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Progress in Livestock Handling and Slaughter Techniques in the United States, 1970–2000

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I have worked as a consultant to the meat industry since the early 1970s. I’ve been in more than 300 slaughter plants in the United States, Canada, Mexico, Europe, Australia, New Zealand, and South America. During the course of my career, I’ve seen many changes take place, but I’m going to focus in this paper on my work to improve conditions for the slaughter of cattle and calves and later address transport and other animal-handling issues.

The U.S. Humane Slaughter Act, passed in 1958, required that all meat sold to the federal government had to come from animals that had been humanely slaughtered. Use of the pole axe to render animals unconscious and the bleeding of fully conscious pigs were replaced by use of the captive bolt stunning pistol in cattle and administration of either carbon dioxide (CO\textsubscript{2}) or electrical stunning for pigs. This change was a major step forward, since scientific studies show that both electrical stunning and captive bolt stunning will instantly render animals insensible to pain (see reviews by Grandin 1994, 1985/86; Eikelenboom 1983; UFAW 1987; Gregory 1998).

Unfortunately, however, CO\textsubscript{2}-induced stunning is not instantaneous, and there has been controversy within the scientific community over whether animals have an adverse reaction to CO\textsubscript{2} gas. Some studies show evidence of aversion; others do not (Forslid 1987; Grandin 1988a; Dodman 1977; Raj et al. 1997). My own observations lead me to believe that some pigs can be anesthetized peacefully with CO\textsubscript{2} while others frantically attempt to escape when they first smell the gas (Grandin 1988a). Genetic factors appear to influence the reaction. Purebred Yorkshire pigs are anesthetized peacefully (Forslid 1987), for example, while other strains become agitated prior to being anesthetized (Grandin 1988a; Dodman 1977). Jongman et al. (2000) found that for Landrace–Large White crossbreeds breathing either 60 percent or 90 percent CO\textsubscript{2} was less aversive than a shock from an electric prod. CO\textsubscript{2}, it may be noted, causes highly variable reactions in people. It causes anxiety in some and has little effect on others (Perna et al. 1994; Biber et al. 1999; Perna et al. 1996). It is my opinion that CO\textsubscript{2} is suitable for some genetic types of pigs but causes problems with other genetic types. CO\textsubscript{2} experiments should be conducted with stress-susceptible pigs, in particular. The potential of other gases, such as argon, for use in stunning is also worthy of investigation.

In 1978 the Humane Slaughter Act was amended to cover all federally inspected plants. (Federal inspection allows a plant to engage in interstate commerce, regardless of who the buyer is.) The act was also extended to cover the handling of animals prior to slaughter while they were on the premises of the slaughter plant. Cruel practices such as dragging conscious, crippled, non-ambulatory (downed) animals were prohibited. However, the handling of animals for ritual slaughter was—and is—exempt, as is the slaughter of poultry. In ritual slaughter, both kosher (Jewish) and halal (Muslim), the throat of an unstunned animal is cut.

My First Project
My career started at the Swift Fresh Meats plant in Tolleson, Arizona, in 1973. The plant manager allowed me to visit every week so I could learn the industry. Nobody knew who I was and no attempt was made by the plant employees to be on “good behavior” while I was there.

The equipment available was of poor quality, but at a line speed of 165 cattle per hour, most animals were stunned correctly with one shot from a captive bolt pistol. Swift had a stunning box that consisted of a long, narrow stall in which three cattle at a time were loaded. If the animals became agitated while in the box, they jumped on top of each other. Another problem was that slaughter...
plants were heavily unionized, and union work rules made it very difficult to discipline any employees who deliberately abused the cattle.

In 1974 I worked on my first equipment project, replacing the stunning box at the Swift plant with a new device, a V conveyor restrainer. This system, a larger version of a system already in use for the slaughter of pigs (Regensberger 1940), had been constructed in the early 1970s by Oscar Schmidt of Cincinnati Butcher's Supply Company and Don Willems of Armour Company. The animals rode along supported by two conveyors. Compared to the old multiple-animal stunning box, it was a great improvement. The V conveyor system was safer for plant employees and much less stressful for the cattle. The one the plant engineer at Swift and I installed was the third V conveyor restrainer system in the United States. By 1980 the V conveyor restrainer had replaced many of the dreadful old stunning boxes that had held several panicked cattle at a time. (Today, stunning boxes are used mainly in small plants; those that hold only one animal work very well in such circumstances, provided they have non-slip floors.)

**Kosher Slaughter in the 1970s**

Late in the 1970s, I had the opportunity to observe kosher slaughter at Spencer Foods, the world's largest kosher slaughter plant. Cattle weighing 1,200 pounds each were hoisted off the floor by one back leg, and a nose tong attached to a powerful air cylinder was used to stretch their neck so that the schochet, a rabbi who performs kosher slaughtering, could make the throat cut. I was horrified at the sight and sounds of bellowing, thrashing beasts. Workers wore football helmets to protect their heads from the animals’ flailing front hooves. I could even hear the cattle bellowing from the plant’s office and parking lot. I vowed I would design a system to restrain the cattle in a more comfortable upright position. Many of the smaller kosher slaughter plants that slaughtered large cattle used a holding box called the ASPCA pen (Marshall 1963) (Figure 1). The American Society for the Prevention of Cruelty to Animals (ASPCA) had bought the patents on the box in the 1960s so that any plant could use the box royalty free. Spencer Foods slaughtered 150 cattle per hour, and it would have had to buy two ASPCA pens—and construct a building addition—to accommodate this volume of traffic. Since pre-slaughter handling for kosher slaughter was exempt from the Humane Slaughter Act, shackling and hoisting fully conscious cattle was an economical alternative.

I proposed to plant management the idea of building a head-holding device on the V conveyor restrainer. (It is completely described in Grandin 1980a.) I worked with Spencer to help design the system, which involved no structural alterations to the building already in use. For the large kosher plant, it was a great improvement over shackling and hoisting.

The next big improvement in equipment was the development of upright restraint devices for kosher-
slaughtered calves and sheep. The Council for Livestock Protection (CLP)—a consortium of The Humane Society of the United States, American Humane Association, The Fund for Animals, Massachusetts Society for the Prevention of Cruelty to Animals, and others-funded research at the University of Connecticut to develop a system for holding calves and sheep in an upright position for kosher slaughter. At that time the only piece of equipment available for holding an animal in an upright position was the ASPCA pen for adult cattle. A restraint device was needed to replace the shackling and hoisting of kosher calves and sheep. A laboratory prototype was completed during the early 1970s (Giger et al. 1977; Westervelt et al. 1976). Stress research conducted at the University of Connecticut demonstrated that having an animal straddle a moving conveyor was a low-stress method of restraint. The laboratory prototype was a major innovation, but many more components had to be developed to make a commercially viable system. Since no slaughter plant was interested in implementing the design, the prototype was put in an old sheep barn.

The 1980s

During the early 1980s, plant line speeds increased and the labor unions were no longer so powerful. The old Swift and Armour plants, which had employed union labor, were closed. They could no longer compete with new companies that paid lower wages and had fewer restrictive work rules. The emphasis was now on speed, speed, and more speed. In some large plants, stunning practices actually worsened compared to conditions in the 1970s. Crews were reduced in size, and cattle were being handled at a rate of 250 per hour. It was a bad time for both the animals and the meat industry.

During that decade I completed two major projects. The first was the design for a curved chute and V conveyor system for Moyer Packing. The second one was the completion of the project that the University of Connecticut had started ten years earlier. Curved chute systems were an important innovation for handling cattle because cattle move more easily around a curve (Figure 2). (These systems are described in Grandin 1980b, 1987, 1998c, 2000a.) Curved chutes with solid sides, in particular, facilitate cattle movement because they take advantage of cattle’s natural tendency to want to return to where they came from. The chute’s solid sides and curves prevent cattle from seeing moving people and equipment ahead of them in the slaughter facility so the animals are less likely to react to the sight by attempting to go backward.

In 1986 the CLP asked me to design and install the University of Connecticut system in a veal calf plant, Utica Veal. We rescued the plywood prototype, which was practically on its way to the landfill, and added several other components to make it work commercially (Grandin 1988b). One was a new entrance design that positioned the calves’ legs on each side of the moving conveyor. For the first time, equipment was available to replace shackling and hoisting of kosher calves and sheep. The new system was later installed in two other veal plants.

The 1990s

and Behavioral Principles

By the end of 1999, half of all the cattle in the United States and Canada were being handled in systems I had designed for slaughter plants. I had received a grant to make a large-cattle version of the conveyor system at Utica Veal (Grandin 1991, 2000a) (Figure 3). Cattle entered it more easily and rode more quietly than they had in the V conveyor restrainer. One challenge was that adult cattle are wilder and more difficult to handle than are tame veal calves. The first time the restrainer was run at the Excel plant in Schyler, Nebraska, the cattle refused to enter and they did not ride quietly as had the tame calves at Utica Veal. Two very simple changes solved the problem, and...
their success showed the power of using behavior modification, instead of force, to handle cattle. Both changes calmed the cattle by controlling what they could see.

First, I installed a false floor made of the conveyor belting. Since the restrainer conveyor was seven feet off the floor, the entering cattle had been greeted by a “visual cliff” effect. Ruminants such as cattle and sheep can perceive depth (Lemman and Patterson 1964). The belting under the conveyor provided the animals with the illusion of a solid floor to walk on (Grandin 1991, 2000a).

The second change was even easier. A piece of cardboard positioned six inches above the animals’ backs blocked the animals’ vision straight ahead. The cardboard was replaced with metal, and the system worked perfectly. Twenty-five of these center-track restrainer systems are now in use around the world.

Although the center-track conveyor restrainer was rapidly adopted by the industry, one of my biggest frustrations has been getting people to fully understand the power of using behavioral principles to handle animals. Equipment companies have often tried to “improve” the restrainer by removing parts they perceive as unnecessary. They have not been able to understand why a piece of metal that blocked the animal’s vision was so important.

At one plant I visited recently, cattle were balking, refusing to enter the restrainer or not riding quietly. The equipment company had left out the false floor and had shortened the piece of metal that blocked the animals’ vision. It had also added a hydraulic cylinder to forcibly push rearing cattle down, thinking that this was an improvement! I had the maintenance shop build a false floor and add more metal sheeting to block the cattle’s vision. After these parts were installed, the cattle rode calmly. A two-foot difference in a piece of metal was the difference between calm and agitated cattle.

Kosher Slaughter in the 1990s

Between 1993 and 1995, several large shackle-hoist systems were ripped out and replaced with either ASPCA pens or a center-track restrainer system. I designed a new head-holding device for the center-track restrainer (Figure 4). The new design was a great improvement over the system at Spencer Foods. The new head holder was very similar to the one on an ASPCA pen. It was mounted on two sliding doors, and the two halves of the chin lift slid apart sideways (Grandin 2000a).

Employee safety was a major reason corporations sought to eliminate shacking and hoisting of fully conscious cattle. Another was Henry Spira, a well-known animal activist, who wrote letters pointing out the method’s shortcomings to several corporations still using it. Today 90 percent of the kosher-slaughtered cattle in the United States are held in an upright restraint system. (Unfortunately, about half the kosher veal calves and most of the kosher sheep in the United States are still shackled and hoisted prior to the throat cut.) In Europe, Canada, and Australia, upright restraint is now required for all animals. However, countries such as Uruguay and Guatemala still use shacking and hoisting techniques. Both export meat to Israel and the United States.

From an animal welfare perspec-
tive, the variables of kosher slaugh-
ter—the throat cut and the method
of restraint—must be evaluated sepa-
rately. When conscious animals are
shackled and hoisted, it is impossible
to observe the reaction to the throat
cut itself because the suspended ani-
mal is fighting the highly stressful
restraint. Once I had built a restraint
device that would hold the animal
gently, it became possible to observe
the reactions to the throat cut, or
shechita (Grandin 1994, 1992; Grandin
and Regenstein 1994). When the cut is made cor-
rectly, the animal appears not to feel
it (Grandin 1994, 1992; Grandin
and Regenstein 1994). When the head
holder was loose enough for the ani-
mal to move it, the animal did not
move at all when the cut was per-
formed correctly.

From my work with kosher restraint
devices, I developed four behavior-
based principles of restraint. They
are: 1) the animal's vision should be
blocked so that the animal does not
see people and other moving objects;
the view of a pathway for escape
should also be blocked until the ani-
mal is fully restrained; 2) optimal
pressure of holding machinery should
not be too tight or too loose, otherwise
the animal will struggle; 3) equipment
should operate with a slow, steady
movement; sudden jerky motion
scares the animal; and 4) the fear-of-
falling righting reflex should not be trig-
gered; the restrainer must either fully
support an animal or have non-slip
footing (Grandin 2000a, 1994).

How Stressful is Slaughter?
Literature shows equivalent levels of
cortisol, a stress hormone, in animals
handled at slaughter plants and in
animals restrained for vaccinations
on the farm. Walking through the
chutes at a slaughter plant does
cause some stress, but it is similar to
that of on-farm restraint and han-
dling (Grandin 1997a reviewed Lay
et al. 1992; Crookshank et al. 1979;
Ray et al. 1972; Zavy et al. 1992;
Mitchell et al. 1988; Ewbank et al.
1992; Dunn 1990; Cockram and
Corley 1991; Tume and Shaw 1992.)
The cortisol range for both on-farm
handling and cattle slaughter was 24
to 63 ng/mL. The one exception was
a kosher plant that inverted cattle on
their backs for 103 seconds; those
animals had 93 ng/mL (Dunn 1990).

Current Cattle Industry
Problems
At the beginning of my career, I
thought I could fix all plant problems
with better engineering. I do not
believe this today! By the 1990s the
meat industry had cattle handling
equipment that was vastly superior to
the equipment in the old Swift plant,
but good equipment and engineering
are only one-third of the equation.
Good management and well-trained
employees make up the other two-
thirds. Good equipment provides the
tools that make good handling easier,
but it is useless without good man-
agement. In a few poorly managed
plants, some of the worst acts of cru-
elty I have witnessed happened with
equipment I designed. In these cases,
employees were completely unsuper-
vised. For most of my career, I worked
with the meat industry primarily as a
designer and supervisor of equipment
installation, so I was able to witness
“normal” employee behavior.

In the mid-1990s, cattle stunning
was a definite problem. In 1996 only
30 percent of the plants stunned 95 percent of their cattle correctly—with one shot (Grandin 1997a,b). Cattle were re-stunned prior to bleeding. (Pig stunning was much better, with 90 percent of the plants stunning pigs correctly.) Eisnitz [1997] did describe horrific conditions in two terrible plants, where pigs were scalded alive and cattle were skinned alive. I have observed many abuses, such as broken stun guns, the dragging of downed, crippled animals, and deliberately driving animals over the top of a downed animal; but in the vast majority of plants, I have never observed live pigs going into the scaldor or live cattle being disemboweled. When a live pig is scalded, the USDA will usually condemn the carcass as unfit because water has been aspirated into the lungs. This provides an economic incentive to stun and bleed pigs properly.

People often mistakenly equate reflexive kicking with animal consciousness. Grandin (1994) and Gregory (1998) explain how to assess insensibility. The beef plant described by Eisnitz (1997) was a small plant where the same employee who bled the animal also skinned the head. Doing something terrible like skinning a live head is more likely to occur in a small plant where the same person performs both bleeding and the initial stages of skinning. In a large plant, stunned and bled cattle carcasses suspended by one rear leg are moved along a power chain. The first part of the animal skinned after the legging stand. (It should be noted, however, that supervisors also put pressure on stunner operators to keep the line moving rapidly, so operators may not always be so careful about making sure that the animals are stunned properly.)

**Employee Psychology**

I have observed hundreds of people working in slaughter plants. They fall into three basic psychology types: 1) box stapler 2) sacred ritual 3) sadist (Grandin 1988c). The vast majority of the employees who stun cattle become “box staplers.” They do their job as if they were stapling boxes on an assembly line. They will seldom engage in deliberate cruelty. Rabbis who perform kosher slaughter view it as a religious ritual and they concentrate on their work within that context. Unfortunately, there are a few people who become sadists, and management should remove them from contact with animals.

The well-managed plant has a manager or quality-control person who acts as a “conscience” to control behavior. In a poorly managed plant, employees may become rough unless someone in authority controls their behavior. It is important not to overwork employees who handle or stun animals. Bad behavior is more likely to occur if the employee is overwhelmed or if equipment is in need of repair. For good conditions, animal-handling and stunning jobs must not be understaffed.

I have observed that many plants will have good management and good handling in the stockyards, but supervision in the stunning area will be poor. This trend was very evident in my USDA survey (Grandin 1997a,b). People who are too close to killing all the time become callous. The person who supervises employee behavior in the stunning area must be involved enough in the day-to-day operations to care about the process, but not so involved that he/she becomes callous and indifferent to suffering. (In my USDA survey, the two worst-behaved employees were kill foremen.) The supervisor must have the authority to discipline employees who abuse animals.

**A Major Change**

I saw more improvement in both handling and stunning from 1997 to 1999 than I had seen previously in my entire career. Two fast-food companies started auditing U.S. plants during 1999 to make sure they complied with the American Meat Institute Guidelines (Grandin 1997c). Both federally inspected beef and pork plants were scored objectively. Many plants now have better stunner maintenance, and electric prod usage has been greatly reduced. One company audited forty-one beef plants in 1999; I was present at about half of the audits. By end of 1999, 90 percent of beef plants were stunning 95 percent of the cattle they processed with one shot; 37 percent were stunning 99 percent to 100 percent with one shot (Grandin 2000b). If the first shot missed, the animal was immediately restunned. This was a big improvement over performance noted in the 1996 USDA survey (Grandin 1997a,b). Large flags were being used to move pigs, and a piece of plastic on a stick was being used to move cattle. These devices had replaced many electric prods.

In beef production, plants were scored on percentage of cattle stunned with one shot, insensibility on the bleed rail, and vocalization during handling. Vocalization (moos and bellows) is a sensitive indicator of welfare-related problems such as excessive electric prod use, slipping and falling, missed stunner shots, and excessive pressure from a restraint device (Grandin 1998a,b).

Researchers have found that vocalization in both cattle and pigs is correlated with physiological indicators of stress (Dunn 1990; Warriss et al. 1994; White et al. 1995). Vocalization is also correlated with pain (Watts and Stookey 1998; Weary 1998). Vocalization scoring can pinpoint handling problems. Beef plants with good handling practices will have 3 percent or less of their cattle vocalizing during handling in the stunning chute (Grandin 1998b). (To keep scoring simple, vocalization is scored
on a “yes” and “no” basis—a cow either vocalizes or it does not. Vocalization in the yards where cattle are standing undisturbed is not scored.) In 1999 74 percent of forty-two U.S. beef plants had vocalization scores of 3 percent or less for cattle. In 1996 only 43 percent of the plants had a vocalization score of 3 percent or less. Excessive electric prod use, due to cattle balk ing, had raised vocalization scores to as high as 17 percent at some plants.

Vocalization scoring can be used to chart handling improvement within a plant. It also works well on feedlots and ranches. Vocalization scores will often be higher than 3 percent when animals are ear-tagged on ranches or feedlots. In contrast, it is easy to have a 0 percent vocalization rate for animals moving through the chutes, being restrained in the squeeze chute, and being vaccinated.

The presence of distractions, which makes cattle balk, makes a 3 percent or less vocalization score almost impossible. The movement of a small chain hanging in a chute, for example, will make an approaching animal stop and impede the flow of the other animals. Lighting a dark restrainer entrance will often improve animal movement. (Information on debugging systems and removing distractions can be found in Grandin 1998e, 1996.)

People manage the things that they measure. Bad practices become “normal” if there is no standard to which they can be compared. Vocalization scoring can be used to chart progress as a plant improves its equipment and practices. Table 1 shows vocalization scored from seven audits of 100 cattle each in a single plant. These audits took place over a period of several months.

### Dairy and Pig Industry Problems

The number-one transport problem in the 1970s—and the number-one transport problem today—is loading onto a truck animals who are not fit for transport. The dairy industry has some of the worst such problems. Baby dairy calves, who are too young to walk, are not fit for transport. Emaciated or lame dairy cows are not fit for transport. Downer dairy cows, those who are unable to walk, are more prevalent now than in 1994. Numbers of beef cattle downers have decreased slightly (Smith et al. 1994, 1995; Roeber 2001). The 1999 audit by Smith et al. indicated that 1.5 percent of all culled dairy cows arrived at a slaughter plant down and unable to walk. In the beef industry, 0.77 percent of the cows were downers.

In the past thirty years, although the handling of beef cattle on ranches and feedlots has improved, welfare problems in the transport of old, culled dairy cows have worsened. Genetics is partly to blame. Selection of individuals for milk production has increased the incidence of lameness. John Webster at Bristol University in the United Kingdom states that the typical cow’s foot can no longer support its weight. A dairy veterinarian in Florida told me that the incidence and aspects of lameness in dairy cows are horrendous. Leg conformation is heritable, and good conformation will help prevent lameness (Boettcher et al. 1998; Van Dorp et al. 1998).

Slaughter plant managers and truck drivers have reported that dairies that use bovine somatrophin (BST), bovine growth hormone, in their dairy herds sometimes have more thin, weak cows. Administration of BST reduced body condition score (Jordan et al. 1991; and West et al. 1990). Unless the cow is fed very well, it may lose body condition. The degree of body condition reduction is related to the dose of BST.
Single-trait selection of pigs for rapid growth and leanness has created pigs who are more fragile and likely to die during transport. I have observed that death losses during transport have tripled in the 1990s compared to the 1980s. Some hybrid pigs are very excitable, which makes handling them more difficult (Grandin 2000a). These pigs act as though they have high sympathetic nervous system arousal. A tap on the rump will make them squeal. Normal pigs are much less likely to startle. Pigs who are selected solely for productivity may have a loss of disease resistance. Genetic factors affect susceptibility to disease.

One of my biggest concerns is the possibility that producers are pushing animals beyond their biological limits. The pig industry, for example, has repeated most of the mistakes that the broiler-chicken industry made. Genetic traits are linked in unexpected ways. Some pigs grow so fast that they have very weak bones. These pigs have large bulging muscles but are so fragile that livestock insurance companies will not sell transport insurance to producers to cover them. Fortunately, some breeders are now selecting for more “moderate” pigs, which will have fewer problems.

Good Stockmanship Pays

Good stockmanship can improve productivity of pigs and dairy cattle by more than 10 percent (Hemsworth 1998; Rushen et al. 1999). Animals who are fearful around their caretakers are less productive. They experience lower weight gain and lower milk production. Pigs have fewer piglets. At the highest-producing dairy in Colorado, the cows are very tame and approach people for petting. Good stockmanship costs very little. Feedlots that handle cattle gently find that the animals go back onto their feed more quickly than those who aren’t handled gently. One feedlot that handled cattle roughly in the squeeze chute recorded a 16 percent drop in feed consumption the following day.

If good stockmanship could be purchased, everybody would buy it immediately. I have observed that people buy twice as many books on corral design as videos on low-stress cattle handling and stockmanship principles. They would rather buy equipment than change their behavior. To be a really good stockman, one has to change one’s attitude toward the animals. Animals can no longer be viewed simply as economic units.

I have observed that when people on farms and in feedlots and meat plants start handling animals more gently, their attitudes toward the animals change. In 1999 when one company’s audits started, many workers at the company’s plants replaced electric prods with other driving aids such as flags. I noticed that the employees’ manner toward the animals changed. Instead of aggressively poking at animals with an electric prod, they patted them gently on the rear. Changing the worker’s actions helps to change the worker’s attitudes.

Conclusions

Promoting better stockmanship is essential to improving animal welfare. Large meat-buying customers such as fast-food restaurants in the United States and supermarket chains in the United Kingdom can motivate great change by insisting that suppliers uphold better animal welfare standards. The greatest advances of the last thirty years have been the result of company audits. To maintain such progress, handling and stunning must be continually audited, measured, and managed. Handlers tend to revert to rough handling unless they are monitored and managed. An objective scoring system provides a standard that can be upheld. An overworked employee cannot do a good job of taking care of animals. Good stockmanship requires adequate staffing levels. More efforts are also needed to address problems of faulty stunning equipment, ever-increasing line speed, and enforcement of the Humane Slaughter Act when violations occur.

Attitudes can be changed, and that change can improve both animal welfare and productivity.

Literature Cited


