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A REVIEW OF FACILITY DESIGN AND STUDY OF
HANDLING METHODS ON STRESS AND BEHAVIOR IN MARKET SWINE

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LORRIE R. BRUNDIGE

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**A REVIEW OF FACILITY DESIGN AND STUDY OF HANDLING METHODS ON
STRESS AND BEHAVIOR IN MARKET SWINE**

By

Lorrie R. Brundige

A THESIS

**Submitted to
Michigan State University
In partial fulfillment of the requirements
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ABSTRACT

REVIEW OF FACILITY DESIGN AND STUDY OF HANDLING METHODS ON STRESS AND BEHAVIOR IN MARKET SWINE

By

Lorrie R. Brundige

Ten Michigan Livestock Exchange® branches were surveyed for their loading and handling facilities. The study revealed that there are difference in design with respect to width and angle throughout MLE®'s facilities, but this may not reflect the variety of designs used in the field to load market swine. This study also revealed great variation in handling time during loading.

A second study examined the use of an electric prod or a hurdle, on pig behavioral patterns and physiological responses during loading. Significant responses were observed in body temperature and heart rate between handling methods ($P < .0001$) and ($P < .0001$) respectively. Cortisol was not significant between the two handling levels ($P > .2621$). Observations of pigs during handling produced four behaviors between to two treatments that were significantly different. Pig: vocalization ($P < .0001$), Jump ($P < .0001$), Climb ($P < .0001$) and Fall ($P < .0005$). Post handling observation revealed significant responses in two of four pig behavioral patterns. Pig: Investigate ($P < .0018$), Root ($P < .0001$), Idle ($P > .1021$), Step ($P > .3983$).

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INTRODUCTION

Scope of Thesis

Two separate projects were completed and are presented in this thesis. Project I, "The Collection Point Study" is a field study and is a survey of Michigan Livestock Exchange® (MLE®) collection sites. Ten MLE® collection sites were surveyed for their handling and loading facilities. Information was gathered on the design of loading ramps and pig handling during loading.

Project II, "Pig Response to Two Methods of Handling: Some Behavioral and Physiological Observations", is a controlled experiment conducted at the Michigan State University Swine Farm and examines pig behavioral and physiological responses associated with two types of pre-slaughter handling methods. Forty-eight pigs were selected and allocated to two handling treatments. Data on behavior and physiology of the pig were collected and analyzed for the presentation.

Both of the above studies are considered "methods studies" in that they are precursors to future, more comprehensive experiments on pig behavior and physiology, and their relation and causation to pig welfare and pork quality.

Chapter 1

Literature Review

1.0.0 Introduction

The following studies have been undertaken to more fully understand the physiological and behavioral responses of pigs during pre-slaughter handling and loading for the following reasons. First, there is a growing concern in the swine industry over economic losses from pre-slaughter handling and transportation. These include death, excess bruise trim, pale, soft, and exudative lean (PSE) and, undesirable pale to gray and watery lean. Second, there is a humanistic concern over the welfare of pigs subjected to potentially unnecessary acute stressors prior to slaughter.

1.2.0 Pork Quality Implications

The pig industry is urging its producers to market more pigs via the carcass merit system. As of 1992 many processors were already paying better premiums for leaner carcasses and bigger discounts for excess carcass fat (Marbery, 1992). Traditionally, there have been costs in the form of discounts that have been absorbed by the producer. Some of these costs include; sudden death during handling and transport, bruising, pale, soft, and exudative meat (PSE), and dark firm and dry (DFD) meat, each of which results in lower-value processed meats (Knowles et al., 1994; van Laack et al., 1993). These were estimated at more than 43 million dollars in 1994 (Pork Quality Chain, 1994). Kaufman et al., (1993) estimated that greater than twenty percent of all pork carcasses in the U.S. contained PSE meat.

Kaufman's survey also revealed that twenty-five percent of the pork he surveyed was either "too pale" or "too dark" (Kaufman et al., 1993).

When farm animals are handled or transported, biochemical changes [especially those associated with glycogen metabolism], occur in the muscle (Hails, 1978). Pale pinkish-gray pork usually is caused by the rapid conversion of muscle glycogen to lactic acid; where rapidly falling pH and a high carcass temperature induce protein denaturation (van Laack et al., 1993; Hails, 1978). As a result, the water-binding capacity of muscle proteins declines, water leaks out of the meat (purge) and the color becomes pale and grayer (Hails, 1978).

DFD meat is produced if glycogen reserves are depleted before death so that little lactic acid can be produced in the muscle after death and pH remains high (Hails, 1978). Sudden death arises from uncontrollable skeletal muscle contractions with attendant hypermetabolic and hyperthermic reactions which may be triggered by handling, sexual intercourse, excessive ambient temperature and a number of chemical agents (Otsu et al., 1991).

"PSE pork has many variations and is related to age, handling and environment, bacterial contamination, nutritional factors (fasting before slaughter)" and genetics (Pommier and Houde, 1993; van Laack et al., 1993). Handling and environment and other factors promote the incidence of PSE, but genetics account for sixty-percent of the problem (Kaufman et al., 1993). However, according to Pommier and Houde (1993) genotype only partially

predicts the expression of PSE, and that pre-slaughter management practices were equally critical in controlling the occurrence.

We have known about the porcine stress syndrome (PSS) and PSE problem since the late 1960's (Marbery, 1992), and have not eliminated the problem because the gene has both beneficial and deleterious effects. The gene in pigs produces leanness, muscle hypertrophy resulting in a 2-3 % increase in carcass lean weight (MacLennan and Phillips, 1992). But PSS hogs are more easily excited, (Marbery, 1992) "with reactions triggered by acute stressors prior to slaughter" and devalued meat products (MacLennan and Phillips, 1992).

1.3.0 Welfare Implications

Broom and Johnson (1993) define welfare as "the state of an animal as regards its attempts to cope with its environment". According to Moberg (1985) one approach to defining the welfare of an animal is to use its stress response [behavioral and physiological] as a criteria for assessing an individual's state of well-being. Specific criteria may include injuries to animals following handling or transport, pathology, death or the incidence of blemishes, bruised or PSE meat character, which may give us information about the welfare of the animals in the period shortly before slaughter, but the substantial genetic variation in the likelihood of PSE meat production must be taken into account (Knowles et al., 1994; Guise and Penny, 1989; Broom, 1987; Blackshaw, 1986). However, defining an animal's 'well-being' or welfare has not been precise because it inevitably incorporates subjective feelings derived from

personal experiences and views of life (Moberg, 1985; Barnett and Hutson, 1987) which will broaden or narrow the scope of 'welfare'.

1.4.0 Animal Reaction to Stimuli: Stress Defined

There is a growing concern about the welfare of animals, particularly food animals, a complex task that requires objective descriptive criteria to establish. Therefore, researchers have turned much of their attention to defining quantitative benchmarks for determining good, fair and poor welfare of animals. Assessing the 'state' of the animal, both physiologically and behaviorally, under various stimuli is complicated. One factor that contributes to the state of the animal is exposure to stress or stressors (Moberg, 1985). It is also this variable that has contributed to problems in establishing sound indicators for determining the 'welfare' of animals (Broom and Johnson, 1993; Barnett and Huston, 1987; Moberg, 1985). "A thorough understanding of the concept of stress is necessary to answer this question and studies with pigs allow some physiological limits to be suggested for acceptable and unacceptable welfare" (Barnett and Hutson, 1987).

Stress can be short-term (acute) or long-term (chronic). Broom and Johnson (1993) have defined stress as "an environmental effect on an individual which overtaxes its control system and reduces its fitness or appears likely to do so". Seyle (1973) defines stress as "the biological consequence of exposure to adverse conditions". Seyle's concept of acute stressors is defined as lasting minutes to hours and is corticosteroid dependent (Barnett and Hutson, 1987). The physiological state of stress

disappears on removal of the stress [stimulus] with no ill effects on the animal other than depletion of reserves (Barnett and Hutson, 1987). Stephens (1980) has also defined stress as “ when the rate at which stimuli are perceived by an animal deviates from the normal, or is unusually prolonged, then such stimuli can be classified as stressors”. These seemingly slight differences in definition have profound implications for how animals are reported to respond to various stressors.

1.5.0 Pig Behavior

In order to determine what constitutes a behavioral ‘stress’ response, it is important to understand the pig and its behavior under normal conditions (McGlone, 1991; Martin and Bateson, 1986). According to Fraser and Broom (1990) there are two main categories of behavior production that take place. First, there are behaviors associated with ‘maintenance’ and include behaviors associated with ingestion, locomotion, resting, body care, thermoregulation and some social actions. More specifically, these behaviors include eating drinking, rooting, playing, exploring agonistic behaviors, comfort and eliminative behaviors, and walking (McGlone, 1991). Second, there are behaviors needed for dealing with occasional, specific and often critical circumstances (Fraser and broom, 1990). These include sexual, reproductive and maternal/neo-natal behaviors. Specifically, sexual behaviors include the number of mounts, ejaculations, intromissions and, dismount events. Reproductive behaviors include the onset of puberty, duration of courtship and reproductive success such as pregnancy, delivery weaning and offspring.

Maternal and neo-natal behaviors include periparturient behaviors including shelter seeking, nest building, actual parturition, and early neo-natal-maternal bonding (McGlone, 1991).

1.5.1 Physiological and Behavioral Responses to Stress

Animals respond to changes or challenges in their environment by a variety of interlocking anatomical, physiological, biochemical, immunological and behavioral adaptation mechanisms (Barnett and Hutson, 1987; Ewbank, 1985). Perception of an external stimuli such as changes in temperature, a social interaction with a pen-mate, or the experience of pain, is dependent on the central nervous system (CNS) (Moberg, 1985). When a stress is perceived the CNS will (1) organize to determine what type of biological response to use, and (2) organize the stress response (Moberg, 1985). If the stimulus is perceived as threatening, three general types of biological responses are available; behavioral, autonomic, and neuroendocrine (Moberg, 1985). Within these biological responses there exist a patterned animal physical and [behavioral] response to stimulus and includes; (1) Changes in physical orientation to the stimulus in behavioral response include physical posture and olfactory responses (Broom and Johnson, 1993). (2) Startle response which include fight or flight, postural changes, jumps, vocalizations, intensity and is related to the extent to which the animal has been disturbed (Broom and Johnson, 1993). (3) Defensive reactions which range from growling, butting by cattle to biting or prolonged intensity making animal difficult to deflect (Broom and Johnson, 1993). However, Moberg (1985)

includes another response pattern which involves conservation or with-drawl whereby the animal conserves its energy.

1.5.2 Behavioral Responses to Stress

For most challenges [adverse situations] the simplest, and frequently the most economical response for the animal is to alter its behavior: either remove itself from the threat (escape) or use a displacement behavior (Stephens, 1988; Moberg, 1985). The overt expression of reduced welfare [short-term or long-term] may often take the form of abnormal behaviors (Zanella, et al., 1996; Barnett and Hutson, 1987). They define abnormal as “persistent, undesirable actions, shown by a minority of individuals in the population, which is not due to any obvious damage to the nervous system and which is not confined to the situation which elicited it” (Zanella, 1992). Under chronic stress conditions, behavior may take the form of stereotypies; morphologically similar sequences of behavior patterns with no obvious function (Schouten et al., 1991). Behaviors resulting from acute stressors are more difficult to observe and define because acute stress responses are short-term response and generally do not have long term detrimental consequences and thus are difficult to interpret in terms of welfare” (Barnett and Hutson, 1987). However, certain patterns of behaviors resulting from acute stressors can be categorized as follows; (1) fear-related behaviors, (2) anxiety-related behaviors, and (3) behavior due to frustration (Manser, 1993). These behaviors are externalized behaviors based on the ‘emotions’ of the animal.

Though Stephens (1988) states that the term 'emotion' cannot be defined but is usually comprehended to a special state of the motivation of the animal.

According to Stephens (1988) fear is a predominant emotion, "it is not liked and usually produces a change in the underlying motivational state of the animal leading to modified behavior patterns". Some causes of fear include novel stimuli such as handling and transport, maternal-infant separation and predation (Stephens, 1988). Fear responses in pigs include increases frequency of defecating and urinating, pale skin, bristled hair, trembling body, dilated eyes, nose and mouth, moderately loud vocalization, unnatural huddling together and climbing on other pigs (Buchenauer, 1981). Additionally, animals may react with immobility or freezing behavior (Broom and Johnson, 1993; Manser, 1993). The animal may also respond with an inappropriate behavior, or displacement activity, which are frequently found to be associated with evidence of reduced physiological stress (Broom and Johnson, 1993; Manser, 1993).

The level of response to any given stimulus is graded and will depend on the individual animal's situation, partly reflecting its genetic makeup and partly it's psychological state resulting from the conditioning processes experienced at an earlier stage in life (Stephens, 1988; Levine, 1985; Moberg, 1985). And according to Blackshaw (1986) behavior patterns that are expressed need to be qualified by the type of environment or husbandry system that the behavior results in.

1.5.3 Physiological Responses to Stress

Apart from the behavioral changes that an animal makes, biochemical changes also take place to aid in the maintenance of homeostasis or response to a stressor (Moberg, 1985). Actions such as increased synthesis of glucose, redirection of blood supply to certain organs, modification of digestion can help the animal cope with stress and maintain homeostasis during stress (Moberg, 1985). Fight or flight responses are characterized by the release of epinephrine and norepinephrine, an increase in heart rate and cardiac output, and acute elevation of arterial pressure and overall activity increases (Moberg, 1985). Moberg's (1985) 'conservation' is characterized by an increase in adrenal-cortical activity, increase vagal activity, immobility and suppression of environmental directed activity.

An animal's perception of a stressful situation, and its behavioral and physiological modes of responding to it may be dramatically altered by experience, modifying the threat or mode of response (Moberg, 1985). This is supported by Levine (1985), who suggests that novelty and uncertainty are considered primary determinants of response and that novelty of a stimulus requires the animal to make a comparison between present stimulus events and those that have been experienced in the past. According to Moberg (1985), however, novelty does not necessarily represent a threat.

Responses to stimuli vary across species and among individuals in that species and will depend on: species of animal, previous experience, nature

and severity of stressor and the ability to cope with it's situation (Broom and Johnson, 1993; Manser, 1993; Stephens, 1988; Levine, 1985; Moberg, 1985).

1.6.0 Short-term Behavioral and Physiological Stress Indicators

There are indices to measure "short term" or "acute" difficult situations of the animal. The use of behavioral and physiological measures reflect an integrated effect due to both external and internal stimuli imposed on an animal (Broom and Johnson, 1993).

1.6.1 Techniques for Quantifying and Evaluating Behaviors

Behavior observations play a critical role in the assessment of stress (Manser, 1993). Correctly identifying behavioral responses to stress requires knowledge of the biology of the animal and knowledge of normal and abnormal behavioral expressions of the pig (McGlone, 1991; Martin and Bateson, 1986). One of the most common difficulties encountered is establishing a set of criteria which come near to defining the meaning of the term 'stress' (Barnett and Hutson, 1987; Stephens, 1988). Several test designs have already been developed and include open field test, preference test and conditioned emotional response tests (Stephens, 1988). Sequential analysis which is a detailed type of data summary and analysis techniques and T-maze preference tests which have been designed to study preferences for sexual partners, housing and environment to name a few. (McGlone, 1991). Although different in scope and objective all designs have several criteria for identifying, recording and analyzing behaviors. These are:

(1) " Categories are defined for each behavior observed and are generally independent of one another". (2) Few categories will be defined in one

experiment due more reliability in fewer measures. (3) A detailed complete definition of each category and associated recording method would be written down before data is collected and analyzed. (4) Behaviors observed will include frequency, which is the number of occurrences of the behavior pattern per unit of time; duration which is the length of time for which a single occurrence of the behavior pattern lasts. (5) Behaviors will be identified as events or states. Events are behavior patterns of relatively short duration such as discrete body movements or vocalizations which can be approximated as points in time frequency. States are behavior patterns of relatively long duration such as prolonged activity body postures or proximity measures (McGlone, 1991; Martin and Bateson, 1986).

Many behavioral responses are quantifiable, number of distress calls, frequency of kicking at a localized source of, or the duration of the response (Broom and Johnson, 1993). "It is possible to use duration and intensity of the acute stress response to address specific issues of concern by identifying the severity of difficult stressors and to determine management procedures that minimize acute stress responses" (Barnett and Hutson, 1987).

1.6.2 Physiological Measures of Stress

Physiological measure of stress can be quantified. Measures such as heart rate, body temperature, pulse, respiration, blood pressure, renal blood flow, glucocorticoids, catecholamines, and beta-endorphins, to name a few, are useful measures to evaluate the short-term state of an animal (Broom and Johnson, 1993; Manser, 1993; Veum et al., 1979).

Cortisol

"Historically, the concept of stress has involved an emphasis on activation of the endocrine system" and includes the hypothalamus-pituitary-adrenal axis (Barnett and Hemsworth 1990; Levine, 1985). All pleasant and unpleasant stimuli, even if brief, are likely to elicit some hormonal response

(Broom and Johnson, 1993). Glucocorticoid (corticosterone, cortisol) levels rise in response to many short-term problems [and pleasures] in life and their measurement gives valuable information about the welfare of animals (Moberg, 1985).

Adverse emotional stressors and physical challenges can cause an increase in glucocorticoid levels and include, maternal-infant separation, and aggressive encounters, thermal extremes, handling, novel environment, restraint, electric shock, steep ramps, crowding, mixing, vaccination transportation, weaning, social status, etc. (Hicks et al., 1998; Marchant, 1997, 1995; Minton, 1994; Lambooi and van Putten, 1993; Manser, 1993; Hemsworth, et al., 1989; Jesse et al., 1990; Phillips et al., 1988). However there are various other factors which can effect hormone levels such as: (1) diurnal variation, (2) sex differences, (3) specie and breed differences, and (4) early life experience (Manser, 1993; Moberg, 1985; Levine, 1985) and even copulation can produce increases in cortisol levels (Zanella, 1992).

Cortisol (4-pregnene-11 β , 17 α , 21-triol-3, 20-dione) is a naturally occurring adrenal cortical steroid produced by the adrenal cortex of the adrenal gland (Dickson, 1984). Glucocorticoids function to prepare the body for physical activity, thus there is a shift from anabolic to catabolic activity while non-essential processes are suppressed (Manser, 1993). More specifically, glucocorticoids directly stimulate the release of energy in the form of blood glucose by stimulating the liver to break down stored glycogen into glucose and indirectly through the depressions of insulin levels.

Glucocorticoids can also induce the release of amino acids from skeletal muscle, which are further converted by the liver into glucose, while nitrogen is excreted by the kidneys (Martin 1976).

Glucocorticoids are released by the adrenal cortex in response to an emotional arousal. When an animal is exposed to external and internal stimuli, or when a source of arousal is perceived by the central nervous system, neurotransmitters in the limbic system stimulate the hypothalamus. Corticotrophin-releasing factor (CRF) is released by interleukin 1 β , stimulating the release of adrenocorticotrophin hormone (ACTH) from the adenohypophysis (anterior pituitary gland). ACTH is transported in the blood to the adrenal cortex which in turn stimulates cortisol release from the adrenal cortex (Becker et al., 1985; Martin, 1976). Cortisol levels are checked with a feedback mechanism whereby under time of stress ACTH and CRF are produced in large amounts and thus reduce the level of cortisol that is produced (Martin, 1976). The purpose of the feedback mechanism is probably self-protective because persistent high levels of glucocorticoids would be delirious, leading to immuno-suppression and muscle wastage (Munck et al., 1984). High levels of glucocorticoids do not tend to persist in the circulation, and during chronic stress, plasma glucocorticoid levels may be normal due to the feedback mechanism (Manser, 1993). The magnitude of the adrenocortical response varies from species to species and from breed to breed and will depend on the intensity of the stimuli (Broom and Johnson, 1993). According to Broom et al. (1996) in a study comparing housing

conditions and transportation of pigs, found that circulating levels of cortisol returned to control (pre-treatment) levels at two hours post treatment when sampled in fifteen minute intervals.

Cortisol can be measured in saliva or plasma (Cook et al., 1996; Zanella 1992; Laudet et al., 1988). However, the amount of cortisol in saliva is less than that found in plasma and requires a more sensitive test (Broom and Johnson, 1993). Plasma cortisol exist in the free and protein-bound forms whereas cortisol in saliva only exist in the free form and may be the most relevant when assessing reposes to environmental difficulties (Cook, 1996; Broom and Johnson, 1993). In pigs, studies suggest that salivary cortisol correlates with plasma cortisol ($r=0.88$) (Cook et al, 1996; Mendl, et al., 1991; Parrot and Mission, 1989; Parrot et al., 1989). Conversely, Blackshaw and Blackshaw (1989) found a low correlation ($r =0.167$) between salivary and plasma cortisol.

The main difficulty in using plasma cortisol for the assessment of short-term stress deals mainly with the processing of catching and handling the animal in order to obtain a sample (Manser, 1993). The advantages of measuring cortisol in saliva are (1) it is a non-invasive technique, and (2) it exist in a 'free' or biologically active form, with no protein bound component as it does in plasma (Cook et al., 1996; Blackshaw, 1986).

Pig cortisol levels have been have been reported in the literature. Bradshaw et al., 1996) report pre-treatment levels for 80 kg pigs as 2.475 nmol/ l. Becker et al. (1985) report $4.3 \pm .7$ nmol/l. Parrot and Mission (1989)

report pigs in home pen to prior to treatment as 1-2 nmol/l. Post-treatment or 'stressor' has also been reported in the literature. Measuring cortisol in plasma, Barnett and Hemsworth (1990) report significant differences in pigs handled pleasantly and unpleasantly, 0.52 ng/ml and 0.76 ng/ml (1.435 nmol/l and 2.0976 nmol/l) respectively¹. Becker et al. (1985) report a significant effect on serum cortisol activity between pigs electrically stimulated verses control pigs $43.2 \pm .8$ ng/ml over $14.0 \pm .1$ (119.232 nmol/l and 38.916 nmol/l, respectively).

In other studies, Bradshaw et al. (1996) found no significant differences in salivary cortisol before and after loading. In a handling study completed by Gemus (1998) no significant differences were found in salivary cortisol response of pigs subjected to novice or experienced handlers.

There are three cautions with the use of cortisol as a measure of stress. First, pig's show a circadian pattern and experiments using cortisol must be sampled at the same time for repeated measure to gain meaningful information from this index (Broom and Johnson, 1993; Zanella, 1992; Becker et al., 1985). Second, cortisol levels may not accurately reflect severely stressful situations since they tend to reach maximal levels during moderate stress (Manser, 1993). Third, elevated cortisol levels indicate a change, however, it is often normal 'adaptive' responses (Barnett and Hemsworth, 1990).

Conversion factor from ng /ml to nmol/l = 2.76

Body Temperature

Handling and transport which cause increases in adrenal cortex activity can also elevate body temperature (Manser, 1993). Many conditions are capable of causing normal variations in the body temperature of warm blooded animals including: age sex, season, time of day, environmental temperature, exercise, eating, digestion, drinking of water and disturbing events. (Broom and Johnson, 1993; Kluger, 1989; Anderson, 1984).

Body temperature is regulated by peripheral, spinal, and hypothalamic thermo-receptors with normal ranges for swine ranging from 38.7-39.8 degrees Celsius (Anderson, 1984). A deep index of body temperature is most easily obtained in animals by insertion of a thermometer into the rectum (Anderson, 1984). However according to Korthals et al. (1995) and Eigenberg et al. (1995) core body temperature can be easily obtained via tympanic readings. Because rectal temperatures reach equilibrium more slowly than temperatures in many other internal sites, it is a good index of a 'true steady state' (Anderson, 1984).

Body temperature increases in response to handling have been reported for calves (Trunkfield and Broom, 1990) and for pigs in response to electric shock (Veum et al. 1979). Geers et al. (1996) report significant increases in body temperature before and after transport in halothane heterozygous and homozygous compared to halothane negative pigs. Lucke et

There are three cautions when using body temperature as a measure of homeostasis. (1) it is important to insert the thermometer to a constant depth in each animal because a temperature gradient exists in the rectum, (2) core body temperature fluctuates diurnally, and (3) an understanding of the biology of the animal is required to identify types of responses shown when trying to assess welfare using this measure (Broom and Johnson, 1993; Anderson, 1984).

Heart Rate

Increases in heart rate can represent alarm and may be associated with distress (Baldock and Sibly, 1989). The sympathetic nervous system is sensitive to arousal and may be activated by handling or emotional stressors and lead to increases in heart rate (tachycardia) and blood pressure (Broom and Johnson, 1993; Manser, 1993). Functions of the cardiovascular system are largely under the control of the adrenal medullary and the autonomic nervous system with a wide range of stress events being capable of producing substantial alterations in cardiovascular function (Stephens and Perry, 1990).

“Changes in heart rate and blood pressure occur rapidly and may be transitory if the stressor is not severe or persistent. (Manser, 1993). Tachycardia occurs when the level of physical activity of an animal, and hence its metabolic rate increases” (Broom and Johnson, 1993). Other factors that influence heart rate include individual characteristics, seasonality, stage of gestation, and behavior (Marchant et al., 1995,1997). Heart rate varies according to activity level but also changes when animals are preparing for

emergency reaction (Broom, 1987). Resting heart rate is related to body size, metabolic rate, and autonomic balance characteristics of the species and is reported to range from 70-120 beats per minute (bpm) in adult swine (Detweiler, 1984).

Measurement of heart rate gives information about how much the individual is having to do to cope with the situation (Broom, 1991) provided (1) distinctions are made between metabolic changes and (2) if it can be measured without causing disturbance to the animal (Broom and Johnson, 1993; Manser, 1993; Broom 1987).

According to Veum et al. (1979) heart rate pre-treatment levels for homozygous and heterozygous Hampshire pigs were 121.2 and 113.2 bpm's respectively. However, in studies completed by Geers et al. (1994) Stephens and Radar (1982), and Stephens and Perry (1990) reported lower resting or pre-treatment heart rates for pigs 94 ± 3 , 110, and 91 bpm's respectively. Shouten et al., (1991) showed that pig heart rate will respond to a bell sound followed by delivery of food. Marchant et al. (1997) have demonstrated that heart rate will rise in response to agonistic interactions. Stephens and Radar (1982) demonstrated that heart rate will increase in response to simulated transport. Veum et al., (1979) have demonstrated that heart rate will increase in response to electrical shock. Warris et al. (1991) demonstrated that pig heart rate will increase with increasing slope of ramps.

1.6.3 Other Physiological Measures of Acute Stress

Catecholamines

Catecholamine is a term to loosely describe biologically active forms of epinephrine (adrenalin), norepinephrine (noradrenalin) and dopamine which are synthesized in the brain, sympathetic nerves and ganglia, the adrenal medulla and chromaffin cells (Martin, 1976). While the entire spectrum of epinephrine action prepares the animal for sustained physical activity, the hormone performs much broader functions (Martin, 1976). Specifically, epinephrine promotes conversion of muscle glycogen to glucose phosphate and contributes to glucagon stimulation of glycogenolysis and gluconeogenesis in the liver (Martin, 1976). Epinephrine stimulates the heart, increases cardiac output and promotes redistribution of blood supply (Martin, 1976). Epinephrine and norepinephrine together stimulate the heart, raise systolic blood pressure, decrease blood flow through the skin, mucous membranes and kidneys, increase blood flow through coronary blood vessels and dilate the bronchioles, elevate body temperature, metabolic rate and promote lipolysis (Martin, 1976). Dopamine behaves primarily as a neurotransmitter (Martin, 1976). The release of catecholamines occurs within 1-2 seconds of the perception of the initiating stimulus but their metabolism is very rapid (Martin, 1976).

Blood Pressure

In humans emotional stress produces the exercise pattern of cardiovascular changes and includes increased cardiac output and blood

pressure accompanied by increased muscle blood flow (Detweiler, 1984). Blood pressure may be obtained using systolic (SP) diastolic (DP) and mean pressure (MP according to the following formula: $MP = DP + \frac{1}{3} (SP - DP)$ (Manser, 1993).

The most reliable method for obtaining blood pressure is an intra-arterial catheter (Manser, 1993; Detweiler, 1984). However, blood pressure can be measured indirectly and less invasively by compressing an artery and placing an inflatable cuff around the extremity. Draw backs of this method include animal habituation and unreliable results (Manser, 1993; Detweiler, 1984).

Arterial blood pressure is determined by (1) the pumping action of the heart, (2) the peripheral resistance, (3) the viscosity of blood (4) the quantity of blood in the arterial system and (5) elasticity of arterial walls (Detweiler, 1984). Systolic/diastolic blood and mean pressure reported for adult swine at rest are 140/80 (mmHg) and 110 mmHg respectively (Detweiler, 1984). Veum et al., (1979) have demonstrated that blood pressure increases in response to electrical shock. Stephens and Radar (1982) have also demonstrated that blood pressure will increase in response to simulated transportation.

Respiration

Respiration functions to provide aveolar ventilation, panting, purring and nasal cycling. It is controlled by the respiratory center of the brainstem consisting of pneumotaxic center located rostrally in the pons, apneustic located caudally in the pons, dorsal respiratory group in the dorsal medulla

and the ventral respiratory group of the ventral medulla (Reece, 1984). Respiratory frequency (number of breaths per minute) of 23-27 kg (50.6-59.4 lbs.) pigs under lying conditions ranges from 32-58 cycles per minutes (Reece, 1984).

Changes in respiratory rate can occur during emotional disturbances without body activity (Mellor and Murray, 1989). However, as with heart rate, changes in respiration could be a response to a situation perceived by the individual or it could merely reflect greater activity (Broom and Johnson, 1993). A unique advantage of using respiration is that it can be assessed by observation at a distance without disturbing the animal (Broom and Johnson, 1993).

1.7.0 Effects of Acute Stressors on the Pig

Farm environment and management procedures can affect the behavior of pigs in variety of ways (Hunter et al., 1997). "Acute stress responses are short-term response and generally do not have long term detrimental consequences and thus are difficult to interpret in terms of welfare" (Barnett and Hutson, 1987). Situations that can lead to short term welfare problems for animals and cause changes in homeostatic physiology and abnormal behavioral expressions include human intervention by close approach, handling, certain training methods, transport, stocking density, and restraint (Stephens and Perry, 1990; Guise and Penny, 1989; Moberg, 1985). Obvious types of acute stressors reported in the literature include handling and electric shock, (Hunter et al., 1997 ; Grandin, 1989. 1980; Hemsworth and

Barnett, 1991; Stephens and Perry, 1990; Warris et al, 1990; Baldock and Sibly, 1989; Guise and Penny, 1989; Becker et al., 1985; Veum et al., 1979; Van Putten and Elshof, 1978) feed and water deprivation (Parrott and Mission, 1989; Houpt et al., 1983) transport (Dalin et al., 1993; McGlone et al., 1993; Nyberg et al., 1988) and vibration (Stephens and Perry, 1990). However, other environmental stressors include housing system, heat stress on food intake, body weight, physiology, and cellular immuno-function. During heat stress, social stress may also be present (Morrow-Tesch et al., 1994). Hicks et al. (1998) report that heat, cold, and shipping stressors interact with the social status of pigs to produce significant changes in behavior and had an effect on plasma cortisol, globulin, acute phase proteins, body weight and weight changes. Animals may experience acute or chronic social stress such as overt aggressive or submissive behavior (Morrow-Tesch et al., 1994). Agonistic behavior of sows was reported to influence heart rate by Marchant et al. (1995). According to Bradshaw et al. (1996) mixing pigs with other unfamiliar pigs results in marked increases in fighting behavior and travel sickness, plasma cortisol and beta-endorphins. Liptrap and Reaside (1978) showed that aggression increases plasma cortisol.

1.7.1 Effects of Pig Handling

According to Hails (1978) the most stressful period in a pig's life is during loading and unloading. During handling and loading, pigs are exposed to novel handler behavior and a novel physical environment (Grandin, 1997; Petchey et al., 1995). According to Hemsworth, (1993) the most important

objective during pig handling is to minimize their level of fear of close contact with humans and unfamiliar objects. In order to do this, Kiley-Worthington (1990), in writing about circus animals emphasized that

“handling involves understanding the animal's body language and being able to control one's own, so that it does not portray certain emotions that one might be feeling, for example fear. Good handling must leave the animal with a pleasurable experience, otherwise the animal will quickly learn not to be handled.”

Grandin (1997) and Moberg (1985) suggests that an animal's reaction [fear?] will be governed by a complex interaction of genetics and previous experiences. Broom and Johnson (1993) also suggest that an animal's reaction to stimulus, such as handling, will also depend on how the stimulus varies in time (i.e frequency and duration), intensity, (i.e. density and area), mode (i.e. visual, gustatory emotional, etc.) and degree of novelty (Grandin, 1997; Moberg, 1985). In terms of body regulation, animals show a greater response to a given stimulus if they cannot predict it, so it is treated as a novelty (Broom and Johnson, 1993).

Grandin (1989) states that animals remember 'more readily' painful or frightening experiences. Painful and frightening experiences can result from what Hemsworth (1993) describes as handler actions that are “aversive”. Aversive actions during handling that increase the pig's fear of humans include hits, slaps, and kicks, electric shock (Hemsworth and Barnett, 1991). “If an unpleasant imposition was made by a human, handling may become more difficult for the human and more disturbing for the animal which is handled” (Broom and Johnson, 1993).

Gonyou et. al. (1986), Grandin (1988, 1987) and Petchey et al. (1995) indicated that regular handling of a positive nature resulted in an improvement in the ease of handling of pigs. Hemsworth, (1993) described some of these positive actions as pats, strokes and the hand resting on the back of the animal neck. Notwithstanding the behavior of the handler toward the pig, "there is some evidence to suggest that knowledgeable handling of pigs will improve the ease of subsequent handling and improve the welfare of pigs (Weeding et al., 1993). English (1991) defined the components of 'stockmanship' as appropriate knowledge, technical efficiency (skills), good judgement and observational abilities and the time available to employ these skills and abilities. In studies completed by Hemsworth et al. (1991, 1986, 1981) and Gonyou et al. (1986), results indicated that aversive handling treatments (poor stockmanship) resulted in increased levels of fear in humans, increased corticosteroid levels, and depressed growth rate in young pigs and reproductive performance in both gilts and young barrows. In a study completed by Stephens and Radar (1982) they found that handling pigs doubled heart rate. In a study completed by Robertson (1988) they found a significant association between knowledge of handling and pig death during transport. More recently Hunter et al. (1997) noted that pigs that had been handled adversely prior to the slaughter-house were more difficult to move at time of slaughter.

Notwithstanding the above remarks, there are variations in behavioral responses in pigs subjected to unfamiliar handling, driving and attempts to

move them up a ramp and on to a vehicle (Broom and Johnson, 1993). Warris et al. (1990) suggests some of these variations may be due to important interactions between different handling methods and between handling and genotype. And according to Grandin (1997) high variability results in determining physiological stress on farm animals during handling and transport is likely to be due to great differences in stress levels due to a number of sources including handler and the environment.

1.7.2 Effects of an Electric Prod

Studies show that electric shock can have physiological effects in stress-susceptible pigs (Veum et al., 1979). Other studies that indicate the use of an electric prod can have consequences on behavior and future interactions with pigs as well as damage to carcass. Hunter et al. (1997) noted that pigs that were easy to move [at the slaughter-house] were not subjected to harsh handling and electric prods. According to Hemsworth and Barnett, (1991) pigs subject to brief shocking were more fearful of humans upon close approach. In a study completed by Geverink and Lambooy (1994) of five Dutch slaughter-houses they found that rough handling (electric prod) resulted in severe skin damage of pigs at one slaughter-house. However, in a study completed by Guise and Penny (1989) the use of an electric prod had no effect on pH of the longissimus dorsi muscle value in pigs slaughtered although they found a significant interaction between skin blemishes, stocking density and use of an electric prod. However, according to Petchey et al. (1995) transport increases sexual and aggressive behaviors though the

previous results may be confounded with transport effects. In a study by Van Putten and Elshof (1978) they found electric prod produced an additive effect of heart rate with reactions progressively stronger with successive prod application

1.7.3 Effects of the Physical Environmental

Grandin (1997) writes that pigs respond strongly to novel things, and that during handling and loading, pigs are exposed to a host of novelties in their environment. Broom and Johnson (1993) note that the novelty of the stimulus will enhance the impact of a stimulus on an animal. According to Hunter et al. (1997) it is possible to manipulate the rearing, finishing and loading environment so that pigs do not react adversely to novelty and likely be subject to harsh handling during transport and lairage. Novelties in the physical environment that can cause pigs to balk or turn around or become excited include shadows, created by uneven light distributions, extremely bright focused light sources, new or fresh bedding, reflections due to shiny surfaces, bright colors, moving or flapping objects, loud noises, and odors (Grandin, 1980, 1988, 1989, 1990, 1991). Van Putten and Elshof (1978) found marked behavior differences of pigs entering unfamiliar light and darkly tunnels.

Pigs have color vision (Klopfer et al., 1964). Therefore, Grandin's (1989) suggestion of painting handling and loading facilities a uniform color may result in decreasing the pig's response to novel bright, uneven reflective surfaces that may cause pigs to balk during handling and loading. Other

novelties common in the swine industry that pigs may encounter for the first time include electric livestock prods and loading ramps (Grandin, 1980, 1989, 1990, 1991; Warris et al., 1991; Hemsworth and Barnett, 1990; Guise and Penny, 1989; Hails, 1978;)

1.7.4 Effects of Ramp Design

During the assembly phase, pigs are typically sorted from pens and moved into an alleyway or sorting pen that precedes the loading ramp. There is some evidence to suggest that pigs may be easily moved through wider alleys than narrower ones. Warris et al. (1991) suggested that races [alleys] of 120 cm (48 inches) over 45 cm (18 inches) greatly facilitated the movement of pigs. Many single file ramps are designed to grow narrower as they approach a plateau, acting as a squeeze chute as the pig steps into the doorway of the trailer. However, Grandin (1989) noted a significant decrease in ascent time on the loading ramp where pigs could file up the ramp side by side, separated only by a railing in which pigs could easily see one another. Van Putten and Elshof (1978) in a study designed to look at pigs moving through passages, observed that under difficult situations pigs like to stay together and that they prefer bodily contact and visual contact during loading.

Studies have also shown that pig loading is more easily facilitated with ramp angles less than 25 degrees (Petchey et al., 1995). According to Van Putten and Elshof (1978), loading bridges [ramps] caused the most heart rate stress and was directly correlated with slope of the ramp. In their study loading ramps of 15 or 20 degrees makes loading much easier for inexperienced pigs.

Grandin (1997) recommends ramp angles of less than 20 degrees. Conversely, in similar studies, Warris et al. (1991) concluded that there was no difference in pig ascent time between 0 and 20 degrees. According to Petchey et al. (1995) non-slip flooring facilitates pig movement. Warris et al. (1991) found that there is a significant interaction between slope and cleat space on a loading ramp designed for pigs. Pigs were able to climb a 35 degree inclined ramp almost as well as the 20 degree ramp with narrow cleat spacing, resulting in an increase ascent time of only 13 %. They found that doubling the cleat spacing from 150 mm (5.9 inches) to 300 mm (11.8 inches) resulted in an increase ascent of the ramp by 57 %. However, Phillips et al. (1988) found that young pigs 7-8 weeks of age preferred cleat spacing of 50-100 mm as opposed to 200-300 mm.

Warris et al. (1991) found that solid ramp floors were preferable to see through or mesh floors while Grandin's (1989) work revealed that loading was facilitated with solid walls as opposed to rails or slats that did not restrict sight distance. Phillips et al. (1988) found that young pigs preferred solid or open sides on a ramp to partially enclosed rail ramps. Pig's have a wide angle of vision (Grandin, 1987), and this would suggest that restricting sight distance, both walls and flooring would have a significant effect on loading pigs.

There are alternatives to using stationary inclined loading ramps. Hydraulic lifts and lifting decks, though physiologically most humane, are more costly and add to the already increasing costs of swine facilities (Petchey et al., 1995). Understanding how pigs respond to physical environments and to

handlers will result in the following benefits; 1) improved meat quality, timeliness, health and safety of personnel, and improved pig welfare (Petchey et al., 1995).

1.8.0 Interaction of Behavioral and Physiological Responses to stimuli

The ability to respond behaviorally to a stressor can affect the level of physiological response (Manser, 1993). Hormonal control systems are subject to nervous influences, just as nervous control systems are affected by hormones. These two components of the response of an animal to its environment can be viewed as elements of a combined control system that determines an animal physiology and behavior (Broom and Johnson, 1993).

“Animals use behavior and physiology methods in an attempt to cope with difficult conditions therefore, their measurement can allow identification of how good or poor their welfare is” (Broom, 1987). Determining when the animal is unable to cope, therefore, requires a discriminating use of behavioral and physiological indicators. There are considerable ranges that compound the problem. Not only do neuro-endocrinological, but, also the behavioral, and immunological responses to noxious stimuli extend across considerable ranges (Broom and Johnson, 1993)

In any discussion on the behavior of animals in relation to stress, it is important to indicate the level (intensity) of the stress response against which the behavior is being assessed (Ewbank, 1985). To show a clear relationship between stress and behavior four criteria must be fulfilled. First, stressor (s) must be identified and ideally quantified. Second, physiological responses

such as epinephrine, norepinephrine or cortisol, must be quantified and ideally correlated with the stressor level and the degree of change in behavior. Third behavior change must be obvious, and, fourth, damage to the physical and or psychological well-being of the animal must be demonstrated (Ewbank, 1985).

In conclusion Barnett and Hutson, (1987) states “there is an erroneous tendency to treat any acute stress response as evidence of suffering and reduced welfare. They continue with some principles to keep in mind when using both physiological and behavioral measures in determining stress responses. First they ask how much change in a physiological parameter indicates reduced welfare? And second, they warn that the sampling methods themselves may reduce the welfare of the animal. Lastly, they ask at what level of change in behavior, such as stereotypies, learned helplessness, vocalizations, reduced exploratory behavior, is welfare at risk? (Barnett and Hutson, 1987).

Chapter 2

Project I: The Collection Point Study

2.0.0 Introduction

The design of a loading facility can be critical to efficient handling and moving of pigs from pens to a livestock truck (see pages 24-27). It is well known that pigs can become excited and agitated during loading, resulting in potential injury to the handler and pig. Poor loading facility design can create animal movement awkwardness during loading, sometimes requiring the handler to use extreme measures of force to load pigs in an efficient manner. Loading facility design is commanding more attention industry wide as marketing venues change in favor of direct sale which may require producers to shore up handling and transportation protocols to accommodate rigid premium standards in the pork industry (Marbery, 1992).

A pilot study was initiated with the cooperation of Michigan Livestock Exchange® (MLE®) to determine the type and use of handling and loading facilities in Michigan's pig industry. It was believed that a representative sample of handling and loading facilities in Michigan could be observed by surveying MLE®'s collection sites. This information could then be used to design an experimental loading system to identify how pigs negotiate and respond physiologically and behaviorally to differences in ramp design.

2.1.0 Methods and Materials

A survey to gather specific data on swine loading facilities was designed. Several drafts were made of the Michigan Livestock Exchange® Collection Point Survey (SURVEY) and reviewed by selected faculty of the

Animal Science Department and staff from MLE[®] for relevance and completeness.

2.1.1 Development of Survey

The SURVEY, (see Appendix A) was drafted into five sections including: (1) collection point identification and pig flow information, (2) holding area, (3) loading area and ramp specifications, (4) shipping, and (5) additional loading ramps. Section one was designed to get general information on pig flow and type of pig coming through each facility. Section two was designed to gather information on how pigs are housed while at the facility including type and size of pen, and feed and water allocation. Section three was designed to gather specific information on the primary load out dock including; ramp construction, type and material, length, width, height, and flooring. Section four was designed to observe shipping protocols each facility uses in order to ship pigs from collection point to processor. Section five was adapted to accommodate additional loading ramps periodically used by each facility during peak pig flow.

In addition to the survey completed, photos² and video³ were taken of handling and loading facilities, and actual loading of pigs onto a semi-truck trailer. Photos were taken for comparative-study purposes in future analysis. Video was taken in order to compare pig behavioral response in the 'loading chute' and would be used for the future design of the experimental loading ramp. Video was taken at the discretion of each branch manager. Each

² 35 millimeter camera with a flash utilizing 200 and 400 ISO film

video was coded and dated for future analysis of pig loading from each collection point. Following completion of video analysis, all video tapes were returned to management staff of Michigan Livestock Exchange®.

2.1.2 Ramp Measurements

All loading ramps were measured using a standard tape measure. Loading ramp angles were calculated according to the following formula: $\sin \theta = \text{Opposite (height at front edge of ramp in feet) divided by hypotenuse (length of ramp floor in feet)}$. Each ramp was measured along the hypotenuse (ramp floor) and opposite angle (front edge of ramp) and recorded. Figure 2.1 illustrates the method for obtaining the necessary measurement to calculate the angle of loading ramps in the field. All other measurements such as height of walls, etc. were measured using the same measuring device using "top to bottom" and "bottom to top" methods as necessary.

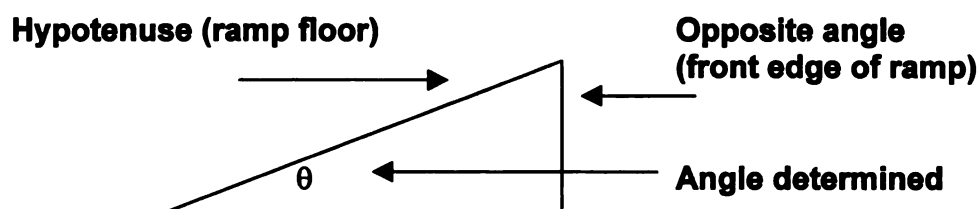


Figure 2.1 Method used to determine angle of ramp

2.1.3 Video Taping

The opportunity to videotape pigs being loaded onto to a truck occurred at eight of MLE® collection sites. All video taken at the collection sites was

³ JVC Super-VHS camera with light adapter and 2 hour SVHS tapes

reviewed for content following the completion of collection point survey visits. After contents of videos were reviewed, a video analysis worksheet was drafted (Appendix B). Each identical worksheet contained four decoding categories: (1) number of pigs loaded, (2) number of groups observed, (3) time taken to load pigs and (4) number of people loading. Information on individual pig behavioral responses during loading was not gathered.

The number of pigs in each group loaded was determined by video observation (counting them as they passed through viewing area) or by asking the handler how many pigs were loaded in the group. The number of groups of pigs loaded was determined by handler entering and exiting the semi truck. Beginning handling time was established by either audio or visual closing of the gate posterior to the loading ramp. Handling time completion was established when the last pig in the group was maneuvered through the semi truck gate. The number of people loading pigs was established by counting persons helping the handler in the sorting pens, the number of people carrying a whip or prod and the number of persons on the loading ramp or entering the semi-truck.

2.1.4 Changes to Survey

Some questions were removed from the survey and analysis due to the lack of relevance to the primary objective. In section one the question “what percentage of your pigs handled at this facility are “farm fresh”. In section two, “size of holding pens, construction type, and comments”. In section three the question, “on average which way does the wind blow”, was removed from the

analysis of survey. There were no questions removed in section four or section five and all information was gathered on loading docks. However, only the primary loading dock was considered relevant for the survey analysis and is reported here.

2.2.0 Results of the Study

Ten of Michigan Livestock Exchange® collection points were surveyed. Nine of the collection points were in Michigan and the tenth in Ohio. Figures 2.2 and 2.3 are representative docks that were surveyed in the field.

Table 2.1 provides specific results on the primary docks surveyed. Nine out of the ten primary docks surveyed were movable type docks. A movable dock in this case indicates that the floor of the ramp is adjustable to load trailers with more than one tier. It also indicates that the angle (elevation) of the ramp changes according to the height of the tier. No movable ramps were observed in the inclined position.



Figure 2.2 A narrow loading ramp



Figure 2.3 Narrow (left) and wide (right) loading ramps

The base or frame material consisted of one of three types of material: wood, cement and metal. The height at the ramp front edge was consistently 1.2 meters high (4 ft.), which corresponds to standardized livestock trailers that haul from 100-200 head of livestock. Dock width ranged from 0.6 meters (2 ft.) to just over 2.5 meters (8.5 ft). Estimated angles of ramps ranged from 0 to 23.5 degrees. Ramp floors varied over three types of material, cement, wood, and metal while floor design varied from a stair [cleat] type design to grooves in the case of cement flooring.

The material of the walls or sides of the ramps were wood except for one, which was metal and all but two ramps had solid type walls.

2.2.1 Video analysis

Video taken at each collection point allowed for more detailed analysis. Table 2.2 reveals the differences in pig handling over eight of ten collection points surveyed. The number of people observed to load pigs ranged from one to three persons. The minimum time taken to load pigs with one person was 23 seconds. The maximum time taken to load pigs with one person was 6 minutes and 25 seconds. The time taken to load pigs with three people ranged from 25 seconds to 4 minutes and 19 seconds. All pigs loaded were observed to be handled with a whip or a prod, or both.

2.3.0 Discussion of Project I

Our initial objective in visiting MLE[®] collection sites was to gather information on loading ramp design and, more importantly, how pigs respond to differences in ramp design. Differences were observed in loading systems with respect to ramp width and angle. Differences in ramp width may reflect the need to utilize ramps for several species of animals. These differences can have an effect on pig behavior and physiology (see pages 24-26). These differences however, are confounded with the problems of precisely measuring the angles of the ramps. The problems associated with determining ramp angle were. (1) ramps were not consistent in construction, (2) opposite side (front edge) did not always sit at the same level with floor of building where ramp was located, and (3) in some cases it was a step or a hump in the middle of the ramp. An alternative method that should have been employed for measuring the slope of ramps in the field was the protractor and

Table 2.1 Summary results of ramp design of 10 Collection points visited

Collection point ID	<u>CP1</u>	<u>CP2</u>	<u>CP3</u>	<u>CP4</u>	<u>CP5</u>	<u>CP6</u>	<u>CP7</u>	<u>CP8</u>	<u>CP9</u>	<u>CP10</u>
Primary Dock	Movable	Movable	Movable	Movable	a	Movable	Movable	Movable	a	Movable
Base material	Cement	b	Wood	Wood	Cement	Wood	Wood	Wood	Metal	Wood
Height (m)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Width (m)	2.5	0.75	0.68	0.65	1.70	0.60	0.75	0.65	1.0	0.68
Length (m)	6.1	9.0	12.2	9.8	5.0	6.6	6.7	9.3	10.4	4.9
Angle*	11.4	15	9.6	15	11.2	23.5	0	0	18.5	12.4
Sides	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Metal	Wood
Design	Solid	Solid	Solid	Slatted	Slatted	Solid	Solid	Solid	Solid	Solid
Height (m)	2.4	2.4	2.4	1.8	1.5	2.4	2.4	2.4	1.3	1.5
Dock floor	Metal	Cement	Wood	Wood	Cement	Wood	Wood	Wood	Metal	Wood
Design	Stair	Grooved	Stair	Stair	Grooved	Stair	Stair	Stair	Stair	Stair

a Indicates a stationary (non-movable type dock

b Indicates that this dock is a wood-cement combination

* Calculated angle is an estimate

Table 2.2 Summary results of pig handling differences of 8 collection points visited

Collection point ID	<u>CP 1</u>	<u>CP 2</u>	<u>CP 3</u>	<u>CP 4</u>	<u>CP 5</u>	<u>CP 6</u>	<u>CP 7</u>	<u>CP 8</u>	<u>CP 9</u>	<u>CP 10</u>
Width (m)	2.5	0.75	0.68	0.65	1.70	a 0.60	a 0.75	0.65	1.0	0.68
Angle* (m)	11.4	15	9.6	15	11.2	23.5	0	0	18.5	12.4
No. of people loading pigs	2	1	3	1	1	b	b	2	1	2
No. of groups	9	9	8	6	8	b	b	2	10	2
Pigs loaded	11-25	8-26	7-27	12-25	12-19	b	b	15-18	8-43	b
Loading time range (minutes)	0:32-3:45	0:23-2:24	0:25-4:19	0:54-2:17	0:37-2:05	b	b	0:44-0:50	0:28-6:16	1:38-1:52
Movement enhancer	Whip/ Prod	Whip/ Prod	Whip/ Prod	Whip/ Prod	Whip	b	b	Whip/ Prod	Whip/ Prod	Whip/ Prod

a No video taken

b No data reported

* Angle in an estimate

a plumb bob method (Doanes, 1981). This may have more precisely identified the slope in at least 8 of the primary ramps in the field.

Video taken at each collection point allowed for more detailed analysis. However, upon complete review of all video, it was realized that a representative sample was not achieved. Statistical analysis was not performed on any man or pig behavioral results for the following reasons. First, limitations in the use of one camera (sight and sound) did not provide for more accurate decoding of man or pig behaviors. Second, a representative sample was not obtained for a complete an unbiased analysis.

2.4.0 Conclusion

Overall, ramp systems observed in this study were very different with respect to ramp width and angle. In this survey there were considerable differences in handling reported for one to three people loading pigs. This may suggest that the handler may influence pig response during loading greater than ramp design. Difficulties were encountered in (1) precisely measuring ramp angle (2) compiling a representative sample of pig loading across different loading systems and (3) video taping the sensitive nature of pig handling in view of the public concern over animal welfare. However, this study did provide (1) the basis make preliminary observations of pig behavior response patterns in the 'loading chute' and (2) define behavioral patterns and aid the development of the experimental design for Project II.

Loading facility design industry wide will necessitate more research into the implications it will have on stress of the pig and the resulting welfare, and overall meat quality due to behavioral and physiological changes.

Chapter 3
Project II:

**Pig Response to Two Methods of Handling: Some
Behavioral and Physiological Observations⁴**

3.0.0 Introduction

The physiological and behavioral responses that a pig undergoes during loading and pre-slaughter handling are complex and not yet easily identifiable. Measures of injury, pathology and immunological defenses are relatively precise indicators of poor welfare (Broom and Johnson, 1993). However, it is more difficult to assess stress or 'poor welfare' under short-term or 'acute' adverse conditions such as handling with an electric prod, loading up a steep ramp, and transport in a trailer that vibrates or is not well bedded. The one consideration that may play a role in improving pig welfare on the way to slaughter are the causal factors that result in poor meat quality including bruising, pale, soft and exudative (PSE) and dark firm and dry (DFD) that may result from pre-slaughter handling. The following experiment was undertaken to explore the possible relationship between pre-slaughter handling and loading and indicators of pig welfare.

This study used salivary cortisol, heart rate, and body temperature along with behavioral observation to determine the physiological and behavioral consequences that result when pigs are subjected to two different handling methods.

⁴ This study is one part of a two-part study which is not presented here. Some methods presented here reflect the other project needs.

3.1.0 Treatment Use and Identification

A total of two treatments were used for the handling and loading study. A treatment group consisted of three pigs. Pigs received one of two handling approaches; either method 1 (hurdle) or method 2 (prod). The treatments were designed in a nested split plot with each treatment replicated eight times over a four-week period.

3.1.1 Description of Handling Methods

Handling Method 1 Hurdle (n=24)

On treatment days (Tuesday or Thursday) the handler, using a hurdle⁵ moved three pigs out of their home pen, into the alley-way, through the access area, down the ally-way, onto the trailer⁶, and secured them into either pen D or E⁷. The handler was instructed to use only hands, hurdle, and vocalization to complete loading. Figure 3.1 illustrates the route pigs traveled during this handling method.

Handling Method 2 Prod (n=24)

On treatment days the handler moved three pigs out of their home pen and into the access area using a hurdle. When all pigs were in this area and the handler ready, treatment application began using a livestock prod⁸. The electric prod (shock) was applied in thirty-second intervals on one of six designated points on the pig during a three-minute period. Figure 3.2 shows

⁵ A 2 ½ ft x 3 ½ foot board made of wood

⁶ Hart Featherweight Livestock trailers

⁷ Each compartment of the trailer measured 5.3 m² and maintained a stocking density throughout monitoring period of 1.77m² per pig

⁸ Sabre-Six, 5, 000 volts, 15 mA, Hot-Shot Products Co. Inc., Savage Minnesota

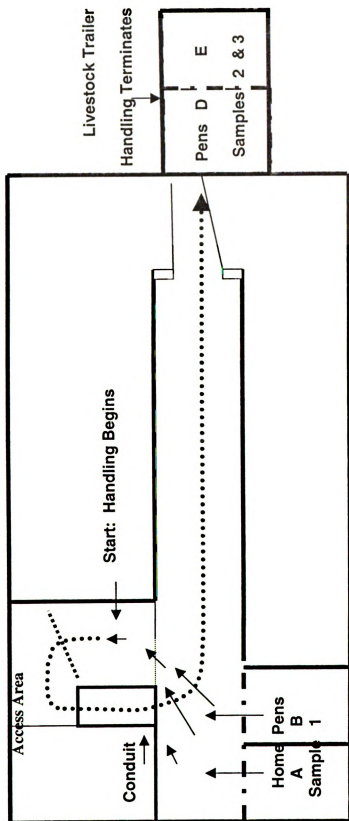


Figure 3.1 Top view: Schematic of pig handling route
(Figure not drawn to scale)



Figure 3.2 Designated prod points on the pig

five of the six designated points on the pig where the handler was designated to make a 'contact'. In addition to these, two points, one on each rear hind leg (hock), was designated as a contact spot. Each prod consisted of a 'contact' between the prod probe and the skin of the pig. Throughout the three-minute period each designated point received a 'contact'. The standard three minutes of prod application was used prior to any pigs being loaded in this treatment. When three minutes elapsed, the handler was instructed to continue loading the pigs down the alleyway and onto the trailer where the pigs were secured into pen D or E. After the three-minute treatment application, the handler was instructed to use as much time as needed to load the pigs. Figure 3.1 illustrate the handling route.

All handling times, including the three-minute prod application, was monitored and recorded by a project staff person. Thirty-second intervals were indicated to the handler by vocalization. Handling began when the handler closed

indicated to the handler by vocalization. Handling began when the handler closed the gate to the access pen. Handling time ended and was marked when the treatment group was secured onto the trailer in pen D or E and when the gate closed. Pigs in both handling treatments were left on the trailer for 15 minutes in order to complete behavior and physiology sampling.

3.2.0 Methods and Materials

3.2.1 Pig Housing and Environmental Conditions

All pigs were housed in the Michigan State University Grow/Finish Facility. Pigs were penned in two treatment pens. Pen A measured 8.8 m² and Pen B measured 7.56 m². Pigs were initially grouped according to the following stocking density: 6 pigs per pen with the exception of group E handling level 2 (prod), pen A, which had only five pigs due to the lack of additional pen-mates. Pen A stocking density with six pigs per pen was 1.47 m² per pig. At five pigs per pen the stocking density equaled 1.76 m² per pig. Pen B stocking density at six pigs per pen equaled 1.2 m² per pig. Stocking density was within specifications used for this age of pig housed on partial or full slatted floors (PIH, 1987). Pigs were allowed ad libitum access to a standard grow/finish ration and access to water. Environmental temperatures were recorded for both Control day and Treatment day sampling and are summarized in tables 3.1 and 3.2.

Table 3.1 Summary of environmental temperatures during control day sampling

Sampling period		TM-1	TM-2	TM-3
Mean (C ⁰)		20.5	19.9	19.6
Range (C ⁰)		16.3-23.7	16.3-21.0	16.3-21.1

Table 3.2 Summary of environmental temperatures during treatment day sampling

Sampling period		TM-1	TM-2	TM-3
Mean (C ⁰)		20.4	7.8	8.5
Range (C ⁰)		18.6-22.6	2.7-15.0	4.2-15.0

3.2.2 Pig Selection and Use

A total of forty-eight (48) pigs were used in the pig handling and loading study. Pigs were selected, pair-matched, and allocated to treatment groups (B to I) weekly based on: (1) genotype, (2) sex, (3) weight (4) pen-mate availability, and (5) littermate avoidance. The table 3.3 is a synopsis of pigs allocated to treatment groups (handling levels) used in control and treatment periods.

The genotype of the pigs used in this experiment consisted of purebred York, York-Landrace cross, and Newsham stock⁹. All groups were evenly divided between gilts and barrows. Pigs were selected from growing and finishing pigs

Table 3.3 Pig group composition and treatment allocation¹⁰

<u>Group</u>	<u>Sex</u>	<u>Genotype</u>	<u>Weight (kg)</u>	<u>Handling Method</u>
Group B	Gilts	3 Newsham	89.5 – 92.3	1 Hurdle
		3 Newsham	97.3 – 123.6	2 Prod
Group C	Gilts	3 Newsham	103.6-126.4	1 Hurdle
		2 Newsham	102.7-125.9	2 Prod
		1 York-Landrace		
Group D	Barrows	3 York	90.9-120.9	1 Hurdle
		2 York-Landrace	104.5-135.9	2 Prod
		1 York		
Group E	Barrows	2 Newsham	106.8-122.3	1 Hurdle
		1 York-Landrace		
		2 Newsham	106.4-123.2	2 Prod
Group F	Barrows	1 York-Landrace		
		3 Newsham	120.0-145.0	1 Hurdle
Group G	Gilts	3 Newsham	120.4-134.5	2 Prod
		3 York	118.2-123.6	1 Hurdle
		2 Newsham	105.4-115.9	2 Prod
Group H	Gilts	1 Newsham		
		3 York	103.6-117.3	1 Hurdle
		2 York	121.4-127.7	2 Prod
Group I	Barrows	1 York-Landrace		
		3 York ^a	102.3-116.4	1 Hurdle
		3 York ^a	124.5-135.5	2 Prod

a. Pigs in group were littermates

⁹ Pigs used in the experiment were from the Michigan State University Swine Teaching and Research Facility.

¹⁰ Group A was a “trial-run” group and is not included in any comparison data.

available from the MSU Swine farm with weights ranging 90 to 145 kilograms. All pigs selected from available pigs were grouped with pen-mates. Littermates were avoided in groups B through H. In group I, pigs in each handling group were littermates. Each Thursday, pigs for both treatments were visually identified and moved into the Grow/Finish barn. At this time the pigs were weighed, marked with an easily identifiable number on the back and sides using a non-toxic, non-permanent grease paint stick¹¹ for video analysis. Pigs were also measured for backfat using ultra-sound¹² and moved into treatment pens home pens¹³ (see figure3.1).

3.2.3 Pig Training and Acclimation Period

Pigs were allowed one day to acclimate to the grow/finish barn before they were subjected to “pig training”. The training of pigs included acclimation to a simulated heart rate monitor strap, saliva collection procedure and body temperature sampling. Pig training was necessary due to the novelty of the procedures used and to deter any confounding effects these procedures could have on treatment effects (Broom and Johnson, 1993; Manser, 1993). Each treatment group (3 pigs per group) encountered a minimum of two training days prior to treatment day. Pig training time varied between treatment groups with

¹¹ Markel LA-Co Industries Inc 1201 Pratt Blvd. Elk Grove Village Ill. 60007

¹² Pie Medical Scanner 200 VET with ASP-18 probe. Pie Medical Equipment B.V Phillipsweg, 6227 AJ Maastricht, The Netherlands. Marketed in the USA by Classic Medical Supply Inc. 19900 Mona Rd, Suite 105 Tequesta, Fl, 33469.

¹³ Backfat measurements were taken for a different part of this study and are not utilized in this study

each group receiving a minimum of one half-hour sampling each 'training' day. Pig training occurred on Friday and Saturday of each week.

Pig Training Sampling

Simulated heart rate monitoring straps were made out of duct tape and insulated wire. 'Straps' were placed around the thorax of the pig immediately caudal to the forelimbs of the pig and a belt with snaps was latched to it. The straps were tightened and left on the pig throughout the duration of the 'training' period.

Pig saliva was collected using 7.5 cm (3") cotton swabs¹⁴. Three to five swabs were inserted into the mouth of the pig, chewed on by the pig, removed, and then discarded. Each pig was sampled twice during each training period.

Pigs were monitored for body temperature using an over-the-counter digital oral/rectal thermometer¹⁵. The method of sampling is as follows: the tip of the thermometer was lubricated and gently inserted into the anus of the pig. A temperature reading was indicated when the thermometer beeped or discontinued flashing (approximately one minute after insertion). No readings were recorded during "pig training".

3.2.4 Control and Treatment Day Sampling.

All pigs (n=48) were subject to physiological and behavioral monitoring for two days. Sunday and Wednesday were designated as control days. Tuesday and Thursday were designated as treatment days. All variables (heart rate, cortisol, body temperature and behavior) were measured identically in

¹⁴ Q-tip®, Chesebrough-Ponds USA Co. 33 Benedict Place, Greenwich, CT 06830, USA

groups C through I. Group B was not monitored for behavior due to an error in video monitoring.

Sample Collectors

Over the entire experiment a total of four different staff persons were used to collect samples. All sample collectors were familiarized with the sampling procedure before actual data collection was begun.

3.2.5 Samples Collected: Physiological and Behavioral Measurements

Heart rate and behavior were monitored continuously through the experiment. Salivary cortisol and body temperatures were collected according to the following time line in table 3.4.

Table 3.4 Sample collection schedule

	<u>Pre-Handling</u>	<u>Handling</u>	<u>Post-Handling</u>
	TM-1	TM-2	TM-3
Sample	1	2	3

All samples for pigs on control and treatment days were collected between 6:45 a.m. and 8:00 a.m. in the morning. Each pig was sampled three times on each of the control and treatment days for a total of six samples for each measurement collected. Sample 1 corresponds to 'Pre-Handling' and

¹⁵ B-D, Becton-Dickinson Consumers Products, Franklin Lakes, NJ 07417-1883

indicates that a pre-treatment sample was collected before handling treatments were applied. Sample 2 corresponds to 'Handling' and reflects the time interval in which pigs were subjected to one of the two handling treatments. Sample 3 corresponds to 'Post-Handling' and reflects the fifteen-minute interval following the completion of handling in which the third and final sample of each measurement was taken.

Body Temperature

Pig body temperature was taken according the sampling time line. Body temperature was monitored using the process already described in the 'pig training' section (see page 50-51). The readings were recorded onto a worksheet by project staff taking samples.

Figure 3.3 shows the method by which body temperature was monitored.



Figure 3.3 Monitoring body temperature

Salivary Cortisol

Pig saliva was collected using eight-inch cotton swabs¹. Fresh pig saliva was collected in the following manner: a small group (3-4) cotton swabs were gently inserted into the pigs mouth and chewed on for approximately twenty to thirty seconds and then discarded. The Scopette Jr®. was then inserted into the pigs mouth, chewed on, depositing fresh saliva on the bud. Figure 3.4 shows the method in which saliva was collected from each pig using the Scopette Jr®.



Figure 3.4 Saliva collection using the Scopette Jr.

¹ Scopette Jr®, # 34-7021-12, Birchwood Laboratories, Eden Prairie, Minnesota

Following collection, buds were placed in 15 ml conical centrifuge tubes, capped and placed on dry ice in a styrofoam ice chest. Following completion of control or treatment day sampling and monitoring, samples were then frozen at -20 degrees Celsius until assayed. Salivary cortisol samples were analyzed using the Radio Immuno Assay (RIA) Coat-A-Count Cortisol kit¹⁷ following specific instructions for determinations in saliva. Cortisol samples were thawed according to treatment groups (sixty-six samples) at a time. After thawing, buds were removed, a 5 c.c. syringe (minus plunger) was placed into each conical tube, and buds replaced so saliva could be extracted from the cotton bud. Samples were then centrifuged at 4 degrees centigrade for 5 minutes at 1548 x g force. Immediately following centrifugation, cotton buds were removed from sample tubes to prevent re-absorption of saliva into cotton bud. One milliliter of saliva was then aliquoted to 1.5ml eppendorf tubes and frozen until the RIA for cortisol could be performed. On the day the RIA was performed the samples were centrifuged again and 200 micro-liters was aliquoted to coat-a-count tubes in duplicate. Four plain (uncoated) 12x75mm polypropylene tubes were labeled with total counts (TC) and non-specific binding (NSB) in duplicate. The cortisol antibody coated tubes were labeled in duplicate with standards A-F and sample numbers. 25 microliters of standard A was pipetted into NSB and A tubes. Each standard and saliva sample was pipetted (200 ul) into its appropriate tube. One milliliter of [¹²⁵I] cortisol was added to each tube and vortexed. The samples were incubated at room temperature for three hours, decanted, and

¹⁷ Diagnostic Products Corporation 5700 West 96th Street, Los Angeles, Ca 90045-5597

counted using a Mark IV Gamma counter® for 1 minute. Standard curves were calculated and used to determine cortisol concentrations from saliva samples. The intra assay average percent coefficient of variations was 6.95.

Heart Rate Monitoring

Pig heart rate was monitored continuously during control and treatment days. Heart Rate was measured using the Polar Vantage NV Heart Rate Monitor¹⁸ consisting of a receiver (watch) and a belt (transmitter). The receiver has a memory function and stores data from the transmitter, averaging heart rate over five, fifteen or sixty seconds intervals. In this experiment, the interval was set at five-second intervals for maximum detail, which gave a total memory capacity of 11 hours. Heart rate monitors were adapted to pigs in the following manner: the receiver (watch) was protected by being inserted into flexible (durable) clear PVC tubing approximately 12.5 cm in length and 4.50 cm in diameter with holes for crimping ends once watch was activated and inserted into tubing. Insulated electric wire was laced through each end of the transmitter strap and looped at the end. A heavy elastic band with adjustable straps with snaps on both ends was latched to the wire loop. The PVC tubing with the receiver was laced onto the strap and activated. The adapted transmitter and receiver were placed on the pig in a manner described by Marchant et al. (1995, 1997). Figure 3.5 shows the manner in which heart rate monitors were placed on each pig. The transmitter was fitted around the

¹⁸ Polar Electro Inc., 99 Seaview Boulevard, Port Washington, NY 11050, U.S.A.

thorax of the pig, immediately caudal to the forelimbs. K-Y® jelly¹⁹ was substituted for electro-cardiogram gel and was applied to pig and the electrodes of the transmitter to ensure continuous transmission. Each end was duct-taped so that pigs could not easily manipulate or destroy snaps or wire. Each receiver was tested for proper functioning, set according to video monitor time, and occasionally rechecked during sampling. Each monitor was strapped onto pigs prior to the first sampling (pre-handling) of the treatment. Following the end of each treatment, heart rate monitors were removed from the pigs, turned off and information recorded down loaded into the computer using the Polar Advantage Interface System²⁰. Data for the appropriate time period was averaged to a single number. Averages for time 'pre-handling' were calculated using a ten-minute period just prior to "6:55 am". Averages for 'handling' varied from group to group.

¹⁹ Ortho Pharmaceuticals Corp. Rariton, NJ 08869

²⁰ Polar Electro Oy, Professorintie 5, 90440 Kempele Finland



Figure 3.5 Heart rate monitor adapted to a pig

Averages were determined using the recorded handling time for each group. Handling times were matched against heart rate data print outs and averaged based on handle time. Averages for 'post-handling' were calculated beginning four minutes after the completion of handling and averaged over a ten-minute period.

3.2.6 Behavioral Observation

Pig behavior was continuously monitored by a closed circuit monitoring system⁶ and a hand held mini-cam⁷. The handling of pigs was recorded using the hand held min-cam with sound capability. A designated camera-person was instructed to follow both the pigs and handler to the best of their ability through handling treatment. Once pigs were on the trailer behavior

⁶ Panasonic Time lapse video recorder, 2-AG-6730P, 4-Panasonic CCTV Cameras WV-BP310 and 1-Panasonic Quad Unit WJ-410

⁷ JVC SVHS camera with light adapter

monitoring continued with the use of the closed circuit monitoring system.²³ One (1) 4.5 mm black and white camera was mounted in the corner of each of the pens (D and E) on the trailer. A video recorder and monitor were placed in the forward compartment of the trailer.

Video decoding

Video from the closed monitoring system and the mini camera were decoded using the Observer software²⁴. All cassettes were reviewed for content prior to decoding. Behavioral codes for control and treatment day; handling and post handling were developed based on initial review of video.

Control Day Behavior

Control day pig behavior was monitored using two cameras placed in front of pens A and B. Video was taped at 12 frames per second allowing for total recording time of six hours. Sound was not recorded due to the difficulty of adapting a microphone to the monitoring system. Following completion of sampling the video-tape was removed from recorder, labeled and modified to prevent accidental "tape over" of results. Videos were checked to insure proper recording but were not viewed for content until all treatment groups had been completed.

All video-tape and behavior patterns was coded by a single project staff member. Following initial review of video, behaviors and their definitions were established. Pigs in control data were observed and decoded in treatment

²³ The recording system does have sound capability but due to difficulties in finding a suitable adapter, noise and vibration of the trailer it was decided that the sampler could write down any vocal responses.

²⁴ Noldus Technology Systems

groups consisting of three pigs and observed for three periods of ten minutes equal to 600 seconds. Time period “pre-handling” behavior was coded for beginning from 6:45 am to 6:55 am. Time period ‘handling’ was established by project staff from treatment day equivalents and was identified from worksheets used on treatment days. Time period ‘post-handling’ was established fifteen minutes past the established ‘handling’. The ten-minute observation period for ‘post-handling’ began immediately following the completion of time period ‘handling’.

Initial review of video revealed eleven distinct behaviors as describes in table 3.5. Of these a total of seven pig behavior patterns were statistically compared²⁵. Behavior data discarded from statistical comparison included the categories of, “defecate”, “urinate”, “No doing” and “Pig #”.

Treatment Day behavior

Treatment day pig behavior was monitored using a total of five cameras. Two cameras were placed in the alleyway, and one camera each placed in the corner of pen D and E. An additional camera was used as a ‘moving camera’ operated by project staff that monitored handling. During handling the designated camera person with a mini-cam, with sound capability, was instructed to follow the pigs and handler to the best of her/his ability until pigs were secured into pens D or E. Stationary cameras recorded video-tape at 12 frames per second allowing for a total recording time of six hours. The ‘moving

²⁵ A behavior was statistically compared if more than 50 % of pigs expressed the behavior

camera' recorded at 30 frames per second allowing for a total recording time of two hours.

No behaviors were monitored for the "pre-handling" time period due to an oversight of project supervisor. Initial review of video revealed fifteen classes of pig behavior for all time periods and are defined in table 3.6. In time period 'handling' a total of four behaviors were statistically compared for 'handling' and included pig vocalizations, jumping away, climbing, and falling. Because handling time varied between and within treatments, observation and monitoring time varied and a statistical comparison of handling times is not included in this study. In time period 'post-handling' a total of four behaviors were identified and monitored for 10 minutes (600 seconds) following the completion of handling and a four minute interval and included investigative, idle, rooting the number of steps a pig took.

3.2.7 Statistical Analysis

All data reported was analyzed using SAS software version 6.12²⁶. *Proc glm* statements were developed for this nested split plot design. Pig is nested in treatment (rg) but not in (bt) basal or treatment day or tm (time period).

Statistical analysis was generated behavior and physiology using the following models in tables 3.7-3.9.

²⁶ SAS/STAT Users Guide Vol. 1 and Vol. 2. 1990 Version 6.12 4th edition. SAS Institute, SAS Inc., Cary NC., 27513

Table 3.5 Pig behavioral patterns and definitions identified on control day

Behavior	Definition
Feeder	Pig is standing at the feeder, with head down and snout inserted into the trough area.
Water	Pig is positioned at the water nipple, with snout and mouth surround the nozzle
Steps	Pig takes 3-5 strides in any direction
Lying	Pig is not standing on any legs, pig's torso, or side is touching the ground
Sitting	Pig is on it haunches with weight on the hind legs, forelegs stretched out in front
Idle	Pig is standing motionless or almost motionless with head up
Pig #	Not able to determine the pig's number from video
No Doing	Not able to determine what the pig is doing in the video
Invest	Forward movement has slowed or is stopped, head is lowered to the ground and is shifting from side to side
Defecate	The pig defecates
Urinate	The pig urinates

Table 3.6 Pig behavioral patterns and definitions identified on treatment day

Behavior	Definition
Vocal	The pig bellows or squeals
Jump	The pig jumps or climbs the walls of the pen or corridor
Invest	The pig slows forward movement or is stopped, lowers head and moves it from side to side"
Walk	A slow four-beated gait
Run	A fast two- beated gait
Freeze	The pig stops, and stands almost motionless
Defecate	The pig defecates
Fall	The pig falls to the ground
Urinate	The pig urinates
Move	Pig moves away from samples while samples are being collected
Step	Pig steps into trailer compartment
Rooting	The pig is on trailer with snout buried in straw on trailer floor, or has straw in mouth
Idle	The pig is standing, not moving, with head up
Sm. Step	The pig takes 3-5 steps at 1/2 stride
Stride	The pig takes 5 or less full motion steps

Table 3.7 SAS model for pig physiology: Control and treatment days

```
Proc sort data=one;by bt;
Proc glm data=one;class pgno rg tm; by bt;
Model temp cort hr =rg pgno(rg) tm tm*rg;
Test h=rg e=pgno(rg);
lsmeans rg/stderr e=pgno(rg);
Means tm rg*tm/stderr;
Run;
```

Table 3.8 SAS model for pig behavior: Control day

```
Proc sort data=one;by bt;
Proc glm data=one;class pgno rg tm; by bt;
Model pgstp pgly pgsit pgfd pgwt pginvst pgidl =rg pgno(rg) tm
tm*rg;
Test h=rg e=pgno(rg);
lsmeans rg/stderr e=pgno(rg);
Means tm rg*tm/stderr;
Run;
```

Table 3.9 SAS Model for pig behavior: Treatment day

```
Proc sort data=one;by bt;
Proc glm data=one;class pgno rg tm; by bt;
Model pgvc pgjmp pgclmb pgfl pginvst pgidl pgrtpgstp =rg
pgno(rg) tm tm*rg;
Test h=rg e=pgno(rg);
lsmeans rg/stderr e=pgno(rg);
Means tm rg*tm/stderr;
Run;
```

3.3.0 Results of Project II

Results were tabulated using *Proc GLM* statements. Tables 3.10, 3.11, 3.12 and 3.13 reveal the results of the statistical analysis reported for the behavior and physiological measures taken during both control and treatment days.

3.3.1 Pig Behavior Results: Control Day

Table 3.10 reports the results of the statistical comparison of control day behaviors observed. Data reported reflect a ten-minute (600 sec) observation period. No behavior data is reported for group B²⁷. There were no significant differences between any behavioral categories over the three time periods TM-1, TM-2, or TM-3. The mean number of steps a pig took was 7.9 in TM-1, 5.8 in TM-2, and 6.7 for time period TM-3. ($P > .9402$). The amount of time spent lying-down was 22 % in TM-1, 15.7 % in TM-2 and 32.6 % in TM-3 ($P > .9513$). Pigs spent on average, 7.9, 8.9 and, 10.1 percent of their time sitting for the three time periods respectively ($P > .2173$). Pigs were observed to have spent 17.4, 13.4 and, 10.4 percent in 'maintenance' which included feeding ($P > .5885$) and drinking ($P > .6123$) for each of the three time periods respectively. Pigs spent on average 37.0, 37.7, and 35.5 percent of their time in the investigative mode ($P > .1984$). Pigs spent on average 16.2, 24.1, and 19.7 percent of their time ($P > .5392$), respectively, in the idle mode.

²⁷ N=42 because pigs in group B were not video-taped due to a malfunction in equipment

3.3.2 Pig Physiology Results Control Day

Table 3.12 shows the results of the statistical comparison of physiological data gathered on control day. No significant differences in cortisol, heart rate or body temperature, were observed across the three sampling periods ($P > .7883$), ($P > .4817$) and ($P > .0568$) respectively. Mean cortisol was 3.64, 3.53, and 3.42 nmol/l for the three time periods respectively. Mean heart rate over the three time periods was 111.65, 118.21 and, 117.14 beats per minute. Mean body temperature over the three time periods was 39.02, 39.01, and 39.00 degrees Celsius respectively.

3.3.3 Behavior Results Treatment Day

Table 3.11 shows the statistical comparison of observed behaviors on treatment day over time periods TM-1, TM-2, and TM-3.

Time Period TM-1

No behavioral data was recorded for this time period²

Time Period TM-2

All classes of behavioral variables were significantly different. Mean pig number of pig vocalization for handling level 1 was .8333 and 10.33 for handling level 2 and was significantly different ($P < .0001$). Mean number of jumps each pig observed during handling levels 1 and 2 was zero and 5.5 respectively and was significantly different ($P < .0001$). The number of falls recorded for each pig during handling periods 1 and 2 was .042 and .750 and was significantly

² Monitoring of pig behavior was not possible due to limitations in equipment capability

different ($P < .0005$). The other behavioral categories, investigative, idle, root, and steps, were not reported on in this time period³.

Time Period TM-3

Mean time investigative behavior observed across handling methods 1 and 2 was 14.05 and 48.78 seconds respectively and were significantly different ($P < .0018$). Pigs in handling methods 1 and 2 were observed to have spent 2.3 and 8.13 percent of their time expressing this behavior. Mean time spent in the idle mode across handling methods 1 and 2 was 57.5 and 97.8 seconds and was not significantly different ($P < .1021$). Mean time spent rooting across handling methods 1 and 2 was 550.90 and 456.13 seconds respectively and was significantly different ($P < .0001$). Pigs in handling methods 1 and 2 spent 91.82 and 76.02 percent of their time expressing this behavior.

3.3.4 Physiology Results Treatment Day

Cortisol

Table 3.13 shows the results of the statistical comparison of physiological of the measures collected on treatments days over the three time periods TM-1, TM-2, and TM-3. Cortisol levels were not significantly different ($P < .2621$) between treatments over periods TM-1, TM-2, and TM-3. Mean

³ Less than 50 % of the pigs were observed to express this behavior in the time period

Table 3.10 Statistical comparison of pig behavior: Control day

Behavior	TM = 1			TM = 2			TM = 3			
	N	Mean	SD	N	Mean	SD	N	Mean	SD	P-Value
<u>Locomotion</u>										
Step ^a	42	7.9	6.6	42	8.8	5.8	42	8.9	6.7	0.9402
Lying ^b	42	132.7	212.7	42	94.9	171	42	195.9	404.9	0.9513
Sitting ^b	42	47.8	127.9	42	53.5	126.5	42	60.8	125.8	0.2173
<u>Maintenance</u>										
Feed ^b	42	95.4	139.6	42	75.9	109.2	42	57.2	103.4	0.5885
Water ^b	42	9.25	23.45	42	4.6	11.2	42	5.4	14.7	0.6123
<u>Social^b</u>										
Investigative ^b	42	222.2	182.1	42	226.4	159.0	42	213.0	183.4	0.1984
Idle ^b	42	96.9	103.4	42	144.5	107.5	42	118.0	126.7	0.5392

a. This category is number of 'counted' steps during a 10-minute (600 second) period

b. These categories reflect the duration of time pigs spent expressing this behavior over a 10-minute (600 second) period

Table 3.11 Statistical comparison of pig behaviors: Treatment day

Behavior	Level	N	TM = 1			TM = 2			TM = 3				
			Mean	SD	P-value	N	Mean	SD	P-value	N	Mean	SD	P-value
Vocalization	1	24	a	a	-	24	.833	1.55		24	b	b	-
	2	24	a	a	-	24	10.33	4.84	0.0001	24	b	b	-
Jump	1	24	a	a	-	24	-	-		24	b	b	-
	2	24	a	a	-	24	5.5	1.53	0.0001	24	b	b	-
Climb	1	24	a	a	-	24	-	-		24	b	b	-
	2	24	a	a	-	24	1.42	1.10	0.0001	24	b	b	-
Fall	1	24	a	a	-	24	0.042	0.204		24	b	b	-
	2	24	a	a	-	24	0.750	0.897	0.0005	24	b	b	-
Investigate	1	24	a	a	-	24	b	b	-	24	14.05	23.71	-
	2	24	a	a	-	24	b	b	-	24	48.78	45.54	0.0018
Idle (sec)	1	24	a	a	-	24	b	b	-	24	57.463	91.883	
	2	24	a	a	-	24	b	b	-	24	97.783	45.541	0.1021
Root (sec)	1	24	a	a	-	24	b	b	-	24	550.90	51	-
	2	24	a	a	-	24	b	b	-	24	456.13	84.42	0.0001
Step (freq)	1	24	a	a	-	24	b	b	-	24	24.58	13.25	-
	2	24	a	a	-	24	b	b	-	24	21.79	9.03	0.3983

^a No data recorded for analysis

^b Behaviors not observed in fifty percent of the pigs during the relevant time period

Table 3.12 Statistical comparison of pig physiology: Control day

Indicator	TM = 1			TM = 2			TM = 3			
	N	Mean	SD	N	Mean	SD	N	Mean	SD	P-value
Cortisol (nmol/l)	47	3.64	2.32	48	3.53	2.82	45	3.42	2.24	0.7883
Heart Rate (bpm)	43	111.65	14.46	43	118.21	16.74	41	117.14	14.34	0.4817
Body Temperature (C°)	48	39.02	0.697	48	39.01	0.455	48	39.00	0.563	0.0568

Table 3.13 Statistical comparison of pig physiology: Treatment day

Indicator	Level	TM = 1			TM = 2			TM = 3			P-value
		N	Mean	SD	N	Mean	SD	N	Mean	SD	
Cortisol (nmol/l)	1	24	4.08	2.76	23	8.36	6.79	24	8.50	11.26	-
	2	19	3.73	3.01	23	8.80	7.92	24	11.65	7.09	0.2621
Heart Rate (bpm)	1	22	105.26	9.54	21	154.07	16.77	21	120.16	11.89	-
	2	23	106.13	10.77	21	199.12	12.99	23	136.04	12.42	0.0001
Body Temperature (C°)	1	24	38.96	0.609	24	39.09	0.966	24	39.11	0.879	-
	2	24	38.81	0.717	24	39.45	0.502	24	39.39	0.588	0.0001

cortisol values for handling method 1 (hurdle) and 2 (prod) were 4.08 and 3.73 nmol/l for the time period TM-1. Mean cortisol values for pigs in handling methods 1 and 2 for time period TM-2 were 8.36 and 8.80 nmol/l respectively. Mean cortisol values for pigs in each handling treatment in time period TM-3 was 8.50 and 11.26 nmol/l respectively. Figure 3.6 shows the magnitude of cortisol response of handling methods 1 and 2 compared to that of control (basal) levels.

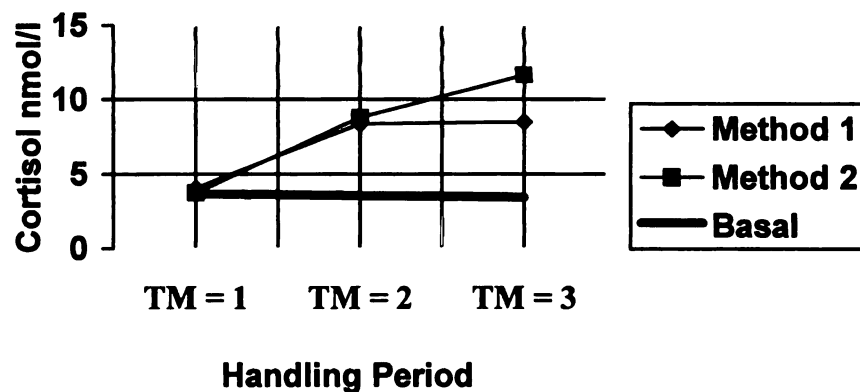


Figure 3.6 Comparison of cortisol response: Control and treatments

Heart Rate

Pig heart rate response was significantly different ($P < .0001$) across both handling treatments over the three time periods. In time period TM-1 heart rate was significantly lower than recorded basal level heart rate for the same pigs. In time period TM-2, heart rate for handling method 1 rose to 1.3 times that of recorded basal levels. Heart rate in handling method 2 rose to 1.7 times that of recorded basal levels. Heart rate over both handling treatments fell in time period TM 3 to 1.03 and 1.16 times that over recorded basal levels for the same

time period. Figure 3.7 illustrates pig heart rate response to handling methods 1 and 2 compared to those recorded during control (basal) day.

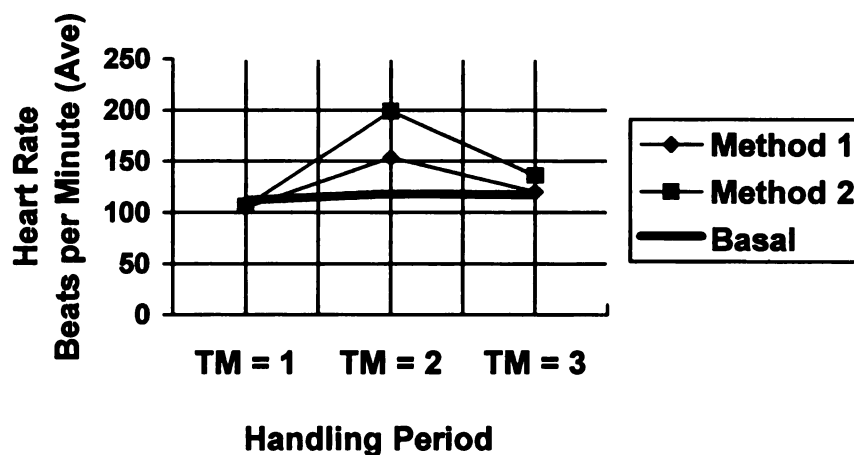


Figure 3.7 Comparison of heart rate response: Control and treatments

Body Temperature

A significant difference ($P < .0001$) in body temperature was observed between handling methods across the three time periods TM-1, TM-2, and TM-3. Mean body temperature ($^{\circ}\text{C}$) for pigs in handling method 1 was 38.96, 39.09, and 39.11 for time periods TM-1, TM-2, and TM-3 respectively. Mean body temperature for pigs in handling method 2 were 38.1, 39.45 and 39.39 centigrade respectively over time periods TM-1, TM-2, and TM-3. Figure 3.8 illustrates the magnitude of response in body temperature.

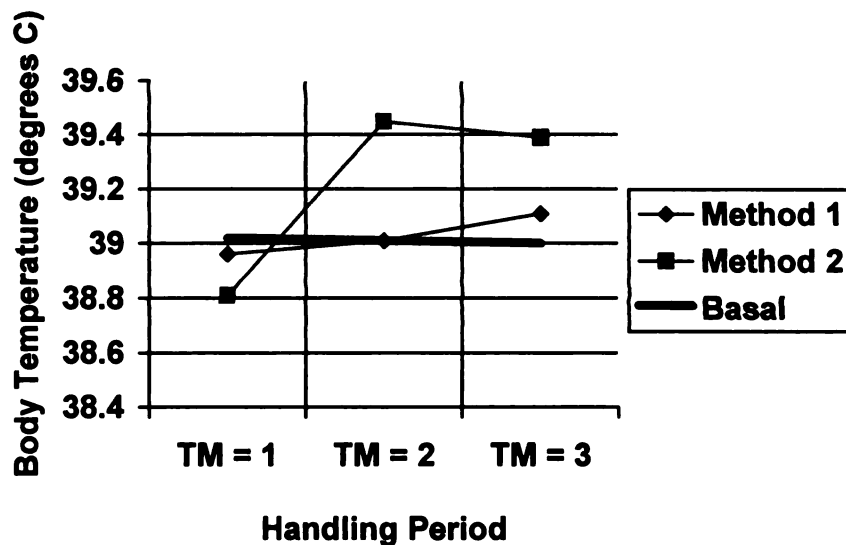


Figure 3.8 Comparison of body temperature response: Control and treatments

illustrates the differences between control day (basal) and differences between handling over the three time periods.

3.4.0 Discussion of Project II

3.4.1 Video Observation and Pig Behavior

Control Day

A total of seven behavioral patterns were observed in fifty percent or more of the pigs. All behaviors 'decoded' during control day monitoring suggest that finishing pigs in this type of environment, a barren traditional intensive type housing system, may spend more time in 'maintenance' and 'lying' behavioral states than other states. The videography methods employed for control day monitoring were an adequate means for observing preliminary animal behavioral patterns of pigs in this environment. These results suggest that, in this study, the selection of pigs, including genotype, sex, littermate and pen

mates were well balanced across the groups. Additionally, the results may indicate that pig handling and sampling, during control day, were consistent for each treatment group through all three sampling periods (Zanella, 1998).

3.4.2 Treatment Day Behavior

Handling TM-2

A total of four behavioral patterns were identified during handling levels 1 (hurdle) and 2 (prod) on treatment day and all were significantly different between the two handling treatments. As expected, pigs vocalized more during handling method 2 than handling method 1. However, the number of falls a pig took between handling methods were different. This may need to be investigated a little more due to the potential for increased carcass damage and poor welfare of pigs being handled under 'farm' or real situations utilizing an electric prod to load pigs. Climbing and jumping in this study are characteristic of 'escape' attempts in which pigs perceiving an adverse situation attempt to avoid or flee from it. These pigs had not been handled 'a lot' prior to this experiment which suggests that pigs handled with a mangate or hurdle will not attempt to climb or jump away from the handler resulting in falls or sustain other injuries. These results suggest that the handler welfare is enhanced by use of a hurdle or mangate. Though the handling methods used in this study did not produce apparent injury to the pig, use of an electric prod did produce actions which may result in injury and would be indicative of poor pig welfare.

This study did not observe other behaviors that have been reported in the literature during loading. The reasons for this are three-fold: (1) there were

not enough cameras in place to observe the various behavioral responses. (2) the use of one moving camera-person requires focus choice on either handler or pigs, resulting in observation losses during handling. (3) cameras used for this project were not well adapted to low-lighting situations. Therefore, clarity and definition in video was poor at times resulting in unclear expressed behaviors of pigs.

Overall, the results in pig behavioral response to handling suggest two things. (1) handling levels 1 (hurdle) and 2 (prod) were different enough to produce a response difference in pig behavior response. (2) However, this must be weighed against the fact that due to limitations in camera surveillance, many other potential behaviors were not observed or coded for in the video (Zanella, 1998).

3.4.2 Sampling and Pig Physiology

Control Day Levels

Mean cortisol, heart rate and body temperature, were not significantly different across the three time periods TM-1, TM-2, and TM-3 during control (basal) day monitoring. All basal values fell within reported ranges from other published studies of pre-treatment application. These results suggest that the methods employed for measuring these variables are valid. These results also suggest that selection of pigs, including genotype, sex, littermate and pen mate were well balanced across the groups during control period and that pig sampling for each treatment were consistent through all three sampling periods (Zanella, 1998).

Treatment Day physiology

Cortisol

Salivary cortisol levels were not significantly different between handling methods over the three time periods TM-1, TM-2, and TM-3 on treatment day. Handling level 2 (prod) did cause an increase in cortisol response over handling method 1. Other studies report variable results. Parrot and Mission (1989) report significant differences in salivary cortisol response of pigs to handling and restraining. However, Bradshaw et al. (1996) studying the effects of mixing and transport report no significant differences in salivary cortisol response of 90 kg pigs after loading prior to treatment. Gemus, (1998) report no significant differences in salivary cortisol response of pigs handled. However according to Becker et. al. (1985) significant differences were observed in plasma cortisol response of pigs electrically stimulated. Lack of significant results in cortisol findings can be attributed to several factors. First, the sampling interval of fifteen minutes may have failed to give maximum response. A longer sampling interval such as 25-30 minutes may have been more appropriate (Zanella, 1998). Second, significant individual differences in pigs may have contributed to lack of cortisol response. Barnett et al. (1987), report that corticosteroid measures should be carried out in the afternoon rather than in the morning because the in-between animal variation in the hormone levels is less and more stable in plasma samples. Third, glucocorticoids can be released in response to situations that are not normally regarded as stressful and therefore, single [few] adrenal indices must be considered questionable (Broom, 1988). Fourth,

according to Blackshaw and Blackshaw (1989) there is a low correlation between salivary cortisol and plasma cortisol. This may indicate that though salivary cortisol levels are a sound measure of HPA activity during prolonged stress, plasma cortisol may be a more reliable measure of adrenal activity under acute stressors.

Heart Rate and Body Temperature

Significant treatment differences in heart rate and body temperature were observed across the three time periods. These results indicate that heart rate and rectal body temperature measures are good indicators of emotional stress and metabolic changes associated with acute stress

According to the results of this study several things are indicated. This study showed an association between accelerated cardiac output and core body temperature. These physiological changes were also related to the number of vocalizations, number of escape attempt (jumps and climbs), and falls in pigs handled with an electric prod. These findings resulted in a post handling relationship in which significant differences in heart rate and core body temperature were associated with more exploratory behavior (rooting and investigative) as opposed to locomotive and non-social or participatory behavior of pigs. According to Broom and Johnson, (1993) "there is considerable diversity in the responses, both behavioral and physiological, which animals show when disturbed. Therefore, producing a 'uniform' behavioral and physiological stress response may be difficult (Grandin, 1997).

3.5.0 Conclusion

The goals of Project I and II were to develop a research and procedure capability at MSU that would form the basis for a field level study on the aggregation and transitory effects of stress and welfare on market swine as they affect loss and meat quality in the pork industry. To this extent, this study deals with the application of the existing tools of behavior science. It has been necessary to develop procedures and techniques within this system at MSU that are accurate, reliable and appropriate. These projects revealed some problems areas and also some meaningful and reliable techniques.

The problem areas were: (1) the need for alternative videography methods, (2) an alternative selection strategy for experimental swine, (3) an extended time frame for cortisol evaluation and (4) the sensitivity of the field sector, both producer and marketing organizations that participate in studies involving animal welfare issues.

The positive aspects of these projects were: (1) the effectiveness of the body temperature and heart rate measures as sensors of animal stress, (2) the development of techniques to handle and collect samples with market swine in gathering transitory functions, (3) the process of observing and measuring behavioral patterns in a market system and (4) the necessity to develop a method to monitor and measure field handler attitudes and techniques.

It was evident in research involving stress application techniques, that it is very difficult to create a uniform, defined level of stress in market swine since animals will use various means to avoid this stress treatment resulting in great

variation in application effectiveness. Not only is there great variation in animal response and coping mechanisms to stressors, but there also exist great variation in handler ability to move market swine.

It will be important to focus on the positive comfort zone aspects of swine handling and management in field trials if research is to be supported by the field industry.

APPENDIX A

APPENDIX A

Collection Point Survey

Code # C- _____

Date: _____

Collection Point: County _____ Township _____

Average number of pigs received: Weekly _____ Monthly _____

Average group size of pigs arriving from farms: _____ Range _____

What percentage of pigs handled at this facility are: Confined __ % Outdoor __ %

What percentage of your pigs handled at this facility are "Farm Fresh"? _____ %

Comments:

Holding Area

Do pigs have free access to water? Yes ☐ No ☐

Do pigs have access to feed? Yes ☐ No ☐ Variable ☐

If variable what percentage have free access to feed at any one time? _____ %

Size of holding pens _____ m x _____ m Capacity _____ hd.

_____ m x _____ m Capacity _____ hd.

_____ m x _____ m Capacity _____ hd.

Construction type: Floor: Wood ☐ Cement ☐ Other _____

Slatted ☐ Solid ☐

Sides: Wood ☐ Metal ☐ Cement ☐

Other _____

Open sided ☐ Solid sided ☐ Rail ☐

Height of sides: _____ m

Comments:

Loading Area

How many days a week do you load pigs onto semi-trucks?

Out of barns: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ Variable: _____

At farms: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ Variable: _____

Number of receiving docks: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐

Number of load-out ramps: 1 ☐ 2 ☐ 3 ☐ 4 ☐

Which direction do load-out docks face? _____: _____: _____:

On average which way does the wind blow? _____

Is load-out dock protected? Yes ☐ No ☐

If yes, is load-out dock: Covered ☐ Siding ☐ Other ☐

Is load-out dock curved or straight? Curved ☐ Straight ☐

Load-out dock 1 Construction type:

Is load-out dock 1: Movable (up & down) ☐ Stationary ☐

Base (frame): Wood ☐ Metal ☐ Cement ☐ Other _____

Height at front edge: _____ m.

Width: _____ m.

Length: _____ m.

Angle: _____° Variable ☐

Sides: Wood ☐ Metal ☐ Cement ☐ Other _____

Solid ☐ Slatted ☐ Rail ☐ Other _____

Height: _____ m.

Load-out dock floor: Metal ☐ Wood ☐ Cement ☐ Other _____

Floor design: Smooth ☐ Stair ☐ Grooved ☐ Other _____

Is bedding used on the load-out dock? Yes ☐ No ☐

If yes what type: Straw ☐ Shavings ☐ Sand ☐ Other ☐ _____

On average how long does it take to load and fill a semi-truck? _____ hrs. Range _____ hrs.

If you have more than 1 load-out dock, do you load more than one truck at a time?

Yes ☐ No ☐ Variable ☐

What type of movement enhancers are used during loading?

Hurdle ☐ Electric prodder ☐ Slapper ☐ whips ☐ Other ☐ _____

Comments:

See back page for additional Load-out docks

Shipping Pigs

What is the shortest distance traveled by pigs coming to this collection point:

_____ km ?

What is the longest distance traveled by pigs coming to this collection point:

_____ km?

On average, how many hours do pigs get shipped to packer from this facility?

In-state < 1 hr. ☐ 1-2 hr. ☐ 2-3 hr. ☐ 3-4 hr. ☐ 4-5 hr. ☐ > 6 hr. ☐

Out-of-State Range _____ hr.

Percentage of hogs transported out-of-state: _____ %

Who loads pigs on to semi-trucks?

Driver only: 20% ☐ 40% ☐ 60% ☐ > 80% ☐

Staff only: 20% ☐ 40% ☐ 60% ☐ > 80% ☐

Driver and Staff: 20% ☐ 40% ☐ 60% ☐ > 80% ☐

How well do semi-trucks match up to ramps: Gaps ☐ No gaps ☐

If gaps, approximate difference:

Width: 2 cm. ☐ 4 cm. ☐ 6 cm. ☐ > 8 cm ☐

Height: 2 cm ☐ 4 cm ☐ 6 cm ☐ > 8 cm ☐

Do you cover gaps during loading? Yes ☐ No ☐

What do you use to cover the gap during loading? _____

On average, how long are pigs housed at this facility before being shipped to packer?

< 6 hr. ☐ 12 hr. ☐ 18 hr. ☐ 24 hr. ☐ 30 hr. ☐ 36 hr. ☐

Longer: _____ Range: _____

On average how long do pigs sit in the truck before leaving this facility? ____hrs.

Is bedding used on the semi-truck?

Summer: Yes ☐ No ☐ Variable ☐

Winter: Yes ☐ No ☐ Variable ☐

If yes, bedding type: Summer: Straw ☐ Shavings ☐ Sand ☐

Winter: Straw ☐ Shavings ☐ Sand ☐

Comments: _____

Additional load-out docks and receiving docks Date: Code # C- _____

Load-out dock 2:

Is load-out dock 2: Movable (up & down) ☐ Stationary ☐

Base (frame): Wood ☐ Metal ☐ Cement ☐ Other _____

Height at front edge: _____ m.

Width: _____ m.

Length: _____ m.

Angle: _____° Variable ☐

Sides: Wood ☐ Metal ☐ Cement ☐ Other _____

Solid ☐ Slatted ☐ Rail ☐ Other _____

Height: _____ m.

Load-out dock floor: Metal ☐ Wood ☐ Cement ☐ Other _____

Floor design: Smooth ☐ Stair ☐ Grooved ☐ Other _____

Comments:

Load-out dock 3

Construction type:

Base (frame) : Wood ☐ Metal ☐ Cement ☐ Other _____

Height at front edge: _____ m.

Width: _____ m.

Length: _____ m.

Angle: _____° Variable ☐

Sides: Wood ☐ Metal ☐ Cement ☐ Other _____

Solid ☐ Slatted ☐ Rail ☐ Other _____

Height: _____ m.

Load-out dock floor: Metal ☐ Wood ☐ Cement ☐ Other _____

Floor design: Smooth ☐ Stair ☐ Grooved ☐ Other _____

Comments:

APPENDIX B

APPENDIX B

Video Analysis Worksheet

Collection Point: _____

Date Analyzed: _____

Time: _____

Width of Ramp _____

Length of Ramp _____

Angle of Ramp _____

of Pigs Loaded _____

of Groups Observed _____

Time taken to Load _____

Number of People Loading _____

APPENDIX C

APPENDIX C

Table A.1 Complete Collection Point Study Results

Collection point ID	<u>CP 1</u>	<u>CP 2</u>	<u>CP 3</u>	<u>CP 4</u>	<u>CP 5</u>	<u>CP 6</u>	<u>CP 7</u>	<u>CP 8</u>	<u>CP 9</u>	<u>CP 10</u>
Date	1/23/97	2/4/97	2/10/97	2/11/97	2/12/97	2/13/97	2/14/97	2/18/97	2/19/97	3/11/97
Video	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
# of Pigs received	1100	1500	1700	1,000	200	1500	1000	1300	2500	2350
Ave. group size	50	35	40	25	12-25	45-50	50	10-40	1-80	20
% Confined	10	90	85	80	30	50	65	95	60	> 45
<u>Holding Area</u>										
feed & water ?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pigs housed (hrs)	18	6-18	16-72	18	18	6-12	12	12-18	18-20	6-24
<u>Loading Area</u>										
Load out of barns	6	5	6	6	1	6	5	6	5	1-6
Load out at farms	2	6	<1	1	0	5	2-3	6	2	4-6
# of receiving docks	4	3	5	3	3	4	3	4	5	5
# of Load-out docks	2	2	2	2	2	2	1	3	1	2
Direction dock faces	South	East	North	West	South	South	East	South	West	South
Dock protected	No	No	No	No	No	Yes	No	No	No	No
Straight or Curved	Straight	Straight	Straight	Straight	Straight	Straight	Straight	Straight	Straight	Straight

Table A.1 (cont'd)

Collection point ID	CP 1	CP 2	CP 3	CP 4	CP 5	CP 6	CP 7	CP 8	CP 9	CP 10
Construction										
Primary Dock	Move	Move	Move	Move	a ¹	Move	Move	Move	a	Move
Base Material	Cement	b ²	Wood	Wood	Cement	Wood	Wood	Wood	Metal	Wood
front edge (m)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Width (m)	2.5	0.75	0.68	0.65	1.70	0.60	0.75	0.65	1.0	0.68
Length (m)	6.1	9.0	12.2	9.8	5.0	6.6	6.7	9.3	10.4	4.9
Angle (degrees)	11.4	15	9.6	15	11.2	23.5	0	0	18.5	12.4
Sides	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Metal	Wood
Design	Solid	Solid	Solid	Slatted	Slatted	Solid	Solid	Solid	Solid	Solid
Height (m)	2.4	2.4	2.4	2.4	1.5	2.4	2.4	2.4	1.3	1.5
Load-out dock floor	Metal	Cement	Wood	Wood	Cement	Wood	Wood	Wood	Metal	Wood
Floor design	Stair	Grooved	Stair	Stair	Grooved	Stair	Stair	Stair	Stair	Stair
Bedding on floor ?	No	Yes	No	No	Yes	Yes	No	No	No	No
Bedding type		Sawdust			Sawdust	Sawdust				
Ave. loading time	3/4 hr	1 hr	1 hr	1 hr	1 hr	3/4 hr	1-1/2 hr	3/4 hr	1 hr	3/4 hr
More than 1 semi	No	No	Yes	No	No	Yes	No	Yes	Yes	Yes
Movement enhancer	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod	Prod
	Whip	Whip	Whip	Whip	Whip	Whip	Whip	Whip	Whip	Whip
Trailer-to-docks										
Gaps	Yes	No	Yes	Yes	No	No	No	No	No	No

¹ Indicates a stationary (non-movable) type dock

² Indicates this dock is a wood-cement combination

Table A.1 (cont'd)

Collection point ID	<u>CP 1</u>	<u>CP 2</u>	<u>CP 3</u>	<u>CP 4</u>	<u>CP 5</u>	<u>CP 6</u>	<u>CP 7</u>	<u>CP 8</u>	<u>CP 9</u>	<u>CP 10</u>
Gap width (cm)	5.1		10.2	< 5.1						
Gap covered with?	c ³		c	c						
Who loads the pigs	Staff 40	d ⁴	d	d	d	d	d	d	d	d
<u>Shipping Pigs</u>										
To facility (miles)										
Shortest distance	0.5	1	0.5	1.5	6	5	3	0.25	5	4.5
Longest distance	150	70	360	60	60	60	45	120	50	100
<u>Instate Packer hrs</u>										
Out-of-state (hrs)	3-4	1-2	2-3	1-2	2-3	2-3	2-3	3-4		2-3
% go out-of-state	20	> 12	13	9-13	7	6	7	7	9-12	6
Pigs sit on truck (min)	10	14	40	20	65	30	50	25	< 5	15
Bedding on truck		15	< 30	10	5	5	5	5	30	10
Summer	Yes	Yes	Variable	Yes	No	Variable	No	No Data	No	No
Type	Straw	Sawdust		Sawdust						
Winter	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No data	Yes	Yes
Type	Straw	Straw	Sawdust	Straw	Sawdust	Straw	Sawdust	No data	Straw	Straw

³ Indicates that gap is covered with metal plate

⁴ Indicates the truck driver load pigs greater than 80 % of the time

Table A.1 (cont'd)

Collection point ID	<u>CP 1</u>	<u>CP 2</u>	<u>CP 3</u>	<u>CP 4</u>	<u>CP 5</u>	<u>CP 6</u>	<u>CP 7</u>	<u>CP 8</u>	<u>CP 9</u>	<u>CP 10</u>
Additional Docks										
Secondary Dock	a	a	a	e ⁵	Move	a	e	a	e	a
Base (frame) material	Cement	Cement	Cement	e	Wood	Cement	e	Wood	e	Cement
Height front edge (m)	1.2	1.2	1.2	e	1.2	1.2	e	1.2	e	1.2
Width (m)	2.5	2.3	2.0	e	0.65	0.65	e	2.2	e	1.95
Length (m)	6.1	7.2	7.4	e	4.5	6.6	e	12.6	e	4.9
Angle (degrees)	11.4	24.2	9.6	e	15	23.5	e	11.5	e	14.1
Sides	Wood	Wood	Wood	e	Wood	Wood	e	Wood	e	Wood
Design	Solid	Solid	Solid	e	Solid	Solid	e	Solid	e	Open
Height (m)	2.4	1.1	1.5	e	1.2	2.1	e	1.3	e	1.2
Load-out dock floor	Wood	Cement	Cement	e	Wood	Wood	e	Cement	e	Cement
Floor design	Stair	Groove	Groove	e	Stair	Stair	e	Groove	e	Groove

⁵ No data on loading dock

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