

Livestock Handling and Transport

3rd Edition

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3rd Edition

Edited by

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Preface

The purpose of this book is to serve as a source of the latest scientific research information and as an archive of practical information. In this third edition, the goal is to bring together in one book the latest research data and practical information on animal handling, the design of facilities and transport. Some of the most valuable contributions to the knowledge of animal handling and transport are often located in producer publications that are difficult to obtain. The extensive reference lists in each chapter will help preserve important knowledge that may not be available on the Internet. At the end of the book there is an index of useful web pages on handling, behaviour and transport.

The first edition was published in 1993 and this third edition was published 14 years later. It is fully updated with the latest research. An extensively revised introductory chapter covers the increasing awareness of animal welfare around the world and outlines the effective auditing programmes of large, corporate meat buyers. Three new authors have chapters on sheep transport, biosecurity and low-stress methods for sorting cattle and weaning calves.

To provide an additional perspective on livestock management in South America, Asia, India and other regions, two new co-authors have been added to the chapters on cattle transport and the handling of cattle raised in close association with people.

The best of the older material – including all the popular handling system layouts and behaviour diagrams – has been kept. Many readers reported that they found these diagrams useful.

All aspects of animal handling are covered, such as handling for veterinary and husbandry procedures, stress physiology, restraint methods, transport, corral and stockyard design, handling at slaughter plants and welfare. Principles of animal behaviour are covered for cattle, sheep, pigs, horses, deer and poultry.

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1 Introduction: Effect of Customer Requirements, International Standards and Marketing Structure on the Handling and Transport of Livestock and Poultry

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Introduction

Since the 2000 edition, there have been great changes in the industry that have brought about improvements in handling and transport of livestock. Both new international standards and animal handling audits by major meat-buying customers have been drivers of these improvements. Large companies such as McDonald's Corporation, Wendy's International, Tesco Supermarkets and others conduct audits to ensure that meat suppliers maintain high standards.

The author has worked with McDonald's, Wendy's, Burger King and other companies in implementing slaughter plant auditing programmes in the USA, Australia and other countries. These programmes have brought about great improvements since their implementation in 1999 (Grandin, 2001, 2005a). To remain on a customer's approved suppliers list, the plants had to upgrade their practices. Many of the improvements were accomplished by improved equipment maintenance, better training and supervision of employees, and by simple, inexpensive modifications.

Animal handling and welfare auditing programmes are now being conducted in many countries around the world, ranging from South America to Asia. In the USA, Canada, Australia and New Zealand, approximately 90% of the

large beef and pork slaughter plants are audited by major customers. The author has observed that the places with the worst practices are slaughter plants that are not audited by customers.

Another significant development since the 2000 edition has been the development of animal welfare guidelines by the OIE (World Organization for Animal Health) in Paris (OIE, 2005a). Due to the increasing globalization of the entire livestock industry, OIE guidelines are being used in more and more countries to determine standards for trade. These guidelines cover welfare during both slaughter and transport of cattle, pigs, sheep, goats and all types of poultry (OIE, 2005b, c). OIE guidelines are *minimum* worldwide standards for animal welfare. The welfare requirements of major meat-buying customers are usually more strict. The European Union has also made regulations of livestock transport more strict: more rest stops are required and truck drivers will be required to take training courses.

A third major factor of increasing importance is the demands for animal identification and source verification by both commercial customers and governments in countries that import meat. Animals have to be able to be traced back to the farm of origin (Smith *et al.*, 2005). Identification and traceback holds producers accountable for losses due to bruises,

dark-cutters and disease. A major motivator for improved animal identification has been the advent of BSE (bovine spongiform encephalopathy) and other animal diseases, the dramatic changes having been brought about by requirements from meat buyers. Both government and private companies require producers to adhere to strict guidelines for animal welfare and food safety. The most effective programmes originate from countries and companies that have a large economic influence on the market.

Guidelines and training materials

Livestock producers' associations, governing bodies and animal welfare groups have responded by publishing more guidelines and training materials for handling and transport. Europe has had guidelines for years but, since 2000, the European Commission has published a major report on animal welfare during transport (Broom *et al.*, 2002). The Farm Animal Welfare Council in the UK has also issued reports (FAWC, 2003, 2005). Canada, the USA and South America have published more training guidelines since 2000.

Various guidelines and programmes are now in place: (i) the US Pork Board Truckers Quality Assurance programme for the training of truck drivers; (ii) Canadian guidelines on transport of unfit animals (Fisher *et al.*, 2005; Mason, 2005; OFAC, 2005; Ontario Beef, 2005); and (iii) South American guidelines for the training of those people handling livestock (Barros and Castro, 2004; Gallo and Stegmaier, 2005). Australia has National Animal Welfare Standards on handling and transport (Edge *et al.*, 2005). The guidelines used by many restaurant companies for auditing meat plants have been updated and now have a standardized audit form (Grandin, 2005b). Retailers are also using standards developed by producer groups to audit farms in many countries.

Both the Canadian and the US governments have new restrictions on the transport and slaughtering of non-ambulatory animals: in the USA, non-ambulatory cattle are not allowed to enter the food supply. To guide USDA (US Department of Agriculture) veterinarians on humane handling enforcement, the Food Safety Inspection Service started HIKE (Humane Interactive

Knowledge Exchange), which provides meat inspectors with case histories of handling and stunning problems that have occurred in actual plants. These real-life scenarios provide easy-to-understand instructions on how to enforce the various regulations (see <http://www.fsis.usda.gov>).

Effect of Customer Audits on Animal Handling

Audits conducted by the large restaurant companies have been one of the most significant factors that have improved animal handling and stunning in the USA and many other countries. The most effective audit programmes encourage suppliers to continuously improve, and plants that repeatedly fail audits are removed from the customer's approved supplier list. This has the effect of making plant management take the audit seriously. Table 1.1 compares measures of stunning and handling before and after the audit programmes started in 57 US beef plants (Grandin, 1997a, 2002, 2005a). Pork plants have also greatly improved. The incidence of cattle or pigs falling down due to slippery floors or rough handling has almost been eliminated in plants that have been in a customer auditing programme for 2 or more years.

Poultry plants that have been in a strict restaurant welfare auditing programme, where they are required to correct deficiencies, also have much better standards of treatment compared with other plants. Twenty-six poultry complexes that had been in a strict handling and stunning audit programme for 3 or more years had no acts of severe abuse observed during an audit. However, 18 complexes that were not part of this programme had acts of severe abuse in 28% of the complexes. Abusive handling included throwing and kicking chickens, putting live chickens in the trash and scalding live chickens. The plants in the strict restaurant audit programme also had superior plant scores on stunning, broken wings and transport cage repair (see Table 1.2).

Constant vigilance is required by both the customer's auditors and plant management to keep standards high. The best beef and pork plants have their own internal audits, but a few plants have had continuous problems and have let their standards slip. The key is plant management

Table 1.1. Improvements in cattle stunning and handling in slaughter plants that were audited by a major customer with strict requirements.

	Cattle rendered insensible with one shot from a captive bolt (%)		Plants passing the stunning audit with 95% or more cattle stunned with one shot (%)	Handling stress indicator – cattle that vocalize (moo or bellow in the stun box and during movement into the stun box) (%)		Plants passing the vocalization audit with 3% or less of animals vocalizing (%)
	Average of all plants	Worst plant		Average of all plants	Worst plant	
Baseline – before customer audits started (<i>n</i> = ten plants for stunning)	89	80	10	8	32	43
Fourth year of being audited by three major customers ^a (<i>n</i> = 53 plants)	97	86 ^b	94	2	6	91

^a These customers were very strict and plants that failed to correct deficiencies were removed from the approved supplier list.

^b Cull cows and bulls. One plant has fluctuated from year to year, passing and failing audits due to poor management.

(Grandin, 1988). In several large audited plants, a change in management solved their problems with failed audits. In another case, when a plant lost a good manager it started to fail audits.

In most US, Australian, European and Canadian beef and pork plants, good standards could be achieved and maintained by improvements in stunner maintenance, installation of non-slip flooring and the elimination of distractions such as shiny reflections that cause animals to balk and refuse to move (Grandin, 1996, 2005b, 2007; Grandin and Johnson, 2005). They did not have to build a new facility. Often, changing the lighting or adding solid sides on a race or stun box was all that was needed to improve animal movement. Moving a lamp will often remove a reflection, and the installation of additional indirect lighting will attract all species into dark stun boxes, restrainers or races.

However, plants in other countries that did not previously have proper stunning equipment have now installed stunners and thereby improved their handling facilities. Since the year 2000, there has been a boom in remodelling and renovation of plants in South America and Asia. This was done to fulfil customer and international requirements for both animal welfare and food safety.

Importance of outcome-based objective standards

A well-written standard that can be consistently applied avoids vague terms such as adequate or proper. What one person may consider proper handling another may consider abusive. An example of a clearly worded standard is: 'all pigs

Table 1.2. Improvements in poultry handling and stunning in slaughter plants that are audited by a major customer with strict requirements.

	Plants having 3% or less broken or dislocated wings (per bird basis, %)	Plants passing the stunning audit with 99% or more of the chickens stunned in a waterbath stunner (%)	Plants passing the audit with 95% or more of the transport cages in good repair (%)
Plants that were not part of a strict restaurant audit programme ($n = 12$ plants for stunning and broken wings; $n = 18$ for level of cage repair)	58	42	88
Plants that were in a strict restaurant audit programme for at least 3 years ($n = 26$ plants ^a)	100	96	92

^aThis customer was very strict and plants that failed to correct deficiencies were removed from the approved supplier list.

must have enough space so that they can all lie down at the same time without being on top of each other’.

One of the reasons for the success of the restaurant programmes is that they have used a simple, objective, outcome-based numerical scoring system that minimized subjective judgment. Outcome-based audits that are based on activities and things that auditors can directly observe are much more effective than audits based on the examination of paperwork. Plant management knew exactly what was expected and the objective nature of the scoring system produced similar results with different auditors.

The principle here is to measure relatively few really important outcome-based critical control points (core criteria) that measure numerous problems. For example, animals falling down is a sensitive indicator of either poorly trained handlers or slippery floors. Vocalization (bellowing or squealing) is another indicator of problems; this can be caused by a broken stunner, slipping on the floor, excessive pressure from a restraint device, use of an electric goad or by leaving an animal in the stun box too long.

The five numerically scored core criteria are:

- percentage of animals rendered completely insensible with one application of the stunner;
- percentage that remain insensible (must be 100% for pass);
- percentage that fall down during handling;
- percentage that vocalize during stunning and handling in the stunning box and lead-up race; and
- percentage prodded with an electric goad.

Each animal is scored with simple yes/no scoring. For example, was an animal touched with an electric goad or not touched? For vocalization, each bovine is scored as being either silent or vocalizing. Scoring of cattle vocalization (moo or bellow) during handling is a sensitive indicator of distress. Grandin (1998a) found that 98% of all cattle vocalization in the stun box or in the race leading up to the stun box was associated with an aversive event such as missed stuns, slipping or falling, excessive pressure from a restraint device, single bovine isolated too long or electric goading. Vocalization is associated with stress (Dunn, 1990; Warriss *et al.*, 1994; White *et al.*, 1995; Weary *et al.*, 1998).

There are also five acts of abuse that would lead to automatic audit failure:

- the dragging or throwing of sensible animals;
- the prodding of a goad into sensitive parts of animals;
- deliberate beating of animals;

- the slamming of gates on animals; and
- the intentional driving of one animal over the top of another.

A more complete description can be found in the following: Grandin, 1998b, 2005a, b, 2007. Abusive methods of restraint and handling that are common in developing countries would also lead to automatic audit failure. The following practices would be banned – shackling and hoisting of live animals by the leg, poking out eyes, cutting tendons and puntilla. Another problem area in some countries is the lack of truck loading ramps: animals are pushed or thrown off vehicles. Ramps are easy to build (see Fig. 1.1) and should be one of the required standards.

To pass the audit, a plant must have an acceptable score on all five core criteria and exhibit no acts of abuse. Measurement with numerical scoring enables management to determine if handling has improved or has become worse. Continuous measurement is required to prevent a return of rough handling. The scoring method is objective, but what the minimum acceptable scores would be is determined by either the customer or trading partner. Restaurant audits typically have the following requirements:

no more than 1% of the animals falling and 75% or more moved with no electric goad. The minimum acceptable scores are 95% rendered insensible with one captive bolt shot, 99% correct placement for electrical stunning and 5% or less of cattle vocalizing. All animals must be insensible prior to hoisting. Performing any dressing or slaughter procedure on a sensible animal results in an automatic audit failure.

Auditing of truck loading and unloading

A similar scoring system can be used for monitoring animal handling on farms and during truck loading. The percentage of cattle, pigs and sheep falling down, percentage goad-prodded and the percentage that run into fences can be easily measured. Maria *et al.* (2004) have developed an effective scoring system for determining stress during loading and unloading of trucks. Higher scores were associated with higher physiological measurements.

Alvaro Barros-Restano (personal communication, 2006) is achieving good results measuring truck loading and unloading and handling in Uruguayan markets. He measures all of the



Fig. 1.1. Well-designed truck-loading ramp that could easily be constructed in a developing country by local people using readily available materials.

previously stated measures plus the percentage of cattle running. Moving animals at a walk or trot is an indicator of good handling, and running is usually an indicator of rough handling. He audited 1200 cattle at a large market, and 99.5% were moved at a walk or trot. Continuous measurement improves handling. Other outcome variables that can be measured are percentage of downed, non-ambulatory animals and dead animals in a truck.

Trucks can also be monitored for waiting time to unload and stocking density. Poor truck scheduling that increases the time pigs have to wait in trucks before unloading will increase the number of dead (Ritter *et al.*, 2005). For poultry, the percentage of birds with broken wings is an effective measure to assess chicken handling standards. Scoring of broken and dislocated wings is being used by customer auditors in many different countries. Other effective measures for poultry transport are the percentage of damaged transport cages, percentage of overstocked cages and birds dead on arrival.

The use of measurement to reduce losses

Programmes that reward animal handlers and truck drivers for low levels of damage to animals can be very effective. Hartung *et al.* (2003) reviewed many transportation studies and recommended paying truck drivers based on reducing losses. These programmes must have accurate measurements of losses. In the poultry industry, paying chicken-catching teams an extra US\$30 per person per week for low levels of damage greatly reduced broken wings. Poultry industry data collected by the author showed that incentive pay, combined with measurement of broken wings, reduced damage levels from 5–6% of birds to 1–2%.

Progressive managers use measurement programmes for accessing the percentage of dead pigs or chickens by loading team and by truck drivers. McGlone (2006) found that some truck drivers were linked with twice as many dead or non-ambulatory pigs. Both measurement and the holding of people accountable brought about a 48% reduction in dead pigs (Hill, 2005). Careful measurements also revealed that worker fatigue is a big factor (Ritter *et al.*, 2005). Hill (2005), at Premium Standard Farms in the USA,

found that truck-loading crews became fatigued and the percentage of dead pigs increased after five or six large trucks had been loaded. To reduce death rates, the workload was reduced to six trucks per shift.

In both the poultry and the pork industries, internal data have shown that it pays to work a truck-loading crew for no more than 6 h. Abuse is more likely to occur when handlers are fatigued or the equipment is either poorly designed or broken. Hill (2005) had to record data on many trucks to discover that it would pay not to overwork loading crews. Some of the most useful information comes from studies where large numbers of animals are monitored. Lewis *et al.* (2005) used a statistical power analysis to determine that over 200 truckloads were required to reliably determine if a new practice made a difference. Another factor is truck driver fatigue: Jennifer Woods, a livestock handling consultant, states that fatigue is a major contribution to livestock truck accidents.

Auditing transport stock density and losses

There are a lot of conflicting data on the proper stocking density for trucks. For both pigs and cattle there is evidence that more space is required for longer trips and those undertaken in hot weather. Pigs will remain standing if the trip is 3 h or less (Guise *et al.*, 1998). After 3 h they will need additional space to lie down. For short journeys, there was little evidence of detrimental effects with a loading density of 281 kg/m²; this is equivalent to 0.35 m² per 100 kg pig (Guise *et al.*, 1998). Similar results have been reported by Ritter *et al.* (2006a).

Very high stocking densities of 0.39 m² for 129 kg pigs resulted in a significant increase in both dead and non-ambulatory animals (Ritter *et al.*, 2006b). The percentage of non-ambulatory pigs and death losses is highly correlated (Hamilton *et al.*, 2003). Similar results have been reported in cattle. On shorter journeys where animals remain standing, they can be stocked more tightly. Filling a vehicle so tightly that closing the gates becomes difficult is a bad practice that should be banned. The author suggests auditing transportation with outcome variables such as death losses, bruising, PSE, dark-cutters, leg injuries and the

number of non-ambulatory animals. These data could be used to determine stocking densities for varying weather conditions, journey times and vehicle types.

Importance of stockmanship

A mistake made by many managers is in assuming that technology such as a mechanical chicken harvesting machine or a fancy new fan-ventilated truck will automatically solve all handling problems. Good equipment makes it easier to handle animals but its use must be managed and supervised. During a 35-year career, the author has observed severe animal abuse in poorly managed state-of-the-art facilities. Technology should never be used as a substitute for good management. Audits and financial incentives are powerful tools for the improvement of animal treatment and the reduction of losses.

Paul Hemsworth, an Australian researcher, has clearly shown that good stockmanship and careful, quiet handling pays dividends. Pigs and dairy cattle that are roughly treated and fear people produce fewer progeny, have lower weight gains and produce less milk (Hemsworth and Coleman, 1994; Hemsworth *et al.*, 2000). The attitude of the stock person is also important: animals perform better when they are handled and raised by people who like animals (Hemsworth *et al.*, 1994).

Observations by the author in numerous feedlots and slaughter plants indicate that when the electric prod was no longer the person's primary driving tool, the worker's attitude improved and they were less likely to yell or hit animals. Since audits started, non-electric driving aids such as flags, plastic bags and plastic paddles are now the main tools. The electric goad is picked up only when a stubborn animal refuses to move.

In the best slaughter plants where distractions that cause backing-up and baulking have been removed, 95% or more of cattle or pigs can be moved easily into a stun box or restrainer with no electric goad. For on-farm pigs and sheep, electric goads should not be used. If animals constantly back up, baulk or turn back, distractions in the facility must be eliminated (Grandin, 1996). This is essential for reduction in use of the electric goad.

Further research by Coleman *et al.* (2003) also shows the importance of removing the electric goad as a person's main handling tool. Measurable improvements in the handler's attitude occurred when they used electric goads with the power turned off. However, there are times when the electric goad is needed. An electric shock is preferable to tail-twisting or beating an animal. Continuous measurement of handling with numerical scoring will help confine use of the electric goad to a very low level.

The quality of stockmanship will have a huge effect on the reduction of dead or non-ambulatory pigs. Multiple shocks with an electric prod and rough handling greatly increased the number of non-ambulatory pigs, and serum lactate levels were greatly elevated (Benjamin *et al.*, 2001). McGlone (2005) conducted observations of hundreds of 115 kg pigs at a large commercial slaughter plant and found that for every 14 pigs electrically prodded, one pig became fatigued and non-ambulatory. Non-ambulatory pigs were approximately four times more numerous when the electric prod was used on over 60% of the pigs compared to the numbers when it was used on fewer than 10%.

Unpublished industry data have also shown that careful truck-driving, with smooth starts and stops, will reduce numbers of non-ambulatory pigs, bruising on cattle and dark-cutters. Economic incentives are powerful motivations for good stockmanship. Large, vertically integrated pork and poultry companies often have a combination of contract farms and company-owned farms. On company-owned farms, hired employees care for the animals; on contract farms, the producer owns the farm and has a bigger financial stake in how well the animals perform. Unpublished internal records from two large companies indicate that contract farms outperform the company operations.

Economic losses from bruising

Smith *et al.* (1995) and Boleman *et al.* (1998) reported a bruised carcass level of 48% in US fed steers and heifers. More recent data taken during 2005 – after the restaurant audits had started – indicated that the percentage of bruised fed cattle had dropped to 35% (Smith *et al.*, 2006). Improvements in handling that

were required by the restaurant companies helped to reduce bruising. Observations in the USA by the author and Vogel (2006) in large beef plants indicated that facilities where management had worked hard to train truckers had much lower bruising rates than the 35% industry average. In these plants, the level of commercially significant bruising was similar to the 4.1% level reported in a British survey (Weeks *et al.*, 2002). Bruising causes huge economic losses (Marshall, 1977; Blackshaw *et al.*, 1987). Bruised meat must be trimmed out and cannot be used for human consumption.

Sheep and cattle sold through markets had a higher level of bruising than livestock sold directly to the slaughter plant (Cockram and Lee, 1991; McNally and Warriss, 1996; Hoffman *et al.*, 1998; Weeks *et al.*, 2002). A Canadian study showed that 15% of the cattle had severe bruising and 78% of carcasses were bruised (Van Donkersgoed *et al.*, 1997). Smith *et al.* (1995) found that 22% of cull cows in the USA had severe bruising and 2.2% of these animals had extreme bruising that had destroyed major portions of the carcass. More than 50% of the meat may be destroyed if a cow falls down in a truck and is trampled by other cattle.

Selling cull cows when they are still in good body condition will provide the greatest economic benefit (Apple *et al.*, 1999a, b; Roeber *et al.*, 2001). A survey of cull sows in Minnesota indicated that 67% had foot lesions and 4.6% had shoulder lesions (Ritter *et al.*, 1999). A more recent survey of sows in two large slaughter plants – by Iowa State University – indicated that 12.5% had shoulder lesions and 4.8% of these lesions were open sores (Knauer *et al.*, 2006). The incidence of foot pad lesions was 67.5% (Knauer *et al.*, 2006). Shoulder lesions that occur in sows housed in stalls cause extensive meat damage.

Stress-induced meat quality problems, such as dark-cutters, cause even greater losses. The National Beef Quality Audit estimates that dark-cutters cost the beef industry US\$6.08 for every fed animal slaughtered (Boleman *et al.*, 1998). In fed beef, approximately 2% of steers and heifers were found to be dark-cutters (McKenna *et al.*, 2002; Smith *et al.*, 2006). Dark-cutting beef is darker and drier than normal and has a shorter shelf life. Informative reviews on dark-cutting beef can be found in Hood and Tarrant

(1981), Fabiansson *et al.* (1988) and Scanga *et al.* (1998). The Scanga *et al.* (1998) study is especially valuable because thousands of cattle were observed.

Weight loss and death losses in cattle

Research at Oklahoma State University (1999) has indicated that the withdrawal of feed from fed feedlot cattle for 24 h prior to slaughter resulted in a loss of \$5.00 per animal due to carcass shrinkage and an increased level of dark-cutters. Feedlot managers sometimes do this so that an extra steer can be transported without violating truck weight limitations, but it is a false economy.

Carcass shrinkage (loss of weight) due to rough handling or long hours in transport causes additional losses. Shorthose and Wythes (1988) reviewed numerous studies that quantify shrinkage in cattle and sheep. Large economic losses also occur due to death losses and morbidity in calves that are transported long distances (Hails, 1978). Death losses in US cattle amount to approximately 1% of fed cattle (Jensen *et al.*, 1976; Irwin *et al.*, 1979; Bartlett *et al.*, 1987; Loneragen *et al.*, 2001).

A high percentage of death loss is due to shipping fever, a respiratory disease caused by a combination of shipping stress and viral and bacterial agents. Shipping fever (bovine respiratory disease) costs the US cattle industry US\$624 million annually (National Agricultural Statistics Service, 1992–1998). Sickness occurs in about 5% of yearlings (Jensen *et al.*, 1976) and in 14–15% of calves (Bartlett *et al.*, 1987; Snowden *et al.*, 2006). In another study, 22% of steers required medical treatment for sickness (Waggoner *et al.*, 2006).

Dr Dan Thomas, feedlot specialist at Kansas State University, states that in feedlot calf programmes, death losses may rise to 5–10% if the calves have not been pre-weaned and vaccinated prior to arrival (Ishmael, 2005). About 70% of all death losses occur in calves weighing < 225 kg (Noon *et al.*, 1980).

Preconditioning, which consists of weaning and vaccinating 35–45 days prior to shipment to a feedlot, resulted in the reduction of death losses due to respiratory disease (shipping fever) at the feedlot from 0.98 to 0.16% (National

Cattlemen's Association, 1994). A combination of pre-shipment vaccination and good trucking practices can keep death losses on 35-h non-stop trips to <0.1% (Mills, 1987; Grandin, 1997b). Savings in medical costs and losses from reduced weight gains in sick cattle would be even higher.

Progressive cattle feedlot operators have found that quiet handling during vaccinating enables cattle to go back on feed more quickly. Low-stress handling can cut doctoring and medical expenses by 50% (Maday, 2005). Steve Cote, a specialist in low-stress cattle handling, states that quiet handling can reduce disease from 10 to 1% in calves after they have arrived at a feedlot. Cattle which become agitated while being handled in a squeeze chute will have lower weight gains and yield tougher meat (Voisinet *et al.*, 1997a, b). In another study, Angus cattle that had become excited during handling had lower marbling scores and poorer meat quality compared to those of calm steers (Vann *et al.*, 2006).

Improvements in vaccination and handling practices to reduce sickness can improve profitability. Researchers at Texas A & M University (1998–1992) found that healthy feedlot cattle were more profitable and provided US\$49.55–117.42 more profit per animal. Fed cattle that get sick lose some of their marbling and are given a lower-quality grade. A more recent study showed that feedlot cattle that became ill were worth US\$69–254 less than healthy steers (Waggoner *et al.*, 2006).

Meat quality losses in pigs

In pigs, deaths during transport, and pale, soft, exudative (PSE) meat cause large financial loss. Rademacher and Davis (2005) found that overloading trucks doubled the number of pigs that died shortly after unloading. PSE is a pork quality defect which is caused by a combination of factors, such as pigs with stress-susceptible genes, rough handling shortly before slaughter and poor carcass chilling. Good reviews on PSE and handling can be found in Smulders (1983), Grandin (1985), Sather *et al.* (1991), Tarrant (1993), Warriss (2003) and Terlouw (2005).

A Canadian study showed that, even when the stress gene had been bred out of 90% of the

pigs, there was still a PSE level of 14.8% (Murray and Johnson, 1998). The authors visited the plant where this study was conducted and observed extremely excessive use of electric prods. In another Canadian plant with good handling, similar pigs demonstrated only 4% PSE. The most recent survey in the USA indicated that 3.34% of the pigs had poor-quality meat having all three of the PSE traits of pale colour, softness and watery texture (VanSickle, 2006).

Pork from heavyweight pigs with the stress gene was judged by a taste panel to be tougher and drier than pork from pigs free of the stress gene (Monin *et al.*, 1999). The author has observed that ultra-lean pigs selected for large muscles have much tougher and drier meat compared to slower-growing pigs with more marbling. Morgan *et al.* (1993) reported that 9.1% of all hams and loins processed in the USA had PSE. In Denmark, pig breeding and handling are closely monitored: PSE levels in Denmark are at a level of about 2% (Barton-Gade, 1989). (See Chapter 19.)

Marketing System Structure and Losses

The structure of the marketing system can provide either an incentive or a disincentive for reduction of losses. The pork industry in both Europe and the USA has used improvements in genetics, handling and transport to reduce PSE. Pigs marketed through a vertically integrated system usually have less PSE because the farms grow pigs to the customer's specifications. They insist on low PSE genetics and improve handling and transport.

Small producers who grow organic cattle are now part of an integrated chain. They contract directly with the meat-buying customer and no longer go through dealers and middlemen. They have to grow their livestock to meet the customer's specifications. However, some pigs and cattle in the USA are still sold on a live weight basis, where the animals are paid for prior to slaughter. Losses due to bruising, dark-cutters, deaths and PSE are absorbed by the slaughter plant.

A survey by Grandin (1981) indicated that bruises on cattle were greatly reduced when producers switched to a carcass-based selling

system where bruise damage was deducted from their payments. Supermarket audits in Brazil – where transporters were held accountable for bruising – reduced bruises on cattle from 20% of all animals to 1.3%. When the frequency of the audits was reduced, bruising rose back to 9% (Paranhas de Costa, personal communication, 2006).

Plants that charge a US\$20 fine for non-ambulatory downer pigs have fewer downers than plants without a fining system in place. Marketing systems that allow losses to be passed on to the next buyer provide little incentive to reduce losses. Segmented marketing systems where cattle pass through one or more middlemen, brokers or order buyers prior to reaching their final destination still contribute to substantial losses in both the USA and Mexico. This problem will be greatly reduced when livestock identification and source verification becomes mandatory. DNA fingerprinting could also be used to facilitate traceback of animals (Davis *et al.*, 2006).

Problems with fraud and tag counterfeiting will need to be addressed, especially in local markets. The meat companies which are exporting to premium markets will be motivated to self-police because they will not want to lose their customers, but local dealers who sell old breeding animals will not have this incentive. To prevent cheating, anti-fraud regulations will need to be enforced. During a 30-year career, the author has observed many unethical practices by livestock dealers, but tampering with the weighing scale seldom occurred because US federal laws on scale tampering were enforced. Penalties for transgression are severe.

Handling of pigs greatly improved when the USA entered the Japanese export trade. When slaughter plant managers watched a Japanese grader reject up to 40% of their pork loins due to PSE, a strong economic incentive was created for the improvement of handling. Observations in three different plants showed that simple changes in handling procedures, such as showering, reducing electric prod usage and the resting of pigs, enabled 10% more pork to be exported to Japan. Handling shortly prior to stunning is critical. Stressful handling, use of the electric goad and excitement immediately prior to slaughter are all likely to increase levels of PSE (D'Souza *et al.*, 1999; Hambrecht *et al.*,

2005; Kuchenmeister *et al.*, 2005; Versteegen and Den Hartog, 2005).

Economic incentives for producers and transporters

A cattle producer is not motivated to vaccinate their calves unless they receive a premium price. There are still many calves entering US feedlots that have not been pre-weaned and vaccinated at the ranch of origin. Only 47% of ranchers had followed recommended guidelines on the weaning and vaccination of calves 45 days before they had left the ranch (Suther, 2006). This bad practice that causes increased illness is gradually decreasing as more producers contract their calves to source-verified beef programmes that require pre-weaned and vaccinated calves.

Fortunately, progressive producer groups are working together to produce truckload lots of calves that have been pre-weaned and vaccinated 5 weeks prior to selling. These calves are being sold at premium prices because buyers know that they will be less likely to become ill, and they also meet strict export requirements for source verification. Powell (2003) and Troxel *et al.* (2006) reported that cattle producers who had sold preconditioned calves at a special preconditioned calf sale made US\$20 more per calf. A total of 52,401 beef breed calves was observed at 15 auctions in Arkansas (Troxel *et al.*, 2006).

Insurance payments for livestock transport must be structured to motivate good practice. If an insurance policy pays for all bruising and deaths, a truck driver has little incentive to reduce losses. Insurance policies should protect a trucking company from a catastrophic loss, such as tipping a truck over, but the policies should not cover one or two dead pigs. People handling livestock or poultry should never be paid based on the number of animals that can run through a race or the number of trucks they can load. This will result in careless work and increased injuries because it provides the wrong incentive. Payment should always be based on the quality of work.

Contracts for buying and selling livestock should have built-in incentives to reduce losses. The Australian sheep-shipping industry provides

three examples of a lack of financial incentives to reduce losses. In Australia, death losses on sheep ships sailing to the Middle East average 1–2.5%, but can rise to 6% (Higgs, 1991; Higgs *et al.*, 1991). Grandin (1983) reported that ships' officers stated that very low death losses of 0.47% were possible if sheep were carefully acclimatized in assembly feedlots and prepared prior to loading.

A contributing factor to high death losses is contracts based on the number of live sheep loaded instead of the number of live sheep delivered at the destination (Grandin, 1983). There was little economic incentive to prepare sheep properly and train them to eat pelleted feed prior to transport or to identify the groups of sheep that were likely to have high death losses. Some lines of sheep have very high death losses and overall death losses could be greatly reduced if susceptible sheep could be identified (Norris *et al.*, 1989a, b).

One of the main contributors to ovine death is refusal to eat prior to loading (Norris and Richards, 1989; Norris *et al.*, 1989a, b; Higgs *et al.*, 1991). Death losses during loading are very low, but death losses during unloading may reach 20% (Norris *et al.*, 1990). High discharge death rates occur at ports which have poor facilities and slow unloading, because it is difficult to keep the sheep cool when the ship is stationary. If the people receiving the sheep were required to pay for shipboard losses, they would be motivated to install better unloading facilities. Sheep deaths have also increased when oil prices are high, because ships sail at a slower speed in order to save fuel (Gregory, 1992). This is an unfortunate example of an economic incentive that has increased death losses.

Genetic and Production Problems

Overselection of animals for traits such as rapid weight gain or increased milk production can cause serious welfare problems in both livestock and poultry. Increased selection for rapid growth and a high percentage of lean meat has resulted in weaker pigs, where more are susceptible to death during transport (Grandin and Deesing, 1998). In poultry, selection for rapid growth has led to increases in heart and metabolic problems

(Parkdel *et al.*, 2005). Very lean pigs which have the halothane stress gene will have higher death losses. Murray and Johnson (1998) report that death losses are 9.2% in homozygous-positive pigs, 0.27% in carriers and 0.05% in homozygous-negative pigs. Similar results based on hundreds of truckloads were reported by Holtcamp (2000). Death losses were 0.27% in pigs that were carriers of the stress gene and 0.1% when the gene was removed.

Market pigs grown to very heavy slaughter weights of 129 kg had death losses of 0.23% (Ritter *et al.*, 2005). Heavy pigs with weights over 130 kg tended to have higher death losses compared with lighter pigs (Rademacher and Davis, 2005).

The author has observed that lean hybrids selected for rapid growth and heavy muscling often have double and triple death losses when grown to heavy weights. British pigs which are slaughtered at lighter weights of 100 kg and taken directly from the farm to the slaughter plant have an average death loss of only 0.072% during transport and lairage (Warriss and Brown, 1994). The best average death loss percentage in a British slaughter plant was 0.045% (Warriss and Brown, 1994). In Denmark, the average death loss during transport in pigs free of the stress gene was 0.012% (Barton-Gade *et al.*, 2003). Instances of fatigued pigs that become non-ambulatory without showing symptoms of the porcine stress syndrome often occur: one likely cause is the growing of pigs to heavier and heavier weights.

Finishing pigs that weigh 120–130 kg are common in North America. Rapidly grown heavy pigs need space to lie down on a truck because they are unable to stand as long as lighter pigs. A survey of 42 truckloads of heavy pigs indicated that overloading the truck could cause death losses of > 1% (Ritter *et al.*, 2006a). Another factor is selection for leanness: Durocs selected for lean growth efficiency have significantly higher lactate levels than non-selected pigs from the same genetic lines (Lonergan *et al.*, 2001). High lactate levels are correlated with fatigued downer pigs. Some genetic lines free of the halothane gene may have greater sensitivity to becoming fatigued (Marr *et al.*, 2004).

Another possible problem area is the use of feed additives such as ractopamine. Feeding too much of this beta-agonist can increase

problems with fatigued downer pigs. A study carried out by Marchant-Forde *et al.* (2003) showed that pigs on ractopamine were more difficult to drive and likely to become fatigued and go down. The detrimental effect is dose dependent. The author has observed a great increase in fatigued non-ambulatory pigs at the slaughter plants when producers were allowed to feed high doses of this additive.

In fed feedlot beef, feeding at 200 mg/day had a slight effect on handling in the squeeze chute (Baszczak *et al.*, 2006). A higher dose may have a detrimental effect on behaviour. Feedlot workers have reported that the additive may increase respiration during hot weather and increase heat stress: the effect appears to be highly variable. Heavy, black-hided Angus-type feedlot cattle are more prone to heat stress. Mader *et al.* (2002) reported that black-hided *Bos taurus* feedlot cattle panted more during hot weather compared to light-coloured cattle. It is possible that indiscriminate use of ractopamine might increase heat-related death losses in these cattle.

Reduced Disease Resistance

There is evidence that selection for greater and greater growth and yield in pigs has resulted in decreased disease resistance (Meeker *et al.*, 1987; Rothschild, 1998). Continuous selection for greater and greater yields of meat and milk provides economic benefits in the short term, but it may ultimately cause a disaster when an epidemic occurs in high-producing animals with a weakened immune system. In the USA, porcine respiratory and reproductive syndrome (PRRS) became a big problem for producers shortly after the introduction of lean pigs that rapidly gained weight.

Australian chicken producers have reported that disease problems increased when new lines of rapidly growing chickens were introduced. Halibur *et al.* (1998) reported that there were genetic effects on the incidence of infection with PRRS. A team of scientists at the University of Nebraska and the USDA Agricultural Research Service found that pigs selected for lean growth were more susceptible to PRRS than pigs selected for large litters (Johnson *et al.*, 2005).

High-producing Holsteins in the dairy industry have high percentages of lameness and poor

reproduction. Zwald *et al.* (2004a, b) reported that data recorded on the farm could be used to select against common health problems. The situation had become so severe that some dairies crossed Holsteins with Jerseys and other dairy breeds to produce more durable animals. The author is concerned that in the future some of the worst animal welfare and disease problems may be caused by over-selection for a narrow range of production traits.

Quality and quantity of meat are two opposing goals. Using either feed additives, hormones or genetics to produce the biggest, fastest-growing cattle or pigs will often reduce quality by reducing tenderness and juiciness. Other quality problems such as dark-cutting beef and PSE pork are also likely to increase. This problem can be avoided if customers pay for quality instead of quantity. Providing the right financial incentives is a major key for the improvement of both animal welfare and meat quality.

Conclusions

Audits by major meat-buying customers have resulted in dramatic improvements in animal handling and transport. The use of objective numerical scoring of handling variables that can be directly observed is more effective than the examination of paperwork. Examples of the handling variables that can be measured in cattle and pigs are the percentages of animals that fall, that vocalize and that are prodded with an electric goad. Losses such as fatalities, bruising and the numbers of downed, non-ambulatory animals should also be measured. Other serious welfare problems that can be easily measured are lameness, emaciated body condition, heat stress symptoms, dirty animals and neglected health problems. In poultry, measuring the percentage of birds with either broken or dislocated wings is an effective method for monitoring handling during catching.

Incentive pay for animal handlers is another powerful tool for the improvement of animal handling. Bonuses based on animal performance and low levels of either sickness or injuries motivate people to handle animals carefully. Another factor that will improve handling is the requirements of both meat-buying customers and

international governments for identification and source verification. Holding people accountable for losses will reduce those. Losses are highest in a segmented marketing system where the financial loss can be passed on to the next buyer.

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