TECHNIQUES FOR EVALUATION AND QUANTIFICATION
OF PIG REPRODUCTIVE, INGESTIVE,
AND SOCIAL BEHAVIORS1,2

John J. McGlone
Texas Tech University3, Lubbock 79409-2141

ABSTRACT

A literature survey was conducted to find papers that reported pig behavior during the period 1987 to June 1990. A total of 171 papers reporting measures of pig behavior was identified. Investigators used either descriptions of behavior or they quantified behavior. Behavior was quantified by recording frequency, durations, sequences, or bouts of behavior. Sexual behavior was often recorded as an all-or-none event (e.g., they were bred or not). Feeding behavior was studied by either weighing feeders often or by operant techniques. Operant feeding devices were commonly used to study pig feeding and drinking behaviors. Social behavior was studied either as interactions among established groups or when pigs fought after grouping. In either case, behavioral frequencies or durations were often reported. A large number of papers documented studies of maternal-neonatal interactions, teat orders, and animal care issues. Only a few studies reported mechanisms controlling pig behavior. Because few studies investigated behavior-genetics or physiological mechanisms controlling pig behavior, these areas of investigation hold great opportunity for future improvements in pork production.

Key Words: Behavior, Sexual Behavior, Ingestion, Social Behavior, Pigs


Introduction

Most animal scientists have made at least casual observations of farm animal behavior. Those of us who study farm animal behavior ponder the small number of animal scientists that have specialized in behavior. Perhaps some scientists believe behavior is a less quantitative science than traditional disciplines. The truth is, ethological studies enjoy being either purely descriptive, precisely quantita-tive, or a blend of qualitative and quantitative in nature. When behavioral techniques are properly applied, these techniques are more precise and more accurate than many techniques employed in other disciplines of animal biology (Arnold-Meeks and McGlone, 1986).

Studies of applied animal science have suffered recently from a perceived lack of depth. Animal scientists are critical of people who simply measure average daily gain and feed efficiency. Today, the animal industries and animal scientists demand more depth in evaluation of housing systems and genotypes. The newer disciplines of immunology and ergonomics, among others, have joined studies of animal behavior in fulfilling our objective of a complete understanding of environments, genotypes, and their interactions.

All aspects of animal productivity hinge on the animal’s behavior. To gain weight is to express feeding behavior. To deliver offspring is to express sexual and periparturient behav-
ior. However, the very behaviors that cause the desired effects are often overlooked in the search for how much weight was gained and how many offspring were produced. Even as mechanisms controlling growth and reproduction are sought, scientists tend to examine the physiology and ignore the crucial behaviors. Behavior is clearly the necessary middle step.

Scope of Review

This review began with a gathering of research literature during the period from 1987 through June of 1990. The last 3.5 yr seemed a long enough period in which to sample current behavioral techniques. For each major category of behavior, a summary of the common techniques is given. Then, a brief sample of papers in each category is described. In this way, the reader can see the types of techniques in use and can gain a basic understanding of the literature before undertaking behavioral studies.

The Agricola data base of the National Agricultural Library (Washington, DC) was used to initiate the search. Key words pertaining to the species (pig and related words) and the discipline (behavior and related words) were used to identify papers. Agricola identified a total of 388 papers. Of course, some were not actually on the subject of pig behavior and other papers on the subject were not identified. Next, the major journals known to contain papers on pig behavior were examined for relevant titles. When this was completed, the bibliographic section was examined from each paper to see whether other entries could be identified.

Summarized in Table 1 is the number of papers in each category. At the completion of the literature review, 171 papers were identified on the subject of pig behavior (a complete citation list is available from the author). Papers were identified in the five general categories of behavioral systems: sexual, ingestive, social, maternal-neonatal, and other. Maternal-neonatal behaviors were separated from the remaining categories because many of these behaviors cross behavioral systems. A notable example is studies of teat order/nursing, which fall in both feeding and social behavior categories.

Within each behavioral system, papers were grouped into either studies directed at mechanisms underlying behavior or management factors that cause or influence behavior. Mechanistic papers were of two general types: physiological mechanisms or detailed descriptions of behavior. Detailed descriptions of behavior give us an indication of the neural connections organizing complex behaviors.

Examination of the papers labeled mechanistic revealed few papers dealing with physiological control of pig behavior. Some basic physiological objectives were found among ingestive and reproductive behaviors, but none were found for social behaviors. Even for feeding and sexual behaviors, a great deal more work is underway using rodents than pigs. Thus, great opportunity exists for studies designed to understand physiological causes of economically important behaviors.

General Behavioral Techniques

Several valuable sources are recommended reading for anyone about to begin studies of pig behavior. These references apply to the study of behavior of any species. Among required reading are books by Lehner (1979) and Martin and Bateson (1986). Sequential analysis is a more detailed type of data.
summary and analysis technique. A person interested in summarizing sequences of behavior might start by reviewing the book by Bakeman and Gottman (1986).

Sampling techniques, primarily for field studies, were reviewed by Altmann (1974). Many of the principles reviewed by Altmann are also applicable to the laboratory and the farm. What is not covered very well in texts and reviews is the use of time-lapse video equipment and electronic data collection equipment.

Most electronic or photographic recordings of animals behaving are not as clear as observing the live animal. However, by varying recording and playback speed, one can see behaviors that otherwise would go unnoticed. Any behavior that happens very briefly (such as a pig ear bite) can be better observed in slow motion. If pigs show slow, gradual changes in posture, this is more obvious when the tape is observed at a high speed.

Electronic or photographic recording of animal behavior can be made in time lapse or in slow motion. Time lapse refers to recording at a slower speed (for example, one frame per second rather than the more typical 30 frames per second). Tapes recorded in time lapse can be easily replayed at a faster speed (thus collapsing time). Scientists can use time sampling with time-lapse video equipment to summarize 24 h of certain pig behaviors in less than 3 h. Thus, by collapsing time we gain a more complete understanding of treatment effects on diurnal cycles of behavior than if we spent the same amount of time observing animals in person. The primary advantage of time-lapse video equipment is that it saves time.

Behaviors that last longer than 1 or 2 s are the best candidates for time-lapse recording and playback. Feeding and lying/standing and some agonistic behaviors are good examples of behaviors that last more than a few seconds. When a behavior such as feeding is viewed at a faster playback speed than the speed at which it was recorded, little precision is lost. As a general rule, major behaviors can be played back up to 10 times faster than real time without loss of accuracy or precision (Arnold-Meeks and McGlone, 1986). Behaviors with a short duration (such as drinking) are best viewed at a playback speed that does not exceed four times the speed of real-time playback.

Slow motion refers to playing back a tape or film at a speed much slower than that at which it was recorded. For example, if one recorded animals on video at 30 frames per second and played back the tape at 10 frames per second, the animals would be viewed in slow motion. The faster the original recording speed, the more clear the picture is when it is played back in slow motion. To obtain very clear pictures in slow motion, film is typically recorded at 100 frames per second or more.

Reproductive Behavior

The category of reproductive behavior is unique among major behavioral systems because three main subdivisions were identified: mechanisms, puberty, and management factors. When scientists study factors that hasten or delay the onset of puberty, the distinction between management factor and mechanism is less clear.

In the simplest form, reproductive behavior studies involve simply counting the number of mounts, pelvic thrusts, intromission, ejaculation, and dismount events. Duration of activities are at times recorded. Measuring frequency and duration of courtship behaviors is uncommon but could be interesting. Reproductive success is measured by pregnancy, delivery, and weaning of offspring.

Techniques to measure onset of puberty involve identifying whether and at what age gilts show the typical standing response. Either intact boars or humans applying back pressure are used as inducers of lordosis. Most often this measure of sexual behavior is recorded as an all-or-none response. Only rarely do scientists attempt to record more detailed catalogs of behavior shown by peripuberal females (or males for that matter).

Mechanisms

As with most other behavioral systems, few studies were identified that sought to better understand physiological mechanisms controlling reproductive behavior. Studies of hormonal control of sexual development were conducted in Nebraska and France (e.g., Levis and Ford, 1989; Signoret et al., 1989). The
typical paradigm is to apply hormones, especially steroid hormones, to castrated males. Sexual behavior is then measured in test situations. For studies of male sexual behavior, hormone-treated barrows are typically evaluated with estrous or pseudo-estrus (hormonally primed) gilts. Female sexual behaviors (measured as lordosis or standing responses) have been evaluated in the context of defeminizing hormonal treatments (e.g., Ford and Christenson, 1987).

Missouri scientists have begun an interesting investigation of the role of intrauterine position on growth and sexual development (Rohde Parfet et al., 1990). These investigations are based on studies in vom Saal’s laboratory using rodents. Vom Saal’s group has reported apparent endocrine and morphological effects resulting from the adjacency in utero of fetuses of the opposite sex (vom Saal, 1981). Intrauterine position had less striking effects in pigs than in rodents. The pig work reported to date has not emphasized effects of intrauterine position on behavior, however.

A detailed description of sexual behavior and sequences of behavior was recently published by Japanese scientists (Tanida et al., 1989). The sequential analysis of pig sexual behavior deserves greater study, particularly in evaluating management factors that may improve mating efficiencies (time to mate, sperm output, number of copulations, and conception rates).

T-maze preference tests have been conducted to evaluate preferences for sexual partners. Pearce and Hughes (1987) showed that sows are attracted to aromatic androgens produced by the boar’s submaxillary salivary glands. In contrast to an earlier classic study reported by Signoret (1970), which found that boars cannot detect estrous sows by olfaction, McGlone and Morrow (1987) showed that some individual boars have the ability to identify estrous sows in a T-maze paradigm.

**Management Factors**

Many of the papers dealing with puberty onset would fit as easily in this category. However, this section contains all management papers dealing with sexual behavior from 1987 to 1990 that did not deal with onset of puberty. Papers in this section dealt primarily with nutritional and housing effects on expression of estrus and on conception rates. As such, few papers report detailed measures of behavior. Several papers reported attempts to induce lactational estrus in sows by such procedures as litter separation, split weaning, or group sow housing (Newton et al., 1987; Gilbertson et al., 1989; Henderson and Stolba, 1989).

Again in contrast to the work of Paterson and Pearce (1989), other Australian scientists found that rough handling of sows by herdsmen caused lower reproductive performance (Hemsworth et al., 1989). Taken together, the Australian work leads to the recommendation to handle gilts roughly to hasten estrus onset but to handle sows and boars gently to improve reproductive performance.

One area of research that has been sorely lacking is the study of genetic influences on sexual behavior. Genetic variation in sexual behavior is expected, just as variation in other behaviors have been identified in other species. One report of genotype interactions with environments in measures of reproductive performance lends support to this hypothesis (Jungst et al., 1988).
Ingestive Behavior

One way to improve weight gain and efficiency of conversion of feed to animal tissue is to get pigs to eat more feed. This can be approached in two general ways: enhance feed intake or remove whatever inhibitory mechanisms are in place. To fully understand feeding behavior, we must understand what controls water intake, because feed and water intake go hand-in-hand (thus the title ingestive behavior).

Ingestive behavior is difficult to study because, unlike copulation, feeding and drinking are repeating off-and-on behaviors (rather than all-or-none). To completely understand ingestive behavior, we must understand meal sizes, numbers of meals, and total nutrient intake.

Sophisticated computerized recording systems have been developed but are not in widespread use. Rather, people use one of two general techniques: 1) weigh or volumetrically measure feeders and water containers often, or 2) use operant techniques. On occasion, papers are published with measures obtained solely from behavioral observations. In this case, the measure is “head in feeder.” The observer actually has no idea whether the pig is eating or hiding (see McGlone and Curtis, 1985); thus, such behavioral observations should be viewed only as a first approximation of ingestive behavior.

To make use of nutrient container weighing, the container must be weighed or measured either frequently or before and after each meal of feed or water (see Feddes et al., 1989, who measured feeder weight each 4 min). This is time-consuming and accounting for feed or water waste is a cause of experimental error.

The alternative technique is to use operant feed and water delivery systems. Used properly, nutrients are delivered in very small amounts by the pig operating a simple device like a paddle switch. Usually, the pig must press the paddle several times to obtain a small amount of feed or water, which is then consumed readily (pigs are less likely to waste feed they work hard for). Eighty percent of the papers in this category used operant techniques to study ingestive behavior.

Operant methodology has been evaluated (Lawrence et al., 1988; Lawrence and Illius, 1989) and put in place in many laboratories.

Pigs will work quite hard to obtain food in an operant setting. When fed diets with a low energy density, pigs pressed hundreds (even thousands) of times per hour to obtain a food reward (Lawrence et al., 1989). The operant techniques have been applied to pig drinking mechanisms as well (see, for example, Houpt and Anderson, 1990).

Mechanisms

Two studies reported direct manipulation of brain tissue (in this case by use of a ventricular cannula) to study brain mechanisms controlling feed and water intake (Thornton et al., 1987; Parrot, 1990). Because the brain controls all behavior, these two studies stand alone among the papers we gathered in touching the surface of a critical area of research into mechanisms controlling pig behavior. Genetic variation in ingestive behavior was not reported.

Management Factors

None of the papers in this category used operant techniques to measure feed or water intake. All papers recorded either apparent feeding behavior or decrease in feeder or water container volume (or weight). Most studies in this category were descriptive in nature. For example, they described how a housing system or diet composition or management procedure (light, sow grunts, or other procedures) caused apparent changes in feed and(or) water consumption. No management factors were identified that could stimulate feed or water intake.

Social Behavior

Most studies of pig social behavior examined agonistic behaviors. Other types of social behaviors studied in this period include the following: tail biting, pig savaging by sows, and studies of nonagonistic social behaviors.

Techniques include either live observation or video-taped recordings. Often pigs are grouped and engage in an agonistic encounter. Frequency and(or) duration of behaviors are then recorded. On occasion, sequences of behavior are noted (see, for example, Blackshaw and Hagelso, 1990). Techniques to study agonistic behavior were reviewed earlier (McGlone, 1986).
EVALUATION OF PIG BEHAVIOR

Mechanisms

Papers in this category did not include investigations into the physiological causes of aggression, submission, or other types of social behaviors. Most studies in this category measured causes of varying levels of pig agonistic behavior such as body weight variation or fighting strategies. One study reported genetic variation in sows’ aggression toward their pigs (van der Steen et al., 1988). Different half-sib analyses showed heritability estimates of .11 and .25, which indicated that selection against sow savaging of pigs may be slow but effective. This work is best described as quasi-behavioral because actual behavioral observations were not made. Pigs were observed for signs of biting injury by the sow. Sows were not observed savaging pigs, but the primary measure was an all-or-none indication of savaging or not.

A new technique for the study of tail biting was developed by Fraser. Canvas or cotton-cord models of tails were soaked in blood and other fluids and hung among pigs (Fraser, 1987a). Using this technique, nutritional and management treatments can be evaluated (Fraser, 1987b). The soaked-cloth model provides a less painful method of evaluating causes of tail biting. However, findings using the tail-model method would eventually need to be confirmed in a live intact-tail pig model.

Pheromonal cues that modulate pig agonistic behavior have been evaluated (McGlone et al., 1987). This more basic work led to identification of aggression-reducing odorous compounds (described below).

Management Factors

Two general types of papers were identified in this category: compounds that reduce aggressive behavior and housing systems that influence social behaviors.

Three compounds were studied in efforts to reduce social stress in newly grouped pigs. Amperozide and Azaperone are brain-active drugs that reduce pig aggressive attack. Amperozide reduced pig aggression and injury severity (Gonyou et al., 1988), but amperozide did not cause sedation (Björk et al., 1988). Azaperone was thought to reduce fighting by sedating pigs (Gonyou et al., 1988).

Androstenone (5α-androst-16-en-3-one) is one of the compounds present in boar secretions. When sprayed in the air on or near prepuberal pigs, androstenone (as little as 5 μg) reduced pig agonistic behavior (McGlone and Morrow, 1988). Of the three compounds injected or sprayed to reduce fighting, only azaperone is available commercially in the United States.

Many papers in this category examined effects of housing systems on some aspects of pig social behavior. Some work is emerging on sow social interactions in computerized feeding systems (Hunter et al., 1988). Important work related to how individually housed sows interact socially has been reported by Australian scientists (Barnett et al., 1987, 1989a,b). Open partitions between adjacent sows increase sow aggression. Stall partition dividers can be constructed to minimize this social contact and apparent social stress.

Maternal and Neonatal Behavior

A wide range of behaviors are found in this category. Maternal behavior includes periparturient behaviors including shelter seeking and nest building, actual parturition, and early maternal-neonatal bonding. To investigate these behaviors, observers record frequency and durations of sow and pig behaviors. Sow-pig interactions require special attention, particularly if sequences of interaction are to be understood (Bakeman and Gottman, 1986). As with other ingestive behaviors, bouts of nursing activity are typically measured. A special case of social behavior is the study of teat orders. The teat order is thought to be a type of social order. Agonistic behaviors are common during the neonatal period.

Mechanisms

Three types of papers were identified in this category. Papers dealing with nipple attachment and teat seeking behavior have emerged and will lead to a better understanding of causes of pig mortality (Rohde and Gonyou, 1987; Morrow-Tesch and McGlone, 1990).

The second category within maternal mechanisms deals with periparturient behavior of sows. Behaviors found around the time of parturition need to be understood if important
welfare concerns are to be addressed. The literature now contains reports of sow periparturient behavior in free-range and confined settings (Jensen et al., 1987; Heck et al., 1988; Widowski and Curtis, 1989; Petersen et al., 1990). Sows seem to be remarkably adaptable. They show a range of "normal" farrowing behaviors regardless of whether they are in confinement or in a free-range setting. The consequence of not having nesting materials or an environment in which a nest can be made is the focus of important welfare concerns.

The third category in maternal-neonatal behavior is studies that examine nursing and teat orders. Some studies were largely descriptive (e.g., Castrén et al., 1989a,b). Castrén and workers have shown that unsuccessful nursings are common, even in seminatural environments, and therefore should not be viewed as a symptom of a poor housing system when they are found among confined sows and litters.

**Management Factors**

Papers in this category primarily deal with ways in which housing systems influence nursing behavior. Nursing bouts and standing/lying behaviors are commonly recorded when sows are in newly designed systems (Fraser et al., 1988; McGlone and Morrow-Tesch, 1990). A computerized system was reported to alert pork producers when the sow is farrowing (Erez and Hartsock, 1990). This system of data acquisition could be used to study periparturient behavior of sows as well as other behaviors.

**Other Behavioral Systems**

This category contained a variety of papers on different subjects. Studies were reported that dealt with behavior when any of the following treatments were examined: space, handling, transport, thermal variations, ergonomics, pen design, and walking postures. A large number of studies asked questions of interest to pig welfare.

Two interesting behavior-genetic studies were reported. Hemsworth et al. (1990) calculated heritability estimates of .38 ± .19 among gilts for the trait "fear of humans." Thus, gilts could be bred to be less fearful of humans. This paper is an excellent example of combining traditional genetic analysis with investigations of human-animal interactions. The work also has important economic and welfare implications.

An investigation of wild and domestic pigs' behavior was reported by Robert et al. (1987). They found that wild pigs generally behave similarly to domestic pigs. Wild pigs were more active than domestic pigs, but social, ingestive, and exploratory behaviors were similar. This leads to the speculation that domestication has not greatly changed maintenance behaviors of pigs.

**Implications**

Readers of this paper should be able to gain a basic understanding of the scientific literature on pig behavior from this review. Techniques to study pig behavior can be either descriptive or highly quantified. Behavior itself is highly variable, but accuracy and precision to measure behavior are very high as well. Great opportunity is evident for studies of behavior-genetics and physiological mechanisms controlling pig behavior.

**Literature Cited**


Blackshaw, J. K. and A. M. Hagenlo. 1990. Getting-up and lying-down behaviours of loose-housed sows and


