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Maximum loading density for road transport of pigs: Making a specific standard in spite of scientific uncertainty

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Introduction

The humane transportation of farm animals is a public good recognized by federal and state statute, and a private benefit reflected in industry codes of practice. Consumers show a growing interest in the quality of agricultural products and the manner of production and distribution, including issues of animal welfare, food safety, and environmental pollution (Den Ouden 1997a).

Concerns over poor animal welfare are determined by people's perception of animal suffering. The boundary between acceptable and unacceptable production practices depends on the alternatives available and the product produced. Most people see the slaughter of farm animals for human consumption as acceptable, although some small degree of animal suffering may be inherent in the process. If people had to kill the animal themselves however, most declare they would become vegetarian (Richardson 1993). What people consider unacceptable may also be "illegal" if there is a federal or state statute dealing with the practice. Codes of practice for animal production methods have developed to describe what is generally acceptable for both animal welfare and environmental protection in Canada.

Consumers of animal products may feel "cognitive dissonance" associated with their consumption of a livestock product (Bennett 1995). Cognitive dissonance is "an emotional state set up when two simultaneously held attitudes or beliefs are inconsistent or when there is a conflict between belief and overt behaviour" (Reber AS, 1984). The concept first used by psychologists is also widely used in a marketing context in relation to consumer behaviour (Bennett 1995). I would assert that the generation of cognitive dissonance in the consumer is the purpose of many animal rights informational campaigns regarding human food of animal origin.

Non-consumers of animal products (vegetarians) may suffer from the knowledge that other members of society are engaged in production systems that they consider inhumane. This perception may be part of a poorly informed conviction; however, this does not change the reality of the perception or the actual harm caused to people when they become outraged at a social concern. As both consumers and non-consumers of meat and other farm ani-

mal products vote, policy makers in the future may adopt measures to ensure that livestock production systems change to maximize the net benefit to society as a whole, not just to producers and consumers.

Measuring current consumer concern

Consumer acceptance of particular livestock production systems is often measured by opinion polls and real value to consumers of various systems of production approximated by measuring consumer willingness to pay additional value for products derived from alternative, more humane, production systems (Bennett 1996).

In a survey of California students, 74% of respondents rated the transportation of farm animals with no food or water for 24 hours to be "very unacceptable" (Bennett 1996). Current Canadian regulation allows for the transportation of monogastric (horses, swine, and poultry) for 36 hours without feed water and rest and the transport of ruminants (cattle, sheep, and goats) for up to 52 hours (Statutes of Canada 1990 HofA Regs Part XII). In the California study, around 50% of the sample stated that they avoided purchasing particular products because they were concerned that their production may cause farm animals to suffer. On average, individuals surveyed declared they would pay an additional \$0.35 per dozen eggs (increase of 18%) if layer cages were to be eliminated through legislation.

When European consumer advocacy groups and swine production experts were compared there was general agreement on the aspects of hog production that are perceived to be animal welfare concerns (Den Ouden 1997a). Both consumer and expert opinion regarded the finishing stage as the most important with respect to the overall welfare of the pig. Transportation accounts for about 1% of the total cost of hog production (Netherlands) but contributes about 20% to overall public welfare concern related to the production system. Compared to radical changes in housing such as access to the outdoors and group housing of sows, modification of transport conditions could result in significant overall improvement in local public perception of swine welfare at low cost (Den Ouden 1997b). The welfare causes for concern in transportation are:

- general handling of animals (electric prods etc.),
- the use of loading ramps,
- mixing unfamiliar animals during transport or prior to slaughter,
- loading from more than one farm, and
- holding animals overnight prior to slaughter.

Improvement in this area can be achieved relatively inexpensively with education, training, and procedure modification.

Most concerns identified as welfare risks for transportation tend to be minimized by an increase in average farm size and streamlining of marketing processes such as just-in-time and direct delivery to the abattoir. There may be a positive relationship between farm or system size and transportation efficiency, with less mixing and a greater proportion of the hogs delivered direct to slaughter. "Industrialization" of hog farming is therefore not an inherent cause of decreased welfare during transportation.

Regulation and law

In Canada and similar free democracies, the only thing governments can do that other groups cannot is use coercion. Best management practices described in a voluntary code, if adhered to, may be a far more effective and financially responsible method of improving animal welfare than regulations. In fiscal year 2001, the administrative costs to write and enforce US federal regulations were estimated to reach an all-time high of \$19.8 billion dollars. Staffing at the 54 federal regulatory agencies was estimated to be at 131,983 people in 2001, a 3.3% rise over 1999 (Warren 2000).

In general, you can regulate, and force people to comply with, only those things you can measure. There are two major types of regulation currently existing to regulate animal transport. I will refer to them as engineering-based regulations and outcome- or performance-based regulation. An example of engineering-based regulation is "it is an offense to transport a horse in a conveyance where the distance from the floor to the roof of the compartment in which the horse is carried is less than 78 inches." A similar performance-based regulation would be worded "animal cargo space of conveyances used for the commercial transportation of equines to slaughtering facilities must have sufficient interior height to allow each equine on the conveyance to stand with its head extended to the fullest normal postural height" (Federal Registrar, 1999, CTHS).

A "good" law, is easy to understand, makes common sense, and is precisely described; a violation is easy to identify and quantify. Also, with "good laws" breaking the law is intuitively associated with a negative outcome

for society and application of the law is flexible in response to local conditions. For example, the rule "do not stick your head out of the window when the train is in motion" would be a good law. Probably the single best law ever written is "it is an offence to exceed the posted speed limit." This law is so intuitively reasonable, so straightforward to administer, and so easily adapted to local conditions, it has been adopted worldwide. This law is completely engineering based and enforcement is easy because an infraction can be objectively measured. There is an increasing pressure from animal welfare groups to draft legislation, which is specific and engineering based to facilitate enforcement. The drive for minimal cage space for research monkeys is an example of this (Blum D 1994).

One problem with all laws is that once written they are very difficult to improve. Also, enforcement individuals and agencies compete for resources, may not understand the purpose or intent of the law, and may either fail to enforce or over-enforce. Another major problem with law is it is usually punishment-oriented, and poor animal welfare should be prevented. Considering the requirements of a "good" law, there is a question as to whether it is possible to write law to effectively and efficiently regulate the transportation of farm animals if the intent of the law is to ensure the animals are treated humanely.

In civil law, negligence is the omission to do something which a reasonable individual, guided by those considerations that ordinarily regulate the conduct of human affairs would do, or doing something which a prudent and reasonable individual would not do. In other words:

"What usually is done may be evidence of what ought to be done, but what ought to be done is fixed by a standard of reasonable prudence, whether it usually is complied with or not"—Justice Holmes 1903.

This standard of peer consultation and examining both what currently "is" and what "should be" has been essential to the development of "The Codes of Practice" in Canada.

Demosclerosis and the "Codes of Practice" industry
Three converging forces are re-shaping the North American food industry

- Fragmentation and development of single cause interest groups leading to congestion of traditional legislative channels.
- Rising affluence of consumers and a market for foods with specific attributes
- Concentration of consumer food markets with a handful of firms dominating each product category (from Schweikhardt 2001).

Essentially, when a group shares a common feature—such as poverty and hunger—achieving consensus on food

policy is quite easy. Economic development allows for differentiation between groups and fragmentation of policy preferences. Demosclerosis is a political concept where the din of so many small voices effectively paralyses the decision-making ability of legislative and political structures. When this is the state of affairs, a solution may be found outside the legislative authority. In the food industry it is politics practiced through the market. An example used in this recent review is the Gerber decision not to use genetically modified food sources in baby foods, despite the fact that Gerber is a subsidiary of Novartis, one of the world leaders in the development of GM crops (Boyens 1999).

In the area of animal welfare there are many social-cause action groups differing slightly in truths held sacred. Governments are, as always, highly motivated to demonstrate wise and competent leadership. Multiple social-interest groups are well funded and efficient at presenting a claim of grass-roots support although much of this support may be astro-turf when closely examined (manufactured opinion). This arena of multiple public opinion and the appearance of urgency, generate considerable difficulty for a government contemplating or responding to pressure to regulate in emotive areas such as animal welfare. The absence of apparent consensus may provide fodder for the expert opinion industries.

In 1993, Agriculture and Agri-Food Canada (AAFC) asked the Canadian Agri-Food Research Council's (CARC) Canada Committee on Animals and Expert Committee on Farm Animal Welfare and Behaviour to take the lead in cooperation with the Canadian Federation of Humane Societies (CFHS) in updating existing Codes of Practice, as well as developing new Codes. In application, the industry to which a code applies normally initiates the process and funds the lions share of Code development. Codes are recommended guidelines not required standards—"While the Codes certainly serve an important adjunct to expert advice/testimony in a court of law, they should not and of themselves be used to determine compliance or the legality of a particular operation" (Direct quote, CARC 1998).

Despite the disclaimer by the publisher, the various codes of practice have been frequently used in prosecutions in Canada related to animal welfare. The Manitoba *Animal Care Act* exempts individuals from prosecution if their management practices are in accordance with a recognized Code of Practice (Statutes of Manitoba 1998). The legal system often recognizes the opinion of experts as truth where actual truth is difficult or impossible to determine.

The Transport Code of Practice (CARC 2001) was intended to be an amalgamation of material present in the previously published species-specific codes with the opportunity to improve where possible. The Canadian Trans-

portation Code was developed in Canada in a typically Canadian cooperative fashion. Experts, or at least reasonably competent individuals from across the country, were solicited to work on developing a consensus of how a reasonable person would transport pigs.

Transporting pigs

In 1998 there were 15,821,732 hogs slaughtered in Canada (CFIA most recent data). Of that population at risk, about 13,733 died on the way to slaughter. The slaughter hog in-transport death risk is very low in Canada at around 8.68 dead pigs per 10,000 shipped (in 1998), which is similar to other industrialized countries, such as Britain 7.2/10,000 (Warriss 1994), which have far less challenging weather and geography. Mortality is an indirect and not very sensitive measurement of animal welfare. Not all mortality in transit can be avoided or is necessarily due to transport, as some low number of animals would die within the transport time period even without leaving the farm. Two common problems identified in roadside and live receiving inspection in Canada are over crowding and frostbite; both are completely avoidable causes of animal suffering and both are illegal under national statute in Canada.

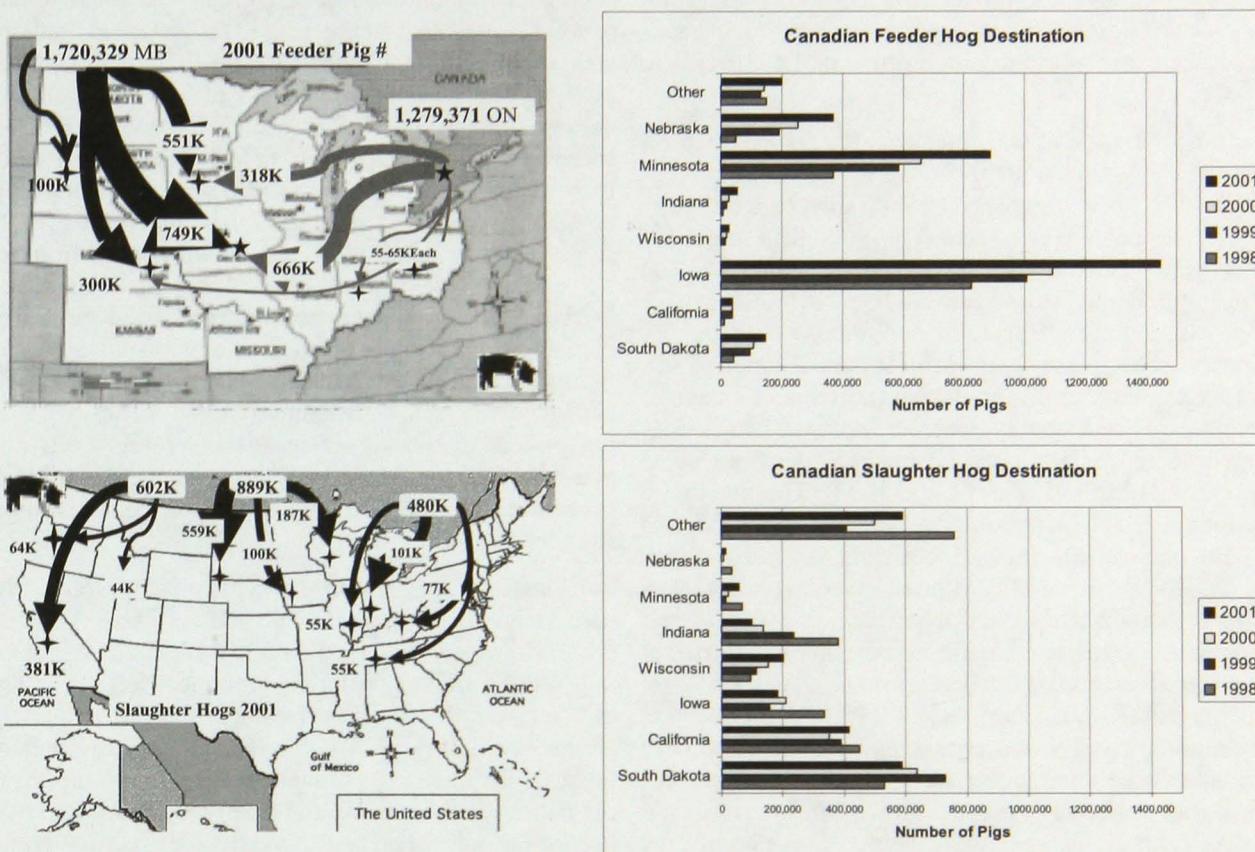
In the recent past, the development of multi-site swine production has fostered a growth industry in the swine transportation sector. Owing to market demand and value (or lack thereof) in the Canadian dollar, there has been increasing total live swine sales to the United States over the past several years (Figure 1). Most of the increase has been in feeder pigs with slaughter numbers relatively constant. The international trend toward centralization of slaughter facilities—larger facilities and fewer of them—will also continue to contribute the humane transport challenges within both Canada and the USA. Every year we as an industry transport more pigs, at a broader range of body weights, greater distances—and the trend appears to be continuing.

Stocking density and trucking

Trucking of livestock is a commercial enterprise and trucking companies need to make a profit. This desire for a profit requires economical movement of large numbers of animals over long distances with the least cost in salaries, machinery usage, and time. The trucker unconstrained by good judgement would load as much as possible and drive as quickly as possible.

Trucking is also a public concern as the roadways are shared with other vehicles. The concern for human health and safety has driven axle weight laws, speed limits, limits on hours of driver operation, and maximal dimensions of vehicles. Provincial and state transportation authorities comprehensively enforce the road weight restrictions with significant fines and inconvenience imposed. Of all

Figure 1. Total Canadian live swine sales to the United States



Total number feeder pigs, swine less than 100-lb., excluding purebreds in 2001 from Canada to the US was 3.169 million up from 1.466 million in 1998. During the same period slaughter hog numbers (market hogs and cull breeding stock) went down from 2.656 million in 1998 to 2.152 million in 2001. Graphs: Number of pigs received per year for the top seven states (which received at least 100,000 either slaughter pigs or feeder pigs from Canada in 2001). Maps: Origin and major destination of slaughter hogs and feeder pigs of Canadian origin in 2001. For slaughter pigs, cull sows and boars included 92% originated from 3 provinces Alberta, Manitoba and Ontario. For feeder pigs exported to the USA, 92% originated in either Ontario or Manitoba.

the regulations a commercial operator must comply with, the load weight restrictions and the driver's log are often the most prominent in his or her mind, as frequent inspection of these aspects of trucking is dependable.

The Health of Animals Regulations (Statutes of Canada 1990) prohibits overcrowding of animals during transport by stating:

Sec. 140.

- (1) No person shall load or cause to be loaded any animal in any railway car, motor vehicle, aircraft, vessel, crate or container if, by so loading, that railway car, motor vehicle, aircraft, vessel, crate or container is crowded to such an extent as to be likely to cause injury or undue suffering to any animal therein.
- (2) No person shall transport or cause to be transported any animal in any railway car, motor vehicle, aircraft, vessel, crate or container that is crowded to such an extent as to be likely to cause injury or undue suffering to any animal therein.

Not many people would argue that crowding livestock during transport to the extent that they suffer is a good idea, so this regulation meets the intuitive standard for good laws. However, to my knowledge there has never been a prosecution in Canada under this statute related to overcrowding. Without a scientific standard of "crowding" this "performance-based" regulation is so nebulous that although generally complied with, it is seldom if ever enforced. Apparently, without an engineering-based standard, enforcement is very difficult.

The behavioral response of cattle and horses to serious overcrowding has been well described. When critical overcrowding occurs, individual animals become recumbent on the vehicle floor and struggle or are unable to regain their footing without the removal of some of the group. This has been described for cattle (Eldridge 1988a, Tarrant 1988) and horses (Whiting 1999). The situation has been described as going down underfoot (Tarrant 1988), clos-

ing over (Tarrant 1992), or involuntary recumbency (Whiting 1999). Responses to overcrowding in pigs have not been as well described, perhaps because postural changes in pigs are not as dramatic and are more difficult to observe.

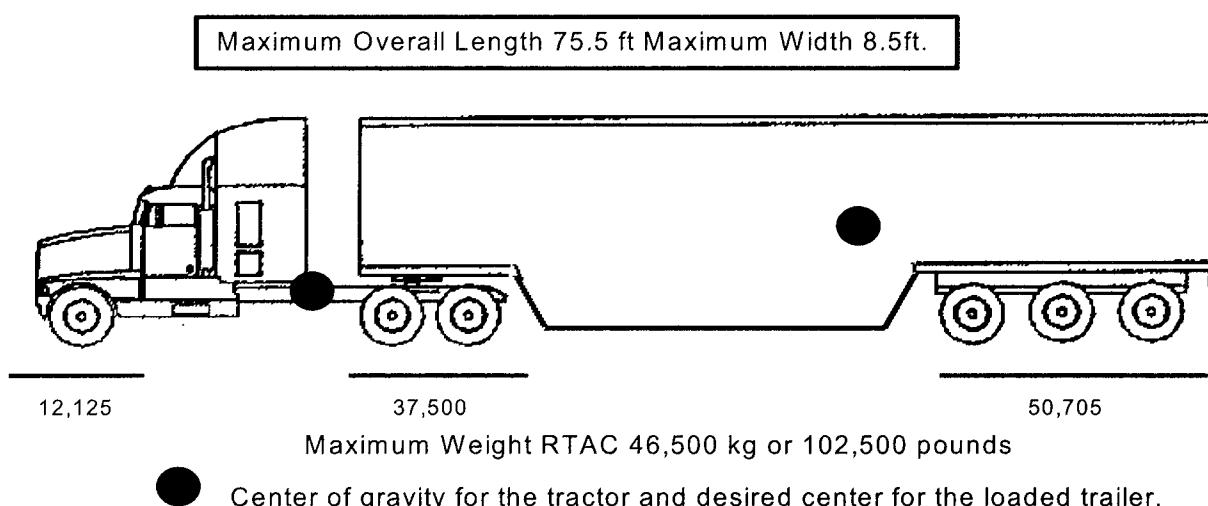
The transportation of slaughter weight pigs has been recently reviewed (Warriss 1998a). Welfare of slaughter pigs in transit has been measured by mortality, carcass bruising, serological measurements of physiological stress, and behavioral observations. Overcrowding, higher ambient temperatures, and feeding within 4 hours of transport have been associated with increased mortality. Pork quality appears to be a relatively insensitive measurement of animal welfare and crowding during transport of slaughter weight pigs. Pork quality does not appear to be dramatically affected by a trip of 2.5 hours at densities up to 285kgBW/m² (58.4lbs/ft²) (Gade 1998). The maximum recommended floor pressure in Europe for transporting market pigs of 90–100kg live weight is 250kgBW/m² (51.2lbs/ft²); however, this is often exceeded in commercial transport (Warriss 1998b). In a recent survey in Great Britain, there was an increase in mortality when market hogs were transported at a density greater than 238kg/m² (48.7lbs/ft²) (Riches 1996). At this level of recommended minimum space allowance it is not possible to be over axle allowance in most provinces of Canada in conventional trailers hauling slaughter pigs. Therefore, maximal axle weight allowances laws give no protection against overcrowding of slaughter pigs in transit.

As animals increase in size, their weight increases as a function of their length³ whereas the floor space they cover

increases as a function of their length² (Randall 1993). Per square foot of trailer floor, you can load fewer pounds of weaner pigs than market hogs. Market size animals are snug when standing if loaded at 60lbs/ft² of deck (Warriss 1998b). Pigs travelling in excess of four hours show a definite preference to lie down and will compete for floor space when insufficient space is provided (Warriss 1998a). It requires around 15% more space for a group of pigs to comfortably lie down simultaneously than it does for the same group to stand. Pigs cool by convection from the skin and when overheating they will pant through the nose. Overcrowding diminishes ability to cool from the skin by continuous inter-animal contact and predisposing conditions such as atrophic rhinitis may diminish the effectiveness of panting as a temperature control mechanism. Fighting for floor space and panting are both muscular activities and combine to increase body heat generation. Biological heat may exacerbate the problems of confinement in summer transport.

For long distance hauling the marketplace is very competitive and profit margins become very fine. With the cost of transport in the units of "per hundred weight per mile," there are increasing motivations to get near maximal axle weights so with livestock haulage to load the animals as tightly as possible (Figure 2). In respecting the real loading density limitations imposed by the physical nature of the animal and axle weight laws, market hogs are at a very real risk of overloading, particularly in the rear compartment of tri-axle trailers (Figure 3).

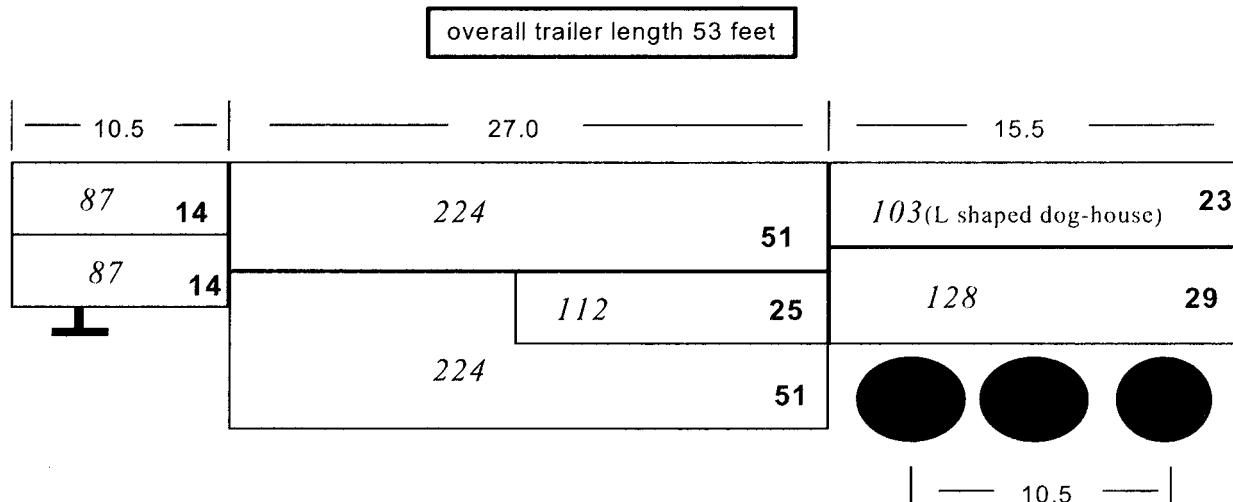
Figure 2. Maximal load weight and ideal load balancing



● Center of gravity for the tractor and desired center for the loaded trailer.

An average tractor has a curb weight of around 19,000 pounds. An empty tri-axle trailer with air ride suspension has a curb weight of around 14,000 pounds leaving a potential carrying capacity 70,000 pounds in Manitoba. To attain maximal legal load weight the driver needs to balance the load by moving the center of gravity of the load toward the rear axles. Balancing the load is easy with a coil of steel and significantly more difficult with live animals.

Figure 3. Standard configuration of a 53' possum belly with a half rail and L shaped doghouse



Lengths are in feet, and a standard 102-inch wide trailer has an internal width of 8.3 feet. The floor space per compartment is in *italics*. The total deck area is 965 square feet. At 60lbs/ft², the possible total live weight of pig would be 57,900lbs, about 12,000lbs under legal axle weight. If, however, you load the two nose compartments at 5200lbs each then the tandem axles on the tractor will be over scale allowance. In practice you have to under-load the nose (45lbs/ft²) and overload the compartments further back. Under perfect weather conditions this trailer can carry around 54,000lbs of live pig or 207, 260-pound market hogs; recommended number of market hogs per compartment in **bold**.

Describing space allowance

Floor area available per animal is commonly referred to as stocking density, although different units are used to describe floor space allowance. Units such as area per animal (area) (Randall 1993), weight of animal per area (pressure) (Eldridge 1988a,b, Tarrant 1988, 1992), or standardized space unit (area per 100kg body weight) (Knowles 1999) have been used to describe the increase in floor space allowance of animals in transit as individuals grow. Regardless of unit of measure, as animals increase in size their space requirement changes.

In the development of the Transportation Code, industry representatives agreed with the principal that smaller animals needed relatively more space than larger animals of the same species. Also, there was unanimous agreement in principle that at some point crowding animals on a vehicle affected their welfare. Whether animals suffered when insufficiently crowded was more contentious. The concept of an optimum space allowance is an extrapolation of work in cattle. One paper reported that cattle loaded with a small amount of space per animal had a lower heart rate and moved less than when given more room. They suggested that cattle could be harmed by excessive space allowance (Eldridge 1988a). In that study, the measurement of good animal welfare was low heart rate. However, the lower level of physical activity which was possible due to the fairly severe crowding in the experiment could explain the lower heart rate recorded. Since maximizing the number of animals carried per load reduces

the marginal cost of transporting pigs, the possibility of welfare risk from under-loading is small in commercial livestock transportation in Canada and the USA.

Individuals working in the industry were questioned as to what unit of measure was most intuitively useful to describe space allowance for pigs in transit. There was general agreement that describing minimum space per animal for a wide range of body weight was not easy to apply nor an intuitive unit of measure in commercial livestock hauling. The unit most preferred by truckers was "pounds per running foot of deck." As almost all commercial vehicles are 102" external width, a running foot of deck is 8.3 square feet on a commercial trailer. For a more general description, and because all trailers are not standard 8.5' wide, mass/area was the second choice of truckers as a suitable unit of measure (lb/ft²). This unit was novel to animal welfare researchers on the expert committee who had been studying space requirements of animals for years. Animal behavior scientists commonly measure area allowed per animal, as they are focused on the individual animal needs, whereas truckers are focused on the need to package an efficient and cost-competitive load.

Floor pressure measured in pounds of live animal per square foot of trailer floor space was deemed the most culturally appropriate and utilitarian unit to describe the differing space requirements of pigs in transit over a wide body weight range. Once the unit of measurement, floor pressure, had been decided the method of communicat-

ing the recommendation was discussed. It was agreed that because there was little threat that pigs would be harmed by under-loading, it was considered wise to agree to and clearly articulate a maximal crowding that a reasonable trucker would consider appropriate under ideal conditions (best weather, best equipment, shortest distance).

In preference to tabular descriptions where at certain weight range is recommended a fixed area, it has been recommended to describe standards and regulations for minimum space allowance as an equation in legislating animal welfare standards on farm (Spoolder 2000). The committee decided to summarize all the opinions and experience represented to them in a graphical manner (CARC 2001, Whiting 2002). The European Commission Scientific Committee on Animal Health and Welfare has also adopted a mathematical formula to describe space requirements for livestock in transit (European Commission 2002). The Canadian and equivalent European recommendation are depicted in Figure 4, after conversion to Imperial measurements and converting the European minimum space formula to a floor pressure equivalent.

Case report

On 4 August 1998, a load of hogs assembled at public yards in Lloydminster, Alberta, was consigned to slaughter in Edmonton, about 3 hours travel. En route they were

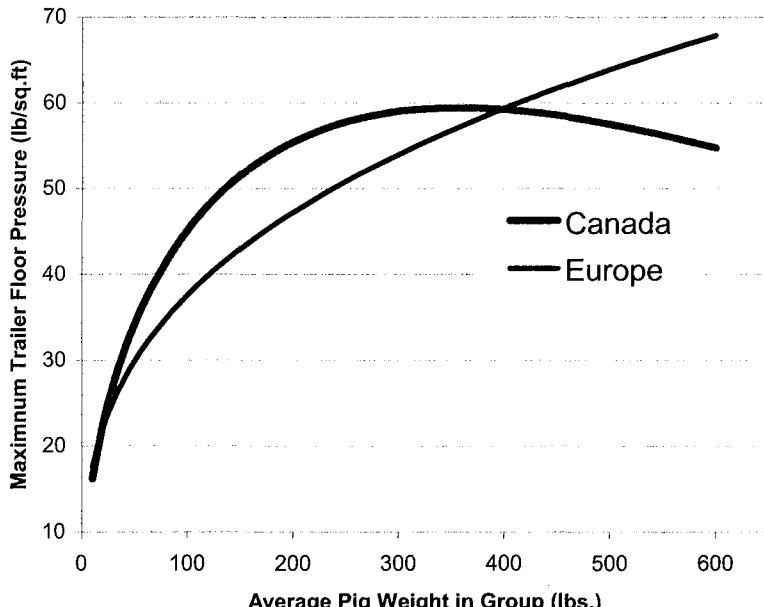
rerouted to Winnipeg, about 18 hours distance. Air temperature ranged from a low overnight of 62°F to a high at arrival of 76°F. Relative humidity was at all times less than 65%. When they load was inspected at slaughter there were 8 pigs dead and a detailed inspection occurred. There were 242, 270-pound pigs loaded; 234 arrived alive for slaughter. Recording the location of the live and dead pigs and measuring the compartment lengths allows calculation of the floor pressure in pounds of body weight per square foot. Based on average pig weight and distribution in the trailer, the floor pressure varied from 51 to 76lb/ft², depending on the compartment in the trailer. Compartments with low and no death loss ranged between 51 and 65lbs/ft². The compartment with 7/8 of the deads was at almost 76lbs/ft² (Figure 5).

This case indicates that, even under good weather conditions, loading pigs at more than 60lbs/ft² is a welfare and financial risk. It is possible that pigs can do math, and are trying to communicate this message to us. With 7 pigs dying in the rear bottom compartment, the floor pressure of live pigs went from 76 to 61lbs/ft².

Other tips

Pigs in transit eating straw are a good indication of cold exposure. A commonly held belief is that during cold weather you should pack in more pigs to generate heat.

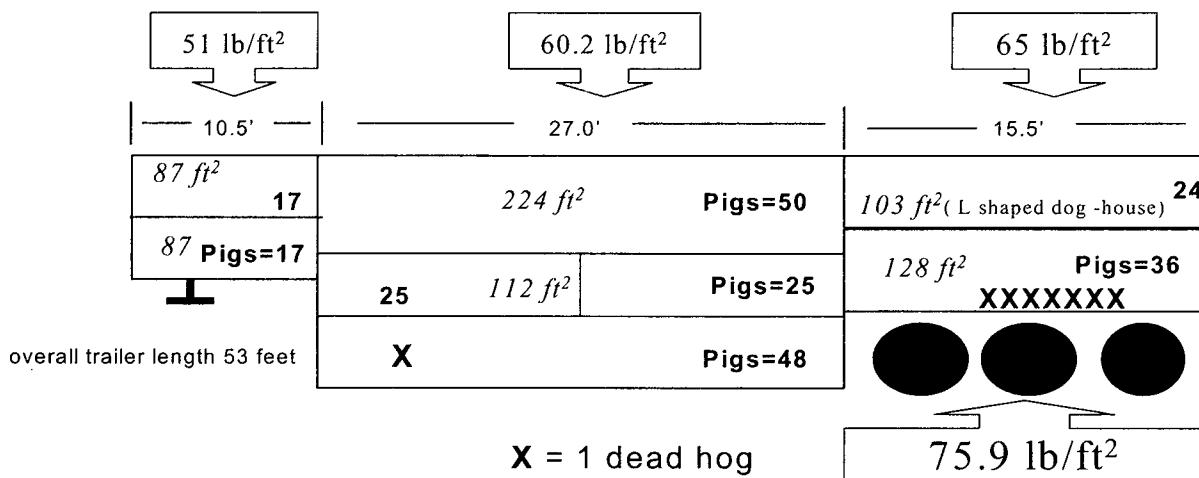
Figure 4. Comparison of maximum loading pressure adapted from Whiting 2002 and the European Commission 2002.



The European recommendation allows for 4.52 square feet for a 220-pound pig (49lb/ft²) whereas the Canadian recommendation would allow this weight of pigs to be transported at 3.8 square feet per pig (58lb/ft²) under ideal conditions. This is actually good agreement, as the Canadian standard is for standing room only for trips less than 3 hours and the European standard will allow sufficient space for each pig to lie down throughout the journey. Advice from Canadian truckers would suggest cull sows and boars require significantly more space than as described in the European recommendation for pigs in excess of the 400lb range.

Figure 5. Location of dead pigs

Load Arrived in Winnipeg Aug 7, 98.
242 (270 lb) pigs loaded, 234 arrived alive



Location of dead pigs identified on a warm summer day after travelling about 16 hours in western Canada. The bottom rear compartment was loaded at 75.9lbs/ft². Pigs prefer to travel at a lower loading pressure than this. With the death of 7 hogs, 29 live pigs in 128 ft² gives a floor pressure of 61.2lb/ft² of surviving pigs. In this incident no pigs died at 65lb/ft²; however, death is a crude indicator of poor welfare and, in studies of poultry transport, the rear compartments of trucks tend to be the best-ventilated (Dalley 1996).

This is an error. In my experience, transporters with the best quality service decrease stocking density in extreme cold and increase the volume of bedding. Frostbite risk increases in overloaded trailers because as you increase the loading density, animals are unable to reposition themselves in response to discomfort. If there is a cold spot in a trailer for whatever reason, if market hogs are stocked at less than 55lbs/ft² they are able to move around in response to chilling and trade places with un-chilled hogs. At a high loading density of 65lbs/ft² individual hogs will be restrained in the cold spot by their group mates and suffer frostbite.

Only trailers where ventilation can be adjusted from the outside should be used for long distance hauling of pigs, and many truckers have installed misting systems in their hog liners to accommodate summer heat extremes.

Conclusion

Most people make their food choices based on taste, food safety, and the perception of health and nutrition. However, many consumers of meat and meat products are also concerned about how animals are treated in production, slaughter, and transport. Successful marketing of animal products requires a sustainable humane production and transport system. One response to popular concern for animal welfare is increasing government regulation. Regulations are written either to prohibit some defined prac-

tice or to require a specific standard be met. The minimum space allowance requirements for a broad range of swine in transit has not until recently been well described or scientifically substantiated.

A Canadian maximal loading pressure recommendation for pigs weighing from 10 to 550 pounds was derived by a consultative process involving the swine transportation industry, animal welfare groups, and literature review. The recommended maximal loading pressure under ideal conditions for swine loaded in groups can be described as a Hoerl Model

$$y = (5.173)(0.9986)^W(W^{0.5008})$$

where y=loading pressure in pounds body weight/ft² and W=average animal body weight in pounds. Quality assurance programs are similar to regulations in that they are based on the ability to objectively measure variables. Contracts for live hauling swine should have a space allowance quality standard included.

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