—an assessment of its effects. In: Behaviour in Relation to Reproduction, Management and Welfare of Farm Animals. Reviews in Rural Science IV. Ed. M. Wodzicka-Tomaszewska, T.N. Edey and J.J. Lynch.
Qld Meat Industry Organization and Marketing Authority 1981. Railed-cattle losses in Queensland.
Ruiz-de-la-Torre, J.L., Velarde, A., Diestre, A., Gispert, M., Hall, S.J.G., Broom, D.M., Manteca, X. 2001. Effects of vehicle movements during transport on the stress responses and meat quality of sheep. The Vet. Record 148, 227–29.
Scott, W.N. 1978. The transport of livestock. In: The Care and Management of Farm Animals. ed. W.N. Scott. Baillière Tindall. London. 216–21.
Selwyn, P., Hathaway, S. 1990. A study of the prevalence and economic significance of diseases and defects of slaughtered farmed deer. New Zealand Veterinary Journal 38, 94–97.
Shupe, W.L. 1985, Transporting sheep to pastures and markets. American Society of Agricultural Engineers, no. 85–6008.
Stephens, D.B. and Rader, R.D. 1982. The effects of simulated transport and handling on heart rate, blood pressure and renal arterial blood flow in the pig. Appl. Anim. Ethol. 8: 409–410.
Sutton, G.D. and Van den Heever, L.W. 1968. The effect of prolonged rail transport on adult Merino sheep. J. Sth. Afr. Vet. Med. Assoc. 39: 31–34.
Sutton, G.D., Fourie, P.D. and Retief, J.S. 1967. The behaviour of cattle during transport by rail. J. Sth. Afr. Vet. Med. Assoc. 38: 153–56.
Tarrant, P.V., 1990. Transportation of cattle by road. J. Ap. An. Beh. Sci. 28, 153–70.
Tarrant, V., Grandin, T. 1993. Cattle Transport in Livestock Handling and Transport, ed T. Grandin, CAB International, UK.
Van Putten, G. 1977. Social behaviour of pigs in relation to intensification and transport. Appl. Anim. Ethol. 3: 201 abs.
Waran, N.K. Cuddeford D, 1995. Effects of loading transport on the heart rate and behaviour of horses. Applied Animal Behaviour Science 43, p. 71–81.
Waran, N.K. Robertson V., Cuddeford D., Kokoszko A., Marlin D.J, 1996, Effects of transporting horses facing either forwards or backwards on their behaviour and heart rate, The Veterinary Record 139, 7–11.
Wythes, J.R., 1981. Animal welfare—a vital issue. Qld. Agric. J. 107(3): 136–43.