Toward a better understanding of pig behavior and pig welfare

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Abstract

Pork production began to flourish in the USA after the practice of finishing pigs on corn was popularized in the late 1600s. By the 1840s, there were 35 million pigs and 20 million people in the USA and Cincinnati was the world’s largest pork market. Between 1890 and the present, the total number of pigs in the USA has remained at 50–60 million, but dramatic changes in swine husbandry over the course of the 20th century have metamorphosed pig production from small, extensive (outdoor), labor-dependent enterprises into large, intensive (indoor), capital-dependent, production systems. This development has led to debate concerning the impact of swine production on animal/human health, the environment, and the welfare of the animals under our care. In a very tangible way, the future of pork production depends on effectively addressing the public’s concerns regarding animal welfare and health. Here, we review basic sensory and behavioral aspects of swine with the objective of reaching a better understanding of pig behavior and pig welfare. The premise of this discussion is that safeguarding animal welfare and health is good for pigs, pork producers and the animal-conscious public.

Keywords: Pig behavior, Pig welfare, Pig production, Senses, Instincts

Introduction

The domestication of *Sus scrofa* may have occurred as early as 10,000 B.C. in Southeast Asia (Lekagul and McNeely, 1977). Pig production was common in early agricultural societies; perhaps because pigs are highly resilient, mature quickly, have large litters and are able to sustain themselves on low-quality feedstuffs. Pigs were introduced into North America by many of the early explorers and settlers, but pork production began to flourish in the USA after the practice of finishing pigs on corn became established in the late 1600s (McGlone and Pond, 2003). This practice was so successful that, by 1847, there were nearly twice as many pigs as people in the USA (35 million pigs versus 20 million people) and Cincinnati was the largest pork market in the world (USDA, 1981). For most of the period after 1850, but particularly between 1890 and the present, the total number of pigs in the USA has remained between 50 and 60 million animals (USDA, 2008). But beginning about 1900 in the USA, and more recently in other parts of the world, the total number of swine farms has been declining, resulting in fewer farms with more pigs per farm (USDA, 2008).

Initial provisions for housing swine were rudimentary, as reflected in Spencer’s (1919) comment that: ‘The ordinary sty with a yard attached is unhealthy for a growing or matured pig, but in the colder weather it is simply cruel for newly born pigs’. An evolution in swine housing occurred concurrently with the decline in the number of producers in the 20th century. Experiments in the early 1900s led Danish agriculturalists to conclude that housing swine indoors (‘intensive’ production) provided for more efficient use of available land, protected animals from weather, eliminated fighting and improved feed efficiency (Shaw, 1938). Spencer (1919) marveled at the two-story barn he observed near Aarhus, Denmark in which the pigs were fed downstairs and slept upstairs, which they reached by walking up a ramp. Shaw (1938) made the crucial comment that removal of manure ‘at least daily’ was required to maintain sanitation under confinement conditions – a reflection of the abundant farm labor
available at the time! The trend toward the production of swine in intensive systems greatly accelerated after 1980 and has resulted in sophisticated, highly engineered, capital-intense facilities designed to reduce manual labor and increase efficiency.

Concomitant with the 20th century’s remarkable changes in swine husbandry were equally dramatic changes in human demographics. World population more than tripled during this period as the 1.65 billion people present in 1900 swelled to 6 billion by the year 2000 (Gelbard et al., 1999). Simultaneously, a vast migration occurred as people left the farms, moved into the cities and found new means of livelihood. The 41% of the US labor force employed in agriculture in 1900 declined to 16% in 1945 and just 1.9% in 2000 (Dikitri et al., 2005). As a result of the increase in world population, and as per capita incomes rise in developing countries, there is increased demand for animal protein. By 2019, it is estimated that the demand for pork, and thus the need for raising pigs, will increase by approximately 24% over the base period of 2007–2009, primarily as a result of increased demand in developing countries (OECD/FAO, 2010).

In the midst of the dramatic and dynamic agricultural and demographic changes we are witnessing, it is important for those of us responsible for animal welfare and health to pause and reflect. It is essential that we continue to assess, scrutinize and strive to improve the welfare of pigs in modern production systems, even as the industry evolves and new health challenges arise. To this end, this paper reviews basic sensory and behavioral aspects of swine with the objective of establishing a better understanding of pig behavior and issues in pig welfare.

**Sense of sight**

The pig’s eyes are deeply placed and may appear small, especially in over-conditioned adults. The eye has a diameter of approximately 24 mm. The overall ocular power of the pig’s eye has been calculated as 78 diopters (Coile et al., 1977), thus, a panoramic view of their surroundings. The radiation wavelengths to which pigs are maximally sensitive are slightly lower than those for humans. Within the range of 465–680 nm, pigs can distinguish wavelength differences as small as 20 nm (Signoret et al., 1975). The retina contains a substantial population of two types of cones with sensitivity peaks at about 439 nm (indigo) and 556 nm (green–yellow) in the spectrum of visible light (Neitz and Jacobs, 1989). The pig is thus believed to have dichromatic color vision.

Pigs generally prefer lighted areas as opposed to darkness. For example, Tanida et al. (1996) found that piglets tended to move toward more brightly illuminated areas and recommended even, diffuse lighting to encourage movement into poorly illuminated areas. Likewise, Grandin (1982) noted that pigs tended to move toward more brightly lighted areas and suggested shining light into the interior space, rather than into the pigs’ ‘eyes, to direct and encourage their movement, e.g. into the unlighted interior of a truck to facilitate loading.

Pigs do respond to color, e.g. the change in the color of the handlers’ uniform (Hemsworth, 2007), but the presence of a particular photo pigment is a weak indicator of the information actually supplied by activation of this pigment. Tanida et al. (1991) concluded that pigs can identify ‘blue’, but suggested that pigs discriminated blue from other colors on the basis of hue rather than brightness and may be red–green color blind. In a study evaluating responses to water dispenser color, Stelios et al. (2006) reported that newborn pigs were not attracted to the green water dispenser and their behavioral reaction to red and blue was gender-driven. Females preferred the blue dispenser, visiting it more times than the males, while males preferred the red dispenser. Edge et al. (2004) found no significant effect of trough color (yellow, red, and black) on feed intake, average daily gain or feed conversion. Overall, it may be concluded that, although pigs have some ability to discriminate among colors, there is little information on the spectrum visible to pigs and even less on the impact of color on pig behavior.

**Sense of taste**

Pigs have taste papillae on the tongue, epiglottis and soft palate epithelia (Montavon and Lindstrand, 1991). Each papillae contains high numbers of garlic clove-shaped taste buds, with each taste bud composed of groups of 50 to 120 sensory cells, each of which projects a number of microvilli to the mucus layer of the tongue (Roura and Tedó, 2009). Taste buds are composed of at least four different types of cells; three taste-type cells (I, II and III) and one basal-type cell believed to be a progenitor of the other three. Type I cells are sour sensing, type II are sweet, umami and bitter sensing and type III cells play an intermediate signaling role between the true taste cells (types I and II) and the sensory neurons.

Kumar and Bate (2004) described five types of taste papillae in pigs: filiform, fungiform, foliate, vallate and conical. Filiform papillae have either sharp or blunt apical tips. Large numbers of densely packed sharp-tipped papillae are distributed throughout the tongue, except in the mid-raised area of the tongue, which is mainly covered with blunt tip papillae. Large, circular, fungiform papillae located on the lateral side of the tongue contain surface taste pores, but fungiform papillae on the dorsal surface of the tongue lack taste pores. Foliate papillae are located principally on the caudal third and lateral part of the tongue and are composed of four to five leaves and additional pseudopapillae. Two vallate papillae, found in the caudal third and dorsal area of the tongue, have well-defined vallum and pseudopapillae on their surface. Finally, two types of conical papillae are present at the
root of the tongue directed caudally in a shingle-like arrangement. The first type of conical papillae has a broad base and a tapering pedicle-like apex, whereas the second type of conical papillae is cone shaped and displays a blunt apex.

All papillae, except for the filiform, have taste buds on their surface. In particular, the fungiform and vallate papillae are involved in taste (Ojima, 2001), whereas the filiform papillae and conical papillae play a role in the mechanical transport of food and liquid toward the pharynx (Ojima et al., 1997). Taste information from the fungi-form taste buds is conveyed in the chord tympani nerve and from the foliate and vallate taste buds through the glossopharyngeal nerve (Hellekant and Danilova, 1999).

Food preference, among other factors, reflects the taste sensation that results from flavor–taste papilla interaction. Recordings of impulses in these nerves have been used to assess a species’ ability to taste (Hellekant and Danilova, 1999). In humans, the sense of taste differentiates between the taste qualities of sour, salty, sweet and bitter. It is not possible to know whether the gustatory sensations of animals are equivalent to the tastes humans’ experience. More likely, each animal species has its own sensory spectrum. Furthermore, individuals within the species have preferences – even cloned pigs respond differently to taste (Archer et al., 2003).

A number of studies have examined porcine flavor preferences. McLaughlin et al. (1983) investigated flavor additives in 248 trials conducted to determine preferences among 129 flavors and found that sweet, meaty and cheese were the most preferred flavors. Pigs rejected foods that taste bitter to humans (Nelson and Sanregret, 1997). Plant extracts and pharmaceutical compounds produced aversion behaviors in pigs, some of which were found to be dose dependent. Many studies have reported a preference for a sweet taste (Jacela et al., 2010) and, for this reason, sweet flavoring agents have been used for creating interest in solid food in weanling pigs (Forbes, 1995). Kare et al. (1965) examined the taste preferences of young pigs to sucrose, glucose and lactose using concentrations ranging from 5 to 40 g l⁻¹ and found that pigs preferred all three sugars to water, but sucrose was more attractive than glucose or lactose. Kennedy and Baldwin (1972) investigated the responses of pigs to 60 artificial sweetener compounds and found that 35 compounds were attractive to pigs, but less so in pigs than in humans. Lugulname and carrelame, the two most potent sweeteners in humans, were also the most readily accepted by pigs.

**Sense of smell**

Certainly the most celebrated anatomical feature of the pig is the snout, the movable disc at the tip of the muzzle (Sack, 1982). The snout incorporates the central part of the upper lip and is supported by the rostral bone – a structure unique to the pig (Dyce et al., 2010). Olfactory cells in the nasal epithelium convert incoming odor molecules into electrical signals, which are then transmitted via the olfactory nerve to the brain. In addition, the vomeronasal organ, located in the upper air passages, contains receptors that access the central nervous system through the accessory olfactory bulb.

The sense of smell develops early in pigs and is important for survival because piglets are very mobile from birth. They can and need to follow chemical cues learned early in life, e.g. the odor of their mother. Pigs use a wide range of olfactory cues in their natural behavior; e.g. piglets use olfactory cues for recognizing their dam and teat position; older pigs use olfactory information as the predominant basis for individual recognition (Curtis et al., 2001).

Pigs have a highly sensitive sense of smell. Sows, for example, were able to identify which of otherwise identical cards they had previously touched. That is, they were able to detect their odor on the cards after several hours and even after the cards were washed (Signoret et al., 1975). Feral pigs use their sense of smell in order to find food, detect potential predators or prey and mark territory. Odors related to eating are also important and can be used to increase the palatability of feeds. Thus, the smells of cod-liver oil, petrolatum, rancid fish meal and fish oil, vegetable oils or sour chicken were attractive when presented in baits for feral hogs (Fletcher et al., 1990).

The effect of odor on pig behavior or stress has not been clearly established. Morrow-Tesch and McGlone (1990) demonstrated that piglets preferred sow fecal odors and were not attracted to novel odors (e.g. the scent of orange and banana). In young or adult pigs, odor preference or aversion varied depending on the individual (Archer et al., 2003). Krebs (2007) evaluated the effect of aroma conditioning (‘aroma therapy’) on aggressive behavior in groups of weaned piglets by treating rooms with either maternal pheromone or amyl acetate, a scent similar to bananas and apples. Pigs exposed to either maternal pheromone or amyl acetate spent less time standing and more time lying down compared to control groups, but none of the treatments reduced serum cortisol.
levels. On the other hand, McGlone and Anderson (2002) demonstrated that the synthetic maternal pheromone decreased aggressive behavior and improved weight gain and feed efficiency. Non-maternal pheromones, such as androstenone and urine from actively fighting pigs also reduced aggression when sprayed in pens of newly weaned pigs (McGlone and Morrow 1988). In contrast, non-pheromonal compounds were not as efficient at reducing aggressive behavior as pheromones and had no effect on performance (Friend et al., 1983).

**Sense of hearing**

Pigs' ears are oval with a fairly wide base attached to the sides of the high caudal part of the head. The ears have a pointed tip and hang down over the face in some domestic breeds, but stand erect in others and in the wild *S. scrofa* (Dyce et al., 2010). Pigs' hearing range is similar to that of humans, but with a shift toward ultrasound. The frequency range for reasonable detection varies between 42 Hz and 40.5 kHz, with a region of best sensitivity from 250 Hz to 16 kHz (Heffner and Heffner, 1990). Spatial discrimination of the source of a sound depends on the difference in time it takes for the sound to reach each ear. Pigs have a sound localization threshold of approximately 4.6°. This is above the average sound localization threshold for mammals (12°), but below the threshold of 1.3° in humans (Heffner and Heffner, 1989). Pigs show an aversion to sudden loud noise, i.e. pigs tested in an open-field situation showed increased heart rate and retreated in response to loud noise (Talling et al., 1996). This response was stronger for a frequency of 8 kHz than for 500 Hz and for an intensity of 97 dB than for 85 dB, although habituation occurred relatively quickly (Talling et al., 1996).

The effect of music on behavior and/or welfare is largely under-investigated in pigs and the experiments conducted to date have produced conflicting results. One study in weaned piglets found that music had no effect on piglet vocalization during stressful events, e.g. castration and weaning (Cloutier et al., 2000). However, de Jonge et al. (2008) reported that music could facilitate play behavior in piglets post weaning if music had been presented pre-weaning as a contextual cue associated with access to a playroom. They also suggested that music elicited play behavior – a positive welfare indicator because play behavior occurs when major stressors are absent and the primary needs have been fulfilled.

**Pig behavior, welfare and health issues**

For both feral and domestic swine, stress is a routine part of life and occurs in the context of social dynamics (feeding, mating, aggressive interactions) and coping with the environment (heat, cold and novel environmental situations). Hessing et al. (1993) suggested that individual pig responses to stress can be quantified using the ‘back test’. In the back test, a pig is manually restrained on its back for one minute, during which time its escape behavior is recorded. Pigs that perform many escape attempts are considered ‘proactive’, whereas pigs that do not are referred to as ‘reactive’. According to Hessing et al. (1993), proactive pigs are also more aggressive in social interactions. When faced with non-social challenges, e.g. exposure to novel situations or objects, proactive individuals more quickly approach novel stimuli, but show more superficial exploratory behavior. In contrast, reactive individuals show higher initial levels of passive avoidance, but spend a longer time exploring after they gain familiarity. Thus, pigs show similar reactions to challenging events over time and across related situations, but demonstrate large variations in behavior among individuals (Lawrence et al., 1991; Forkman et al., 1995; Spooler et al., 1996).

In principle, welfare issues arise in pig production when there is a mismatch between a pig’s instincts and its environment. That is, behavioral impulses may be expressed inappropriately when instinctual behavior is thwarted. Feral pigs are normally active during the day and spend 75% of their active time in foraging-related activities, including rooting, grazing and exploring with their snout (Stolba and Wood-Gush, 1984). Domestic pigs in commercial production, while routinely supplied with the basic necessities (food, water and shelter), continue to express exploratory behaviors and preferentially select environments (pens) with novel objects to investigate (Van Putten and Dammers 1976; Wood-Gush and Vestergaard 1991). The typical porcine response to a novel object is chewing, but it is not certain whether chewing reflects feeding motivation, exploratory motivation or a combination of both (Day et al., 1995). This uncertainty is reflected in the literature, i.e. some authors conclude that chewing behavior is mediated by feeding motivation (Fraser, 1987) and others that chewing behavior reflects exploratory behavior (Van Putten and Dammers, 1976). Day et al. (1996) proposed that the initial exploratory chewing of a novel substrate may lead to nutritional feedback, which could modify subsequent foraging behavior.

The effect of environmental enrichment on the behavior, performance and welfare of growing pigs has been extensively researched. In general, these studies investigated the preferences of the pigs for a variety of objects and attempted to measure their effects on aggression, performance and productivity. Docking et al. (2008) noted that the age of the pigs should be taken into account when selecting enrichment objects because the pattern of use varies by pig age. That is, grower pigs (13 weeks) displayed a shorter latency to approach the novel objects compared to sucking piglets (3 weeks) and weaned pigs (5 weeks), while sucking piglets used the objects to a much lesser extent than either the weaned or grower pigs.
Studies of enrichment for pigs housed in indoor systems have focused on several types of ‘toys’, including objects such as tires, chains, rubber hoses or dog toys (Apple and Craig, 1992; Pearce and Paterson, 1993; Blackshaw et al., 1997; Hill et al., 1998). A number of studies have focused on the inherent properties of enrichment objects, e.g. ingestible, destructible, chewable and odorous (Feddes and Fraser, 1994; Van de Weerdt et al., 2005), and their presentation to the animals, e.g. suspended as opposed to being on the floor (Blackshaw et al., 1997). Feddes and Fraser (1994) concluded from their study of the stimulus features of non-nutritive chewing, that pigs used objects (cotton cords or rubber strips) more if they could alter the object by chewing. Zonderland et al. (2001) tested several characteristics of four materials (rope, wood, chain and metal pipe) in a more systematic fashion and concluded that the most preferred objects combined both ‘flexibility’ and ‘destructibility’, whereas the orientation of the object (‘horizontal’ or ‘vertical’) had no effect on preference. The novelty of an object is important for initiating exploration (Gifford et al., 2007) and has been reported to be intrinsically rewarding to pigs (Wood-Gush and Vestergaard, 1991). However, loss of ‘novelty’ occurs rapidly as pigs become habituated to objects (Apple and Craig, 1992; Van de Weerdt et al., 2003). Although there are less data regarding the question of how long a pig can remember a particular object, one way to renew novelty is by replacing familiar objects with new objects (Gifford et al., 2007).

Pigs’ natural tendency to chew objects in their environment can be misdirected at other pigs. Van Putten (1969) reported that ear and tails are the easiest targets, but ear-chewing is more likely to provoke an attack than tail biting. According to Van Putten (1969), the bitten animal reacts by waving its tail vigorously, but this further attracts bites by other pen-mates. Tail biting is a behavior and welfare problem that has been attributed to a complex of factors including crowding, lack of bedding, poor ventilation, uncomfortable temperatures, disease (Fraser, 1987), diet, e.g. low fiber, inadequate or poor-quality protein, excessive dietary energy and deficiencies or imbalances of minerals (Gadd, 1967; Ewbank, 1973). Van Putten (1969) argues that tail biting is actually misdirected behavior derived from quiet, low-intensity, chewing and rooting on pen-mates. Fraser (1987) developed a cotton rope tail model (rope soaked in pig blood) to measure pigs’ attraction to blood and its effect on their tendency to chew. Pigs showed a preference for the blood-flavored rope against the untreated rope, but the model was not balanced for color and, therefore, it was unclear whether the color of blood or the flavor of blood attracted pigs to chew. Jankevicius and Widowski (2003) studied tail models balanced for color and found that, regardless of color, pigs preferred to chew on tail models soaked in blood. This suggested that pigs used olfactory or taste cues, not color, to discriminate among choices.

Various strategies have been used for countering tail biting, including providing materials to allow natural biting, rooting and play behavior. Blackshaw et al. (1997) evaluated fixed toys hanging from the ceiling and free toys on the pen floor and found that neither affected relative growth rate, but both affected pig behavior by reducing aggressive behavior (tail biting, fighting, etc.). On the other hand, some studies report that the presence of enrichment objects can lead to agonistic behaviors (Van de Weerdt et al., 2006; Day et al., 2008), perhaps resulting from increased competition because of spatially limited access to a particular object (Docking et al., 2008).

Enrichment strategies, such as providing objects suitable for chewing and rooting, may present a stimulus or route for eliciting and reinforcing exploratory activities involving the snout and mouth (Van de Weerdt et al., 2003) and result in a reduction in adverse behaviors, such as tail-biting and belly nosing (Fraser et al., 1991; Peterson et al., 1995). For example, providing growing pigs with straw is considered to reduce harmful social behavior, such as ear and tail biting, and to increase behavior directed toward the straw bedding (de Jong et al., 1998). An experiment by Beattie et al. (1995) showed that growing pigs housed indoors and given a substrate in which to root increased the amount of time spent exploring and decreased the time spent in inactivity or in behaviors directed toward their pen-mates, such as chewing ear and tails. Further work showed that, at 18°C, peat, mushroom compost, and sawdust were the preferred substrates, with sand, wood bark and straw preferred only to concrete flooring. Although there was also a variation of 16% in moisture content among the preferred substrates, Beattie et al. (1993) concluded that particle size or texture played a greater role in determining pigs’ preference than moisture content. However, temperature can also affect pig bedding preferences, i.e. Fraser (1985) demonstrated that pigs only showed a preference for straw bedding over concrete at low temperatures and concluded that straw was beneficial in the role of thermoregulation, but not necessarily the preferred choice for substrate-directed behavior.

Pigs’ natural tendency to chew novel objects in the environment can also be exploited for animal health purposes. For example Prickett et al. (2008a, b) demonstrated that oral fluids collected by allowing pigs to chew on cotton rope could serve as diagnostic samples to monitor for porcine reproductive and respiratory syndrome virus, porcine circovirus type-2 and probably other infections of swine. Kittawornrat et al. (2010) demonstrated that this approach could be applied to individually penned boars. These reports suggested that normal pig behavior could be exploited for the surveillance of a variety of infectious diseases.

In free-ranging feral swine, pigs’ natural inclination to chew novel objects can be exploited for the oral delivery of pharmaceuticals (Kavanaugh and Linhart, 2000) and biologics (Ballesteros et al., 2009). Fletcher et al. (1990)
demonstrated the feasibility of feral swine vaccination via oral baits using tetracycline as a biomarker to estimate coverage. Ballesteros et al. (2009) proved the effectiveness of bait for the oral delivery of vaccine to 2- to 4-month-old wild boar by demonstrating serum antibody titers and recombinant Escherichia coli in the feces after consumption of bait containing a live recombinant E. coli biomarker.

Flavor formulation of baits is important for delivery to the targeted population. Fletcher et al. (1990) reported 95% bait consumption by feral swine using fish meal-based bait against 63% bait consumption using bovine-flavored bait (Mitchell, 1998) and 31–72% consumption of kangaroo-based bait (Fleming et al., 2000). Ballesteros et al. (2009) prepared bait using a matrix of wild boar feed, wheat flour, paraffin, saccharose and cinnamon-truffle powder attractant with polyethylene capsules of vaccine within the matrix. One of the problems with this self-selected method of vaccine delivery is that baits can be attractive to non-target species. Campbell et al. (2006) reported that 22% of the bait was consumed by feral swine, but 51% was consumed by raccoons (Procyon lotor), and 20% by collared peccaries (Tayassu tajacu). Thus, bait flavorings need to be highly specific for feral swine in order to avoid consumption by non-target species.

Vaccine formulation is an important consideration in oral baits. Vaccine stability and suitability for oral delivery is a primary consideration, but effect on non-target species must also be taken into account. For example, gene-deleted pseudorabies (Aujeszky’s disease) vaccines can replicate in susceptible species, e.g. raccoons (Weigel et al., 2003), resulting in death and/or the potential for transmission to other wild or domestic animals. Likewise, fertility-control products or vaccines targeting gonadotropin-releasing hormone (GnRH), a hormone common to wild and domestic animals, may impair reproduction if consumed by non-target animal species (Campbell et al., 2006).

Regardless of the current technical challenges, feral swine are increasing their range and population numbers in many parts of the world, including North America (Wittmer et al., 2003; Ruiz-Fons et al., 2007). Highly destructive to the environment in large numbers, this population also serves as a reservoir for a variety of pathogens of veterinary and public health importance (Meng et al., 2009). Therefore, control of feral swine numbers and/or prevention of disease transmission by these animals will mandate additional work on the efficient and effective delivery of vaccines and contraceptives via oral baits.

Conclusion

The changes in husbandry that occurred over the course of the 20th century metamorphosed pig production from small, intensive (confined), capital-dependent, production systems. Concurrently over the last several years, both production and consumption of pork have risen at the global level. World pork production doubled between 1977 and 1998 (Cameron, 2000) and by 2019 the demand for pork is expected to increase by approximately 24% over the base period of 2007–2009, primarily as a result of increased demand in developing countries (OECD/FAO, 2010). The development of large-scale swine production systems has stimulated debate concerning its impact on animal/human health, environmental effects and concerns for the ethical care of animals. Safeguarding animal welfare and health is good for pigs, pork producers and the animal-conscious public. In a very tangible way, the future of pork production depends on effectively addressing the public’s concerns regarding the health and welfare of the animals under our care. A good place to start is by improving our understanding of the biology behind pig behavior and pig welfare.

References


