

WellBeing International

## WBI Studies Repository

2009

# The Welfare of Sows Used for Breeding in the Pig Industry

The Humane Society of the United States

Follow this and additional works at: [https://www.wellbeingintlstudiesrepository.org/hsus\\_reps\\_impacts\\_on\\_animals](https://www.wellbeingintlstudiesrepository.org/hsus_reps_impacts_on_animals)



Part of the [Agribusiness Commons](#), [Animal Studies Commons](#), and the [Business Law, Public Responsibility, and Ethics Commons](#)

---

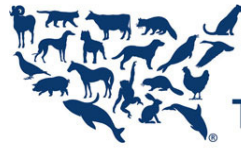
### Recommended Citation

The Humane Society of the United States, "The Welfare of Sows Used for Breeding in the Pig Industry" (2009). *IMPACTS ON FARM ANIMALS*. 26.

[https://www.wellbeingintlstudiesrepository.org/hsus\\_reps\\_impacts\\_on\\_animals/26](https://www.wellbeingintlstudiesrepository.org/hsus_reps_impacts_on_animals/26)

This material is brought to you for free and open access by WellBeing International. It has been accepted for inclusion by an authorized administrator of the WBI Studies Repository. For more information, please contact [wbisr-info@wellbeingintl.org](mailto:wbisr-info@wellbeingintl.org).





**THE HUMANE SOCIETY**  
OF THE UNITED STATES

## **An HSUS Report: The Welfare of Sows Used for Breeding in the Pig Industry**

### **Abstract**

The conditions afforded sows (adult female pigs) used for breeding on industrial pig production operations present a number of welfare problems. Sows are routinely confined in gestation and farrowing crates barely larger than their own bodies, where they are unable to turn around during their pregnancy and lactation periods, often in excess of 128 consecutive days. Behavioral abnormalities such as stereotypic bar-biting and aggression arise due to environmental deficiencies and restricted feeding regimens. Sows in large, industrial operations are also affected by a number of production-related diseases and suffer from higher mortality rates. A reevaluation of current confinement systems and management practices is urgently needed, as there are a number of grave animal welfare concerns for sows in the commercial pig production industry.

### **Introduction\***

The natural behavior and biology of pigs in free-roaming environments have been researched extensively. Studies of wild boars and feral pigs (domestic animals who have reverted to a wild state) show that free-roaming pigs are adapted to diverse habitat, including wooded areas, scrub brush near watering holes, riverine forest, and marshland;<sup>1,2</sup> have a varied diet of roots, grasses, acorns, berries, and small animals such as earthworms, and frogs;<sup>3,4,5</sup> and display extensive foraging and rooting behavior, turning up soil and vegetation with the disc of their highly sensitive snout.<sup>6</sup>

Pigs show complex social behavior, segregating into small family groups. Herds are usually composed of 1-4 sows and their offspring.<sup>7</sup> Daughters often stay with their mothers following weaning, forming stable maternal units.<sup>8</sup> Pigs build nests in which to rest by bedding an often used area with grass, sticks, and leaves. At night pigs sleep in these nests together, huddling to stay warm.<sup>9</sup>

Farrowing is the process of giving birth. Approximately one or two days prior to farrowing,<sup>10</sup> the sow normally leaves her herd and seeks a private, sheltered place in which to build her nest. The process of giving birth takes 4-6 hours.<sup>11</sup> Mother pigs are attentive, respond to piglet vocalizations, and defend their piglets when they are threatened.<sup>12</sup> Sows and their adult daughters have been observed mixing their litters in the same shared nest<sup>13,14</sup> and groups of females may share mothering duties,<sup>15</sup> thus caring for their young communally.

Piglets begin to leave the nest approximately one week following parturition (birth) and gradually integrate into the herd by about 10 days of age.<sup>16</sup> There is little obvious aggression when piglets are introduced into the herd this way.<sup>17</sup> The age at weaning varies between studies, with some piglets nursing for as little as 60 days,<sup>18</sup> and others as long as 22 weeks, until they are gradually weaned.<sup>19</sup> Littermates associate strongly and piglets of approximately the same ages usually form well-integrated groups.<sup>20</sup>

Studies have demonstrated that domesticated pigs, like other domesticated animals,<sup>21</sup> retain the basic behavioral repertoire of their wild counterparts, even when reared in the industrial production systems of commercial

---

\* For more detailed information, see: "An HSUS Report: The Welfare of Animals in the Pig Industry" at [www.humanesociety.org/assets/pdfs/farm/hsus-the-welfare-of-animals-in-the-pig-industry.pdf](http://www.humanesociety.org/assets/pdfs/farm/hsus-the-welfare-of-animals-in-the-pig-industry.pdf) and "An HSUS Report: The Welfare of Piglets in the Pig Industry" at [www.humanesociety.org/assets/pdfs/farm/welfare\\_piglets.pdf](http://www.humanesociety.org/assets/pdfs/farm/welfare_piglets.pdf).

farming operations.<sup>22</sup> However, they are severely limited in the behavior they are able to display in the constraints of artificial production environment.

## Industrial Production

Farming methods have changed dramatically over the last century. Small, pasture-based farms where pigs and other animals were typically raised outdoors and were able to display much of their natural behavior have gradually been overtaken by massive, industrialized operations that restrictively confine animals in impoverished, artificial conditions. A 2006 survey by the U.S. Department of Agriculture (USDA) reported that approximately 80% of gestating sows and 88% of lactating sows were kept in total confinement.<sup>23</sup> Farming has also become more specialized, with the majority of facilities no longer raising a diversity of crops and animals as in years past, but now focusing on a single animal species, further divided into stages of production.<sup>24</sup> Nowhere is this more evident than with pig production.

The specialized stages of commercial pig production start with breeding and gestation. At breeding facilities, sows are bred or artificially inseminated,<sup>25</sup> and farrow after a 114-day gestation (pregnancy) period. Sows nurse their piglets until they are abruptly and prematurely weaned when they are 2-4 weeks of age.<sup>†</sup> The piglets are then typically moved to a nursery facility until they reach 18.1-27.2 kg (40-60 lb) by approximately 8-10 weeks of age, at which point the young pigs are then moved to different facilities for “growing” and “finishing.”<sup>26,27</sup> Pigs are slaughtered when they reach 108.9-122.5 kg (240-270 lb),<sup>28,‡</sup> when they are approximately 6 months old.<sup>29</sup> Some gilts (young female pigs) are kept as replacements for the sows who are no longer considered profitable breeding animals to the industry, at which point the older sows are culled—i.e., removed and sent to slaughter.<sup>30,31</sup>

Sows used for breeding not only endure many of the welfare problems associated with other segments of the commercial industry, such as those arising from barren conditions, poor air quality, and stressful handling and transport, but are also subjected to more restrictive confinement, selective breeding for productivity, and additional health problems.

## Gestation Crates

An estimated 60-70% of gestating sows in the United States are confined individually in gestation crates<sup>§</sup> (also known as sow stalls).<sup>32</sup> A typical gestation crate is 0.6 m (2 ft) wide by 2.13 m (7 ft) long,<sup>33,34</sup> which prevents the sow from turning around or making normal postural adjustments without touching the sides of the enclosure.<sup>35,36</sup>

Gestation crates are a serious welfare problem, and there is ample scientific evidence that farmed animals in chronic, close confinement want and need to move. Research has shown that turning behavior is not influenced by the location of feed and water within the crate, which has prompted scientists to note that most turning is independent of any obvious external stimuli<sup>37</sup> and provides evidence that turning is motivated from within, thereby meeting scientific criteria for a “behavioral need.”<sup>38</sup>

Crates have been described as “unrewarding” and “uncomfortable.”<sup>39</sup> Space restriction in the gestation crate may impede movement when the sow stands up quickly or while lying down.<sup>40</sup> From a management perspective, it is also more difficult to detect sick or injured animals when they are confined in crates, as behavioral signs are limited due to lack of space<sup>41</sup> and cannot be used as indicators of illness or pain. Individually housed sows are

---

<sup>†</sup> For more in-depth information, see: “An HSUS Report: The Welfare of Piglets in the Pig Industry” at [www.humanesociety.org/assets/pdfs/farm/welfare\\_piglets.pdf](http://www.humanesociety.org/assets/pdfs/farm/welfare_piglets.pdf).

<sup>‡</sup> For purposes of this report, the term “hog” will not be used to refer to pigs who weigh more than 54.4 kg (120 lb), as this industry term is not necessarily convention in the scientific literature.

<sup>§</sup> For more in-depth information, see: “An HSUS Report: Welfare Issues with Gestation Crates for Pregnant Sows” at [www.humanesociety.org/assets/pdfs/farm/HSUS-Report-on-Gestation-Crates-for-Pregnant-Sows.pdf](http://www.humanesociety.org/assets/pdfs/farm/HSUS-Report-on-Gestation-Crates-for-Pregnant-Sows.pdf).

also subjected to social deprivation<sup>42</sup> and cannot move toward neighboring sows who may be amicable or away from those who may be aggressive.

The amount of space a sow needs in order to perform even the most minimal body movements have been determined: A sow weighing 250 kg (551 lbs) needs an area 220.3 cm (7.23 ft) long and 86.4 cm (2.83 ft) wide in order to stand up and lie down in one place without touching the sides of an enclosure<sup>43</sup>—a larger area than typical crates provide. Most gestation stalls are not wide enough to allow a sow to lie down on her side without “protruding outside the bars or being compressed against the bars of the side walls.”<sup>44</sup> Indeed, sows can become injured in crates that are improperly designed, in poor repair, or too small.<sup>45,46</sup> Due to selective breeding programs for increasingly larger and faster-growing pigs raised for meat, sows are also gradually becoming larger, further compounding the welfare problems associated with confinement to a crate. According to the industry journal *National Hog Farmer*, Temple Grandin, Professor of Animal Science at Colorado State University and a leading scientific consultant to industry and corporations, has “argued that stalls represent very poor housing systems because sows are becoming bigger and crates are becoming narrower.”<sup>47</sup>

Exercise is important for maintaining cardiovascular fitness, strong bones, and overall health. Feral pigs and wild boars have home ranges varying widely in size from less than 100 ha (0.39 mi<sup>2</sup>) to over 2,500 ha (9.65 mi<sup>2</sup>).<sup>48</sup> In contrast, crated sows are virtually immobilized, able to take only a step or two forward or backward. These restricted animals have higher basal heart rates, suggesting they are less fit than sows allowed to exercise.<sup>49</sup> Periosteal modeling (a sign of bone formation) is stimulated in weight-bearing bone during exercise,<sup>50</sup> and pigs show an increase in muscle weight, bone density, and bone strength when engaging in sufficient amounts of regular exercise compared to sows who are continuously confined in gestation crates.<sup>51,52</sup>

Exercise of the mother also has important implications for the health and survival of her offspring. Piglets are more viable—able to survive the critical period between birth and their first nursing—when born to sows who have had regular exercise.<sup>53</sup> A 2008 study found that litters have greater total body weight and lower levels of mortality when born to gilts who had regular exercise during gestation, compared to sows who were continuously confined to a gestation crate throughout their pregnancy. The scientists postulated that behavioral differences between gilts who were able to exercise and those who were not may explain the lower mortality of piglets; sows who were given the regular opportunity to walk and run had greater control of their hindquarters, reducing the probability that piglets would be accidentally crushed as the sow laid down.<sup>54</sup>

Crated sows likely experience boredom, frustration, and psychological trauma caused by behavioral restriction. In naturalistic environments, pigs spend more than 50% of their daily time budget foraging, rooting, and grazing.<sup>55</sup> In a stall however, oral behavior is often directed to the only substrate available—the bars of the crate. Bar-biting is a type of stereotypy, an abnormal, repetitive behavior induced by repeated coping attempts, frustration, and/or brain dysfunction.<sup>56</sup> Stereotypic behavior, thought to be rooted in stress, lack of control, and lack of stimulation,<sup>57,58</sup> is common in captive animals confined in barren or restrictive conditions.<sup>59</sup> Although bar-biting behavior of sows is probably related to thwarted feeding motivation, many studies comparing housing systems show that sows confined in conventional gestation crates or tethered in stalls show *more* stereotypic behavior than those loose-housed in group pens,<sup>60,61,62,63,64,65</sup> even when fed identical diets.<sup>66,67,68</sup> The frequency of stereotypic behavior thus also depends on the degree to which sows are confined.<sup>69</sup> Where sows are housed in group pens rather than in individual gestation crates, they may partially compensate for the inability to forage naturally by engaging in more social behavior.<sup>70</sup> Stereotypic behavior is generally not observed when pigs are provided large, naturalistic enclosures.<sup>71,72</sup>

In a 2007 interview, Grandin definitively stated, “I think we need to get rid of sow stalls.”<sup>73</sup>

## **Group Housing**

Group housing systems, in which gestating sows are kept loose in pens rather than in gestation crates, are already in use by some producers, and others are phasing out intensive confinement stalls in favor of this method. Maxwell Foods, LLC, for example, has kept gestating sows in group housing since its inception, and the largest pig producer in the world, Smithfield Foods, has pledged to move away from crates and adopt group housing systems.<sup>74,75,76,77</sup> Compared to gestation crates, group housing improves the welfare of sows by allowing more behavioral freedom, including locomotory, investigative, thermoregulatory, and comfort (rubbing and grooming) behavior, and social interaction including mutual grooming, sniffing and nosing, and communal resting. The spontaneous activity of pigs in group pens improves muscle weight and bone mass, and positively affects locomotory ability compared to individual confinement to a stall.<sup>78</sup>

Injuries can occur when sows are newly introduced in group housing and form a dominance hierarchy or aggressively compete for access to feed, but this can be largely and successfully avoided with careful management. Reduced injury rates in stalls have been found compared with group housing,<sup>79,80</sup> although sows confined in crates can experience unresolved aggression from continuous encounters with sows in adjacent enclosures.<sup>81</sup> Aggression in group pens may lead to hoof injuries, lameness,<sup>82</sup> and in combination with restricted feed, fatal torsion of abdominal organs,<sup>83</sup> but it is important to recognize that under naturalistic conditions, aggression among sows is limited,<sup>84</sup> and problems with fighting are largely an artifact of the industrial production system. Pigs would naturally segregate into family groups.<sup>85</sup> Social relationships form between littermates early in life,<sup>86</sup> and groups of pigs in a naturalistic setting develop a stable dominance hierarchy with minimal fighting.<sup>87</sup> Aggression levels are low in free-range systems compared to indoor confinement systems, because aggressive interactions are more easily avoided when pigs have sufficient space to distance themselves.<sup>88,89</sup> Aggression in industrial production settings is thus, in large part, the result of artificial grouping arrangements and disruption of natural social, feeding and spacing behavior.

Improved systems for feeding group-housed sows are available that reduce competition and thereby reduce fighting. For example, by using an Electronic Sow Feeder (ESF), or by using free-stalls competition for feed can be reduced. ESF systems are computer-controlled feeders that recognize a unique transponder fitted to each sow. In an ESF, one sow enters the enclosed feeding station at a time, where she is given her allotted daily feed allowance. While ESF systems must be carefully designed and managed to avoid potential pitfalls, they have the advantages of feeding each sow individually, recording any sows who are not eating (aiding in the detection of sick animals), reducing handling problems, and quieting the animals.<sup>90</sup> In free-stall systems, sows have access to an individual stall, typically with a back gate that closes behind her upon entry. After feeding, the sow can back out, but other sows cannot push their way into the stall from the outside.<sup>91</sup> In this way, each sow can be fed individually and protected from more aggressive sows who might attempt to dominate the feed source. As producers continue to move away from stalls toward group housing, innovation will undoubtedly continue to make further improvements.

## **Farrowing Crates**

In industrial commercial production, sows are moved into farrowing crates after the gestation period for the birth of their young and the subsequent lactation period. The farrowing crate is comprised of two areas—one in which the sow is confined, similar to the gestation crate, and an adjacent “creep area” that is heated to draw piglets away from their mother when they are not nursing. Although they vary in design, farrowing crates typically measure 1.5 m wide by 2.1 m long (5 by 7 ft) with a space allotment for the sow measuring approximately 0.61 m (2 ft) in width.<sup>92</sup> Piglets can reach the sow to nurse, but, as with the gestation crate, the sow’s ability to move is limited mainly to lying down and standing up, and she is unable to turn around.

Conventional farrowing crates have come under criticism due to their restrictive nature and subsequent consequences to the confined sow; however, arguments supporting their use include protection of piglets and space efficiencies, detailed below.

The farrowing crate causes a number of welfare problems. In addition to the physical and psychological challenges crated sows experience (as detailed above), sows in farrowing crates are also prevented from

performing normal nesting and mothering behavior. Lying down can be difficult in the confined space, and, depending on the floor type, sows may get sores on their feet, legs, and udder.<sup>93</sup> Like gestation crates, problems with farrowing crates are exacerbated as sows are selectively bred for larger body size, while crate sizes remain unchanged.<sup>94</sup>

Natural nesting behavior is completely thwarted in the artificial confines of a farrowing crate. In a natural environment, a sow might travel up to 6.5 km (4 mi) in search of a suitable nesting area.<sup>95</sup> This nesting motivation is triggered internally<sup>96,97</sup> by changing hormone levels,<sup>98</sup> and sows show increased restlessness, activity, and locomotion prior to farrowing.<sup>99,100,101</sup> Multiple studies have demonstrated that sows prefer to nest in an enclosed, generously bedded farrowing site,<sup>102,103,104</sup> completely unlike the farrowing crate. Sows in intensive confinement operations attempt to perform nesting behavior—pawing the floor and nosing the bars of the crate—even in the absence of a suitable site and without nest building materials.<sup>105,106,107,108</sup> Sows may even wear down their front hooves and suffer from abrasions on their snouts from performing this behavior in contact with the concrete floor.<sup>109</sup>

The early mortality of piglets is often high. Causes of newborn piglet death include hypothermia, starvation, and crushing by the mother sow,<sup>110</sup> the latter of which is typically used as the rationale for the use of farrowing crates—i.e., that they reduce the incidence of small piglets becoming accidentally crushed by the heavy sow as she changes position.<sup>111,112</sup> A survey of U.S. production sites in 2000 estimated that preweaning mortality was 11.77% (approximately one death per litter),<sup>113</sup> in basic agreement with figures from the European Commission's Scientific Veterinary Committee, which reported that the mortality of piglets generally ranges from 10-20%.<sup>114</sup> Further estimates are that approximately one-third to one-half of preweaning piglet death in the industry is caused by crushing.<sup>115,116</sup>

Scientists have suggested that at least part of the crushing problem within the pig industry may be due to selective breeding for larger sows and the concomitant side effect that heavy bodyweight has had on sows' ability to lay down in a way that would facilitate piglets in moving out from underneath them as they descend into a recumbent position.<sup>117</sup> Indeed, a newborn piglet may weigh just over 1 kg (2.2 lb), while the sow can weigh over 250 kg (551 lb),<sup>118</sup> and the disparity in size puts baby pigs at risk.<sup>119</sup> At least one study has shown that crushing is associated with heavier dams.<sup>120</sup>

Less restrictive alternative systems to the conventional farrowing crate exist with piglet mortality rates that are similar to or below those of farrowing crates. These alternative systems include the ellipsoid farrowing crate,<sup>121</sup> the sloped farrowing pen,<sup>122,123</sup> and English-style outdoor farrowing huts.<sup>124</sup>

In 1994, scientists working at the University of Guelph published a paper on the ellipsoid farrowing crate, which allows the sow to turn around completely, yet does not result in higher piglet mortality. They also found a reduced rate of stillborn piglets (possibly due to the ability of the sow to assume more comfortable postures), more hygienic birthing conditions since piglets did not drop into accumulated manure at the back of the crate, and improved interaction between piglets and their less-restricted mothers.<sup>125</sup> However, sows need freedom to walk rather than simply to turn around in order to more fully accommodate their natural behavior.<sup>126</sup>

Carefully designed sloped farrowing pens can also be effective and offer higher welfare to sows compared with crates. Sloping the pen floor causes the sow to adjust her resting posture, and reduces the rate of accidental crushing to a level comparable to farrowing crates.<sup>127,128</sup> Historically, outdoor sow herds have farrowed and nursed their young in rolling hills without difficulty, and this is the basis for the sloped floor pen design, also called the Hillside pen. The slope of the pen floor causes the sow to more carefully stand up and lie down.<sup>129</sup>

Although less common in the United States, approximately 40% of pig production occurred outdoors in the United Kingdom in 2008.<sup>130</sup> The British Meat and Livestock Commission compile yearly data on productivity measures for indoor and outdoor pig production systems. The Commission found that, outdoor breeding herds in the United Kingdom have lower mortality rates than indoor, crated herds.<sup>131</sup> Outdoor farrowing accommodation for sows is generally small huts on pasture or in paddocks. A number of different farrowing hut

designs for outdoor pig production are in use, but some types have higher piglet mortality rates, highlighting the importance of design.<sup>132,133</sup> Huts that have ample floor space of 3.9-4.6 m<sup>2</sup> (42-50 ft<sup>2</sup>), and guardrails or safe space created by the curved shape of the hut walls provide protection for piglets from a descending sow.<sup>134</sup> Two different studies have found that English-style arc-shaped huts and blunt-top A frames with guard rails have the lowest mortality, as low as 3.7%.<sup>135,136</sup> In a U.S. study directly comparing conventional farrowing crates and English-style outdoor farrowing huts, there was no significant difference in overall mortality rates or stillbirths. In the same study, piglet mortality rates were reduced when sows had previous experience farrowing outdoors.<sup>137</sup> Breeding programs have the potential to further improve the survival of piglets in crate-free, outdoor systems.<sup>138,139</sup>

Within industrial pig production, however, conventional farrowing crates improve the profitability of intensive production enterprises by allowing a greater number of sows to be confined per building<sup>140</sup> and are more convenient for the producer.<sup>141</sup> However, farrowing crates should be phased out in favor of alternative systems that enable higher animal welfare.

## **Breeding and Productivity**

In commercial production, pigs are selectively bred for such industry-preferred traits as rapid growth rate, feed conversion efficiency, carcass leanness, and litter size.<sup>142</sup> Productivity of sows is assessed within the industry in terms of the number of piglets produced per sow per year.<sup>143</sup> The selection of economically important traits without due regard to how they affect the welfare of the animals has had a number of consequences for sows and their piglets.

Small, wild boar sows typically give birth to one litter of five to seven slowly growing, fat piglets each year. Through the use of selective breeding, however, large sows in the commercial pig industry now bear 20 or more fast-growing, lean piglets annually.<sup>144</sup> Genetic selection for increased litter size has led to a decrease in the number of surviving piglets.<sup>145,146,147</sup> Researchers have postulated that genetic changes have altered body fat metabolism, body composition, and hormonal state, resulting in lean tissue growth that makes piglets heavier but less mature at birth, reducing their survival rate.<sup>148</sup> Selection for leanness may have also inadvertently decreased the nutritional quality of sows' milk,<sup>149</sup> in turn affecting survival of the piglets.

Because the progeny of breeding sows are selected for rapid growth, pregnant pigs have a tremendous appetite. However, they are commonly feed-restricted to ensure their "longevity,"<sup>150</sup> an industry term used to convey usefulness until productivity declines and they are slaughtered.<sup>151</sup> If energy intake in feed is not restricted, pregnant sows can get excessively fat and heavy,<sup>152</sup> and gestational diabetes can be exacerbated.<sup>153</sup> Feed restriction prevents obesity and lessens the detrimental effects of excessive weight on reproductive output.<sup>154</sup> Thus, sows are typically given only 50-60% of their voluntary feed intake,<sup>155</sup> which can be consumed in as little as five minutes.<sup>156</sup> In contrast free-ranging pigs spend a great deal of time foraging, approximately half their daily time budget.<sup>157,158</sup> Such severe feed restriction leads to persistent, unfulfilled feeding motivation,<sup>159,160,161</sup> which can in turn lead to frustration and aggression.<sup>162,163</sup> The psychological effect is manifested in the occurrence of abnormal behavior, such as object chewing (repetitive biting of the bars of the crate or other objects), sham chewing (repetitive chewing with nothing in the mouth), and head weaving (repetitive back and forth movements of the head). These abnormal behavior patterns could be reduced if sows were fed a high fiber, bulky diet instead of, or in addition to, concentrates.<sup>164,165,166,167,168</sup>

Water may also be restricted. While most sows are given free access to water, feed restriction can lead to excessive water consumption, and some producers limit access to water to specific periods of the day. Given the risk of thirst and the potential for dehydration during hot weather, this practice is objectionable on welfare grounds.<sup>169</sup>

## **Disease and Mortality**

Ill health and morbidity can affect animals in any setting. On farms where pigs have outdoor access, for example, they may come into contact with pathogens in the soil, other domestic or wild animals such as cats and raccoons, or the feces of these animals,<sup>170</sup> so it is imperative that managers of pasture-based systems take preventative measures such as raising hardy breeds<sup>171</sup> and using management practices that limit contact between animals. However, confinement on large, industrialized farming operations, and breeding programs aimed at maximizing productivity are directly linked to many prevalent disease and mortality issues of sows.

Larger operations tend to have higher sow mortality rates. A survey of more than 600 U.S. farms published in 2000 in the journal *Preventive Veterinary Medicine* found greater annual mortality risk with larger herd size and that the mortality risk increased by 0.44% for every herd size increase of 500 females.<sup>172</sup> Increasing sow mortality with herd size was also found in a 2009 report by the National Animal Disease Information Service in the United Kingdom. In that report, the mortality rate in herd sizes of 1-100 animals was 1-2%, but in herds of more than 500 animals, the mortality rate was 5-6%.<sup>173</sup> Lack of individual care on larger facilities has been implicated as a possible cause of higher sow mortality rates, as personnel on large operations may not have enough time to care for compromised sows showing clinical symptoms.<sup>174,175</sup> Indeed, with the use of modern technology and efficient barn and pen designs, one person may be responsible for the care of 8,000 pigs per day on a large, commercial operation.<sup>176</sup>

Of further concern, sow mortality\*\* in the U.S. pig industry appears to be increasing.<sup>177,178,179</sup> According to USDA records of 6-month mortality figures, 5% of breeding-age female pigs on large facilities (500 or more animals) died in 2006<sup>180</sup> compared to 4% in 2000.<sup>181</sup> The reasons for possible increasing mortality are not clear, but one hypothesis is that it is difficult to adequately care for highly productive females, who have enormous metabolic demands for lactation and increasing numbers of litters per year. Sows' physiological requirements are greater than ever before, and veterinarians have argued that producers may have difficulty managing the nutrient intake of highly productive sows.<sup>182</sup>

Pigs have a delicate cardiovascular system and a small heart with enhanced sensitivity to oxygen deficiency. This predisposes sows to heart failure.<sup>183</sup> Obesity, parturition (giving birth), high environmental temperatures, and stress due to transport, for example, can all trigger cardiac failure. In addition, lack of exercise due to confinement such as that found in commercial production facilities has been implicated as a related factor.<sup>184</sup>

Cardiovascular failure can result from heat stress. Data from 130 pig breeding herds in Canada showed that 11% of the annual death loss occurred on just 3 of the hottest days during June and July.<sup>185</sup> Pigs primarily use behavior to thermoregulate. Because they have only a small number of sweat glands, they are not able to cool themselves by sweating and, in natural environments, wallow in mud when too hot.<sup>186</sup> However, in industrial confinement operations, sows are not afforded the opportunity to wallow and thus are particularly susceptible to heat stress. Even well-designed ventilation systems may not always be adequate to keep sows cool, especially under conditions of high humidity.<sup>187</sup>

One of the most significant causes of sow death is torsions and accidents involving the abdominal organs. Prior to 1980, however, such torsions were not considered a prevalent cause of sow mortality. Veterinarians have suggested that management changes and the intensification of pig production may be involved. The use of finely ground feed rations, rapid feed intake by the sow, the common practice of feeding fewer meals on the weekends,<sup>188</sup> and providing restricted feed amounts<sup>189</sup> may all play a role in the rise of fatalities due to disorders of the abdominal organs.

Cystitis-pyelonephritis is a bacterial infection of the urinary tract. The disease may cause hematuria and pyuria (blood and pus in the urine, respectively), anorexia, and, in severe cases, acute renal failure and death. The incidence of cystitis-pyelonephritis is increasing worldwide, and the rise in cases is thought to be correlated with

---

\*\* These figures are for sows who died and do not include the number of sows who were culled (selectively sent to slaughter) by the producer to be replaced in the breeding herd by younger gilts.



the widespread adoption of confinement housing.<sup>190</sup> Gestation crates may predispose sows to urinary tract infections due to lack of exercise and the fact that sows must lie in their own waste.<sup>191</sup>

Sows are often culled or killed on the farm due to leg problems.<sup>192</sup> Those kept in industrialized confinement systems are often crated on slatted floors, despite the recognized leg problems they cause.<sup>193</sup> The National Animal Disease Information Service in the United Kingdom reports that mortality levels are much higher in indoor systems, especially those using slats, compared to pasture-based systems where sows walk on soil. In the 2009 survey, death losses were 5.4% in indoor facilities with slatted floors, whereas sows kept on straw only suffered a 4.3% mortality rate.<sup>194</sup>

Older sows are more likely to become non-ambulatory, unable to rise and walk on their own accord. There are a number of reasons that sows can become “downed,” but they are especially vulnerable following the lactation period, which takes a substantial metabolic toll. Other causes are traumatic or infectious arthritides,<sup>195</sup> ascarid (worm) infection, respiratory disease, liver damage, ulcers, subtle bone injury, and feet and leg problems.<sup>196</sup> If veterinary intervention is not provided, sows who become, or are likely to become, downed suffer one of two fates: either they are killed on-farm or transported for slaughter. Both of these ends are of grave concern, as some of the current on-farm euthanasia methods in use are problematic and transport of animals, especially those who are compromised in some way, is stressful, at best.<sup>††</sup>

Health issues and leg problems often result in the untimely death of the sow. Large producers usually cull sows after about four years.<sup>197</sup> In contrast, however, the natural lifespan of a pig is 12-15 years<sup>198</sup> and wild boar can live to be 21.<sup>199</sup> As an animal’s health is inextricably linked to overall welfare, these concerns must be addressed promptly.

## Conclusion

Sows used for breeding purposes on industrialized pig production facilities suffer from a number of highly significant welfare problems. Intensive confinement to a crate during gestation and farrowing, selective breeding for productivity, and concomitant disease and mortality issues are scientifically documented welfare concerns on large-scale industrial operations. A reevaluation of current practices is badly needed. A case in point is the farrowing crate, and the mismatch this confinement system creates between the sow and her environment. As Seaton Hall Baxter of the North of Scotland College of Agriculture, now known as the Scottish Agricultural College, explained:

[T]he entire rationale upon which conventional farrowing pens are designed and used needs to be question[ed]...Crate farrowing is also an ‘unnatural’ method of animal exploitation inasmuch as it attempts to suppress rather than exploit the animal’s own biological adaptations. For example, although the main objectives in the farrowing pen design are the provision of a safe (from crushing) and climatically suitable environment for the piglets, restraining the sow in a crate prevents her nest-building, the functions of which would appear to be mechanical and climatic protection...<sup>200</sup>

Scientifically proven alternative systems, which do not so severely confine mother pigs and their young, are readily available,<sup>201,202,203,204,205</sup> yet industry has failed to adopt them broadly. Industry must change course, keep pace with ethical concerns, and work to put the welfare of animals first, so that badly needed reforms can be implemented.

Improvements in welfare also require a more animal-centered view point. Within the pig industry, sows may be referred to as little more than “a pig manufacturing unit.”<sup>206</sup> This underlying attitude toward animals is demonstrative of the lack of compassion that led to the development of current systems and practices that so jeopardize animal well-being. A shift in thinking will be necessary to address growing societal concern and to

---

<sup>††</sup> For more information see: “An HSUS Report: The Welfare of Animals in the Pig Industry” at [www.FarmAnimalWelfare.org](http://www.FarmAnimalWelfare.org).

ensure that the welfare of sows used for breeding improves. This begins with recognizing the welfare problems outlined herein and taking tangible, meaningful steps to address them. Such an effort would raise the bar for the level of care and treatment of sows used for breeding.

- 
- <sup>1</sup> Graves HB. 1984. Behavior and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58(2):482-92.
  - <sup>2</sup> Singer FJ. 1981. Wild pig populations in the National Parks. *Environmental Management* 5(3):263-70.
  - <sup>3</sup> Singer FJ. 1981. Wild pig populations in the National Parks. *Environmental Management* 5(3):263-70.
  - <sup>4</sup> Graves HB. 1984. Behavior and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58(2):482-92.
  - <sup>5</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, pp. 161-2).
  - <sup>6</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, pp. 161-2).
  - <sup>7</sup> Graves HB. 1984. Behavior and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58(2):482-92.
  - <sup>8</sup> Kaminski G, Brandt S, Baubet E, and Baudoin C. 2005. Life-history patterns in female wild boars (*Sus scrofa*): mother-daughter postweaning associations. *Canadian Journal of Zoology* 83(3):474-80.
  - <sup>9</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, pp. 162-3).
  - <sup>10</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
  - <sup>11</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, p. 165).
  - <sup>12</sup> Houpt KA. 2005. *Domestic Animal Behavior*, 4<sup>th</sup> Edition (Ames, IA: Blackwell Publishing, p. 188).
  - <sup>13</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
  - <sup>14</sup> Newberry RC, and Wood-Gush DGM. 1985. The suckling behaviour of domestic pigs in a semi-natural environment. *Behaviour* 95:11-25.
  - <sup>15</sup> Graves HB. 1984. Behavior and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58(2):482-92.
  - <sup>16</sup> Jensen P and Redbo I. 1987. Behaviour during nest leaving in free-ranging domestic pigs. *Applied Animal Behaviour Science* 18:355-62.
  - <sup>17</sup> Petersen HV, Vestergaard K, and Jensen P. 1989. Integration of piglets into social groups of free-ranging domestic pigs. *Applied Animal Behaviour Science* 23:223-36.
  - <sup>18</sup> Newberry RC, and Wood-Gush DGM. 1985. The suckling behaviour of domestic pigs in a semi-natural environment. *Behaviour* 95:11-25.
  - <sup>19</sup> Jensen P and Stangel G. 1992. Behaviour of piglets during weaning in a semi-natural enclosure. *Applied Animal Behaviour Science* 33:227-38.
  - <sup>20</sup> Jensen P and Stangel G. 1992. Behaviour of piglets during weaning in a semi-natural enclosure. *Applied Animal Behaviour Science* 33:227-38.
  - <sup>21</sup> Price EO. 1984. Behavioral aspects of animal domestication. *The Quarterly Review of Biology* 59(1):1-32.
  - <sup>22</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
  - <sup>23</sup> U.S. Department of Agriculture Animal and Plant Health Inspection Service. 2007. Swine 2006 part I: reference of swine health and management practices in the United States. [http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2006/Swine2006\\_PartI.pdf](http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2006/Swine2006_PartI.pdf). Accessed June 29, 2009.
  - <sup>24</sup> MacDonald JM and McBride WD. 2009. The transformation of U.S. livestock agriculture: scale, efficiency, and risks. U.S. Department of Agriculture Economic Research Service. [www.ers.usda.gov/Publications/EIB43/](http://www.ers.usda.gov/Publications/EIB43/). Accessed July 29, 2009.

- 
- <sup>25</sup> U.S. Department of Agriculture. 2007. Swine 2006, Part I: Reference of swine health and management practices in the United States. [www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2006/Swine2006\\_PartI.pdf](http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2006/Swine2006_PartI.pdf). Accessed December 2, 2009.
- <sup>26</sup> Blackwell TE. 2004. Production practices and well-being: swine. In: Benson GJ and Rollin BE (eds.), *The Well-Being of Farm Animals: Challenges and Solutions* (Ames, IA: Blackwell Publishing, pp. 241-69).
- <sup>27</sup> Holden PJ and Ensminger ME. 2006. *Swine Science*, 7th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, pp. 396-7).
- <sup>28</sup> Holden PJ and Ensminger ME. 2006. *Swine Science*, 7th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, p. 388).
- <sup>29</sup> McGlone J and Pond W. 2003. *Pig Production: Biological Principles and Applications* (Clifton Park, NY: Thompson Delmar Learning, p. 20).
- <sup>30</sup> Prunier A, Soede N, Quensel H, and Kemp B. 2003. Productivity and longevity of weaned sows. In: Pluske JR, Le Dividich J, and Verstegen MWA (eds.), *Weaning the Pig: Concepts and Consequences* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 385-419).
- <sup>31</sup> Lucia T, Dial GD, and Marsh WE. 2000. Lifetime reproductive performance in female pigs having distinct reasons for removal. *Livestock Production Science* 63:213-22.
- <sup>32</sup> Barnett JL, Hemsworth PH, Cronin GM, Jongman EC, and Hutson GD. 2001. A review of the welfare issues for sows and piglets in relation to housing. *Australian Journal of Agricultural Research* 52:1-28.
- <sup>33</sup> McGlone J. Undated. Alternative sow housing systems: driven by legislation, regulation, free trade and free market systems (but not science). Pork Industry Institute. Texas Tech University. [www.depts.ttu.edu/porkindustryinstitute/SowHousing\\_files/Sow%20housing%20Manitoba.pdf](http://www.depts.ttu.edu/porkindustryinstitute/SowHousing_files/Sow%20housing%20Manitoba.pdf). Accessed August 6, 2009.
- <sup>34</sup> Holden PJ and Ensminger ME. 2006. *Swine Science*, 7th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, p. 399).
- <sup>35</sup> Marchant JN and Broom DM. 1996. Factors affecting posture-changing in loose-housed and confined gestating sows. *Animal Science* 63:477-85.
- <sup>36</sup> Anil L, Anil SS, and Deen J. 2002. Evaluation of the relationship between injuries and size of gestation stalls relative to size of sows. *JAVMA* 221(6):834-6.
- <sup>37</sup> McFarlane JM, Boe KE, and Curtis SE. 1988. Turning and walking by gilts in modified gestation crates. *Journal of Animal Science* 66:326-33.
- <sup>38</sup> Duncan IJH. 1998. Behavior and behavioral needs. *Poultry Science* 77:1766-72.
- <sup>39</sup> Gregory NG. 2007. *Animal Welfare and Meat Production*, 2nd Edition (Wallingford, U.K.: CABI, p. 102).
- <sup>40</sup> Marchant JN and Broom DM. 1996. Factors affecting posture-changing in loose-housed and confined gestating sows. *Animal Science* 63:477-85.
- <sup>41</sup> Blackwell TE. 2004. Production practices and bell-being: swine. In: Benson GJ and Rollin BE (eds.), *The Well-being of Farm Animals: Challenges and Solutions* (Ames, IA: Blackwell Publishing, p. 250).
- <sup>42</sup> Bergeron R, Meunier-Salaun MC, and Robert S. 2008. The welfare of pregnant and lactating sows. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 65-95).
- <sup>43</sup> Curtis SE, Hurst RJ, Gonyou HW, Jensen AH, and Muehling AJ. 1989. The physical space requirement of the sow. *Journal of Animal Science* 67:1242-8.
- <sup>44</sup> McGlone JJ, Vines B, Rudine AC, and DuBois P. 2004. The physical size of gestating sows. *Journal of Animal Science* 82:2421-7.
- <sup>45</sup> Anil L, Anil SS, and Deen J. 2002. Evaluation of the relationship between injuries and size of gestation stalls relative to size of sows. *Journal of the American Veterinary Medical Association* 221(6):834-6.
- <sup>46</sup> Miller D. 2004. Sows flourish in pen gestation. *National Hog Farmer*, March 15.
- <sup>47</sup> Vansickle J. 2005. Sow Stalls vs. Pens. *National Hog Farmer*, September 15. [http://nationalhogfarmer.com/mag/farming\\_sow\\_stalls\\_vs/](http://nationalhogfarmer.com/mag/farming_sow_stalls_vs/). Accessed August 7, 2009.
- <sup>48</sup> Graves HB. 1984. Behavior and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58(2):482-92.

- 
- <sup>49</sup> Marchant JN, Rudd AR, and Broom DM. 1997. The effects of housing on heart rate of gestating sows during specific behaviours. *Applied Animal Behaviour Science* 55:67-78.
- <sup>50</sup> Tommerup LJ, Raab DM, Crenshaw TD, and Smith EL. 1993. Does weight-bearing exercise affect non-weight-bearing bone? *Journal of Bone and Mineral Research* 8(9):1053-8.
- <sup>51</sup> Schenck EL, McMunn KA, Rosenstein DS, Stroshine RL, Nielsen BD, Richert BT, Marchant-Forde JN, and Lay Jr. DC. 2008. Exercising stall-housed gestating gilts: effects on lameness, the musculo-skeletal system, production, and behavior. *Journal of Animal Science* 86:3166-80.
- <sup>52</sup> Marchant JN and Broom DM. 1996. Effects of dry sow housing conditions on muscle weight and bone strength. *Animal Science* 62:105-13.
- <sup>53</sup> Ferket SL and Hacker RR. 1985. Effect of forced exercise during gestation on reproductive performance of sows. *Canadian Journal of Animal Science* 65:851-9.
- <sup>54</sup> Schenck EL, McMunn KA, Rosenstein DS, Stroshine RL, Nielsen BD, Richert BT, Marchant-Forde JN, and Lay Jr. DC. 2008. Exercising stall-housed gestating gilts: effects on lameness, the musculo-skeletal system, production, and behavior. *Journal of Animal Science* 86:3166-80.
- <sup>55</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
- <sup>56</sup> Mason G and Rushen J. 2006. *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare*, 2nd Edition (Wallingford, U.K.: CABI, p. 347).
- <sup>57</sup> Barnett JL, Hemsworth PH, Cronin GM, Jongman EC, and Hutson GD. 2001. A review of the welfare issues for sows and piglets in relation to housing. *Australian Journal of Agricultural Research* 52:1-28.
- <sup>58</sup> Vestergaard K and Hansen LL. 1984. Tethered versus loose sows: ethological observations and measures of productivity. I. Ethological observations during pregnancy and farrowing. *Annales de Recherches Veterinaires* 15(2):245-56.
- <sup>59</sup> Mason GJ and Latham NR. 2004. Can't stop, won't stop: is stereotypy a reliable animal welfare indicator? *Animal Welfare* 13:S57-69.
- <sup>60</sup> Ekesbo I. 1981. Some aspects of sow health and housing. In: Sybesma W (ed.), *The Welfare of Pigs* (London, England: Martinus Nijhoff Publishers).
- <sup>61</sup> Vestergaard K and Hansen LL. 1984. Tethered versus loose sows: ethological observations and measures of productivity. I. Ethological observations during pregnancy and farrowing. *Annales de Recherches Veterinaires* 15(2):245-56.
- <sup>62</sup> Arellano PE, Pijoan C, Jacobson LD, and Algiers B. 1992. Stereotyped behaviour, social interactions and suckling pattern of pigs housed in groups or in single crates. *Applied Animal Behaviour Science* 35:157-66.
- <sup>63</sup> Vieuille-Thomas C, Le Pape G, Signoret JP. 1995. Stereotypies in pregnant sows: indications of influence of the housing system on the patterns expressed by the animals. *Applied Animal Behaviour Science* 44:19-27.
- <sup>64</sup> Soede NM, Helmond FA, Schouten WGP, and Kemp B. 1997. Oestrus, ovulation and peri-ovulatory hormone profiles in tethered and loose-housed sows. *Animal Reproduction Science* 46:133-48.
- <sup>65</sup> Goossens X, Sobry L, Ödberg F, et al. 2008. A population-based on-farm evaluation protocol for comparing the welfare of pigs between farms. *Animal Welfare* 17:35-41.
- <sup>66</sup> Broom DM, Mendl MT, and Zanella AJ. 1995. A comparison of the welfare of sows in different housing conditions. *Animal Science* 61:369-85.
- <sup>67</sup> Jensen P. 1988. Diurnal rhythm of bar-biting in relation to other behaviour in pregnant sows. *Applied Animal Behaviour Science* 21:337-46.
- <sup>68</sup> Maria Levrino GA and Villarroel Robinson M. 2003. Welfare status of commercial sows in three housing systems in Spain. *Archivos de Zootecnia* 52:453-62.
- <sup>69</sup> Jensen P. 1988. Diurnal rhythm of bar-biting in relation to other behaviour in pregnant sows. *Applied Animal Behaviour Science* 21:337-46.
- <sup>70</sup> Goossens X, Sobry L, Ödberg F, et al. 2008. A population-based on-farm evaluation protocol for comparing the welfare of pigs between farms. *Animal Welfare* 17:35-41.
- <sup>71</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
- <sup>72</sup> Petersen V. 1994. The development of feeding and investigatory behaviour in free-ranging domestic pigs during their first 18 weeks of life. *Applied Animal Behaviour Science* 42:87-98.

- 
- <sup>73</sup> Vansickle J. 2007. Temple Grandin. National Hog Farmer, May 15, pp. 28-30.
- <sup>74</sup> Miller D. 2007. Pen gestation isn't complicated. National Hog Farmer, August. [http://nationalhogfarmer.com/mag/farming\\_pen\\_gestation\\_isnt/](http://nationalhogfarmer.com/mag/farming_pen_gestation_isnt/). Accessed April 15, 2010.
- <sup>75</sup> Ivey B. 2007. Sows can flourish in pen gestation. In: Proceedings of the Sow Housing Forum (Des Moines, IA). [www.pork.org/Documents/Sow%20Housing%20Forum/Proceedings/BobIvey.pdf](http://www.pork.org/Documents/Sow%20Housing%20Forum/Proceedings/BobIvey.pdf) . Accessed April 15, 2010,
- <sup>76</sup> Tuytens FAM, Struelens E, Van Gansbeke S, Ampe B. 2008. Factors influencing farmers' responses to welfare legislation: A case study of gestation sow housing in Flanders (Belgium). *Livestock Science* 116:289-99.
- <sup>77</sup> Barrionuevo A. 2007. Pork Producer says it plans to give pigs more room. *The New York Times*, January 26.
- <sup>78</sup> Petersen JS, Oksbjerg N, Jorgensen B, and Sorensen MT. 1998. Growth performance, carcass composition and leg weakness in pigs exposed to different levels of physical activity. *Animal Science* 66:725-32.
- <sup>79</sup> Rhodes RT, Appleby MC, Chinn K, et al. 2005. Task force report: a comprehensive review of housing for pregnant sows. *Journal of the American Veterinary Medical Association* 227(10):1580-90.
- <sup>80</sup> Goossens X, Sobry L, Ödberg F, et al. 2008. A population-based on-farm evaluation protocol for comparing the welfare of pigs between farms. *Animal Welfare* 17:35-41.
- <sup>81</sup> Mendl MT, Broom DM, and Zanella AJ. 1993. The effects of three types of dry sow housing on sow welfare. *Livestock Environment IV* (Coventry, U.K.: University of Warwick, p. 461).
- <sup>82</sup> Anil SS, Anil L, Deen J, Baidoo SK, and Walker RD. 2007. Factors associated with claw lesions in gestating sows. *Journal of Swine Health and Production* 15(2):78-83.
- <sup>83</sup> Nielsen BL, Thodberg K, Dybkjaer L, and Vestergaard EM. 2006. Feeding behaviour in pigs. In: Bels V (ed.), *Feeding in Domestic Vertebrates: from Structure to Behaviour* (Wallingford, U.K.: CAB International, pp. 156-78).
- <sup>84</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
- <sup>85</sup> Graves HB. 1984. Behavior and ecology of wild and feral swine (*Sus scrofa*). *Journal of Animal Science* 58(2):482-92.
- <sup>86</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, p. 160).
- <sup>87</sup> Jensen P and Wood-Gush DGM. 1984. Social interactions in a group of free-ranging sows. *Applied Animal Behaviour Science* 12:327-37.
- <sup>88</sup> Jensen P and Wood-Gush DGM. 1984. Social interactions in a group of free-ranging sows. *Applied Animal Behaviour Science* 12:327-37.
- <sup>89</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
- <sup>90</sup> Gregory NG. 2007. *Animal Welfare and Meat Production*, 2nd Edition (Wallingford, U.K.: CABI, pp. 100-2).
- <sup>91</sup> Gonyou HW. 2003. Group housing: alternative systems, alternative management. *Advances in Pork Production* 14:101-7.
- <sup>92</sup> Holden PJ and Ensminger ME. 2006. *Swine Science*, 7th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, p. 396).
- <sup>93</sup> Bonde M, Rousing T, Badsberg JH, and Sørensen JT. 2004. Associations between lying-down behaviour problems and body condition, limb disorders and skin lesions of lactating sows housed in farrowing crates in commercial sow herds. *Livestock Production Science* 87:179-87.
- <sup>94</sup> Biensen NJ, Borell von EH, Ford SP. 1996. Effects of space allocation and temperature on periparturient maternal behaviors, steroid concentrations, and piglet growth rates. *Journal of Animal Science* 74:2641-8.
- <sup>95</sup> Jensen P. 1986. Observations on the maternal behaviour of free-ranging domestic pigs. *Applied Animal Behaviour Science* 16:131-42.
- <sup>96</sup> Jensen P, Vestergaard K, and Algers B. 1993. Nestbuilding in free-ranging domestic sows. *Applied Animal Behaviour Science* 38:245-55.
- <sup>97</sup> Jensen P. 1993. Nest building in domestic sows: the role of external stimuli. *Animal Behaviour* 45:351-58.
- <sup>98</sup> Widowski TM, Curtis SE, Dziuk PJ, Wagner WC, and Sherwood OD. 1990. Behavioral and endocrine responses of sows to prostaglandin F<sub>2α</sub> and cloprostenol. *Biology of Reproduction* 43:290-7.

- 
- <sup>99</sup> Haskell MJ and Hutson GD. 1996. The pre-farrowing behaviour of sows with access to straw and space for locomotion. *Applied Animal Behaviour Science* 49:375-87.
- <sup>100</sup> Lawrence AB, Petherick JC, McLean KA, et al. 1994. The effect of environment on behaviour, plasma cortisol and prolactin in parturient sows. *Applied Animal Behaviour Science* 39:313-30.
- <sup>101</sup> Hartsock TG and Barczewski RA. 1997. Parturition behavior in swine: effects of pen size. *Journal of Animal Science* 75:2899-904.
- <sup>102</sup> Hunt K and Petchey AM. 1989. Degree of enclosure preferred by sows around farrowing. *Animal Production* 48:643.
- <sup>103</sup> Petchey AM. 1991. Spatial preferences of farrowing sows. *Animal Production* 52:577-8.
- <sup>104</sup> Baxter MR. 1991. The 'freedom' farrowing system. *Farm Building Progress* 104:9-15.
- <sup>105</sup> Cronin GM, Smith JA, Hodge FM, and Hemsworth PH. 1994. The behaviour of primiparous sows around farrowing in response to restraint and straw bedding. *Applied Animal Behaviour Science* 39:269-80.
- <sup>106</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, p. 165).
- <sup>107</sup> Jarvis S, Calvert SK, Stevenson J, vanLeeuwen N, and Lawrence AB. 2002. Pituitary-adrenal activation in pre-parturient pigs (*Sus scrofa*) is associated with behavioural restriction due to lack of space rather than nesting substrate. *Animal Welfare* 11:371-84.
- <sup>108</sup> Hartsock TG and Barczewski RA. 1997. Parturition behavior in swine: effects of pen size. *Journal of Animal Science* 75:2899-904.
- <sup>109</sup> Hartsock TG and Barczewski RA. 1997. Parturition behavior in swine: effects of pen size. *Journal of Animal Science* 75:2899-904.
- <sup>110</sup> Puppe B, Meunier-Salaun MC, Otten W, and Orgeur P. 2008. The welfare of piglets. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 97-131).
- <sup>111</sup> Weary DM, Pajor EA, Fraser D, and Honkanen AM. 1996. Sow body movements that crush piglets: a comparison between two types of farrowing accommodation. *Applied Animal Behaviour Science* 49:149-58.
- <sup>112</sup> Baxter MR. 1991. The 'freedom' farrowing system. *Farm Building Progress* 104:9-15.
- <sup>113</sup> U.S. Department of Agriculture. 2005. Swine 2000 Part IV: Changes in the U.S. Pork Industry, 1990-2000 USDA:APHIS:VS:CEAH, National Animal Health Monitoring System, Fort Collins, CO #N428.0405, pp. 18. [www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2000/Swine2000\\_dr\\_PartIV.pdf](http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2000/Swine2000_dr_PartIV.pdf). Accessed April 15, 2010.
- <sup>114</sup> Scientific Veterinary Committee. 1997. *The Welfare of Intensively Kept Pigs*. [http://ec.europa.eu/food/fs/sc/oldcomm4/out17\\_en.pdf](http://ec.europa.eu/food/fs/sc/oldcomm4/out17_en.pdf). Accessed April 15, 2010.
- <sup>115</sup> Holden PJ and Ensminger ME. 2006. *Swine Science*, 7th Edition (Upper Saddle River, NJ: Pearson Prentice Hall, p. 403).
- <sup>116</sup> U.S. Department of Agriculture. 2005. Swine 2000 Part IV: Changes in the U.S. Pork Industry, 1990-2000 USDA:APHIS:VS:CEAH, National Animal Health Monitoring System, Fort Collins, CO #N428.0405, pp. 19. [www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2000/Swine2000\\_dr\\_PartIV.pdf](http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2000/Swine2000_dr_PartIV.pdf). Accessed April 15, 2010.
- <sup>117</sup> Baxter MR. 1991. The 'freedom' farrowing system. *Farm Building Progress* 104:9-15.
- <sup>118</sup> Weary DM, Pajor EA, Fraser D, and Honkanen AM. 1996. Sow body movements that crush piglets: a comparison between two types of farrowing accommodation. *Applied Animal Behaviour Science* 49:149-58.
- <sup>119</sup> Arey DS. 1993. The welfare of pigs in confined and non-confined farrowing systems. *Pig News and Information* 14(2):81N-4N.
- <sup>120</sup> McGlone JJ and Morrow-Tesch J. 1990. Productivity and behavior of sows in level vs sloped farrowing pens and crates. *Journal of Animal Science* 68:82-7.
- <sup>121</sup> Lou Z and Hurnik JF. 1994. An ellipsoid farrowing crate: its ergonomical design and effects on pig productivity. *Journal of Animal Science* 72:2610-6.
- <sup>122</sup> McGlone JJ and Morrow-Tesch J. 1990. Productivity and behavior of sows in level vs sloped farrowing pens and crates. *Journal of Animal Science* 68:82-7.
- <sup>123</sup> Collins ER, Kornegay ET, Bonnette ED. 1987. The effects of two confinements systems on the performance of nursing sows and their litters. *Applied Animal Behaviour Science* 17:51-9.

- 
- <sup>124</sup> Johnson AK, Morrow-Tesch JL, and McGlone JJ. 2001. Behavior and performance of lactating sows and piglets reared indoors or outdoors. *Journal of Animal Science* 79:2571-9.
- <sup>125</sup> Lou Z and Hurnik JF. 1994. An ellipsoid farrowing crate: its ergonomical design and effects on pig productivity. *Journal of Animal Science* 72:2610-6.
- <sup>126</sup> Baxter MR. 1991. The 'freedom' farrowing system. *Farm Building Progress* 104:9-15.
- <sup>127</sup> McGlone JJ and Morrow-Tesch J. 1990. Productivity and behavior of sows in level vs sloped farrowing pens and crates. *Journal of Animal Science* 68:82-7.
- <sup>128</sup> Collins ER, Kornegay ET, Bonnette ED. 1987. The effects of two confinement systems on the performance of nursing sows and their litters. *Applied Animal Behaviour Science* 17:51-9.
- <sup>129</sup> McGlone JJ. 2002. Housing options for farrowing: considerations for animal welfare and economics. *Pork Information Gateway factsheet*. [www.pork.org/pig/NEWfactSheets/01-01-02g.pdf](http://www.pork.org/pig/NEWfactSheets/01-01-02g.pdf). Accessed April 15, 2010.
- <sup>130</sup> Edwards S, Roehe R, and Lawrence A. 2008. Breeding for improved piglet survival in non crate systems – the UK perspective. In: Pedersen LJ and Moustsen VA (eds.), *Housing of farrowing and lactating sows in non-crate systems* (AARHUS University, Faculty of Agricultural Sciences; Danish Pig Production, pp. 1-7).
- <sup>131</sup> Edwards S, Roehe R, and Lawrence A. 2008. Breeding for improved piglet survival in non crate systems – the UK perspective. In: Pedersen LJ and Moustsen VA (eds.), *Housing of farrowing and lactating sows in non-crate systems* (AARHUS University, Faculty of Agricultural Sciences; Danish Pig Production, pp. 1-7).
- <sup>132</sup> Honeyman MS and Roush WB. 2002. The effects of outdoor farrowing hut type on prewean piglet mortality in Iowa. *American Journal of Alternative Agriculture* 17(2):92-5.
- <sup>133</sup> McGlone JJ and Johnson AK. 2003. Welfare of the neonatal piglet. In: Wiseman J, Varley MA, and Kemp B (eds.), *Perspectives in Pig Science* (Nottingham U.K.: Nottingham University Press, pp. 169-96).
- <sup>134</sup> Honeyman MS and Roush WB. 2002. The effects of outdoor farrowing hut type on prewean piglet mortality in Iowa. *American Journal of Alternative Agriculture* 17(2):92-5.
- <sup>135</sup> Honeyman MS and Roush WB. 2002. The effects of outdoor farrowing hut type on prewean piglet mortality in Iowa. *American Journal of Alternative Agriculture* 17(2):92-5.
- <sup>136</sup> McGlone JJ and Hicks TA. 2000. Farrowing hut design and sow genotype (Camborough-15 vs 25% Meishan) effects on outdoor sow and litter productivity. *Journal of Animal Science* 78:2832-5.
- <sup>137</sup> Johnson AK, Morrow-Tesch JL, and McGlone JJ. 2001. Behavior and performance of lactating sows and piglets reared indoors or outdoors. *Journal of Animal Science* 79:2571-9.
- <sup>138</sup> Edwards S, Roehe R, and Lawrence A. 2008. Breeding for improved piglet survival in non crate systems – the UK perspective. In: Pedersen LJ and Moustsen VA (eds.), *Housing of farrowing and lactating sows in non-crate systems* (AARHUS University, Faculty of Agricultural Sciences; Danish Pig Production, pp. 1-7).
- <sup>139</sup> Baxter EM. 2008. Neonatal Piglet Mortality: outdoor production vs. indoor pen-housing in relation to breeding for improved survival. In: Pedersen LJ and Moustsen VA (eds.), *Housing of farrowing and lactating sows in non-crate systems* (AARHUS University, Faculty of Agricultural Sciences; Danish Pig Production, pp. 9-11).
- <sup>140</sup> Barnett JL, Hemsworth PH, Cronin GM, Jongman EC, and Hutson GD. 2001. A review of the welfare issues for sows and piglets in relation to housing. *Australian Journal of Agricultural Research* 52:1-28.
- <sup>141</sup> Gregory NG. 2007. *Animal Welfare and Meat Production*, 2nd Edition (Wallingford, U.K.: CABI, p. 94).
- <sup>142</sup> Rydhmer L and Lundeheim N. 2008. Breeding pigs for improved welfare. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 243-70).
- <sup>143</sup> McGlone J and Pond W. 2003. *Pig Production: Biological Principles and Applications* (Clifton Park, NY: Delmar Learning, p 267).
- <sup>144</sup> Rydhmer L and Lundeheim N. 2008. Breeding pigs for improved welfare. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 243-70).
- <sup>145</sup> Rydhmer L and Lundeheim N. 2008. Breeding pigs for improved welfare. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 243-70).
- <sup>146</sup> Su G, Lund MS, and Sorensen D. 2007. Selection for litter size at day five to improve litter size at weaning and piglet survival rate. *Journal of Animal Science* 85:1385-92.

- 
- <sup>147</sup> Edwards SA. 2002. Perinatal mortality in the pig: environmental or physiological solutions? *Livestock Production Science* 78:3-12.
- <sup>148</sup> Herpin P, Le Dividich J, and Amaral N. 1993. Effect of selection for lean tissue growth on body composition and physiological state of the pig at birth. *Journal of Animal Science* 71:2645-53.
- <sup>149</sup> Rydhmer L and Lundeheim N. 2008. Breeding pigs for improved welfare. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 243-70).
- <sup>150</sup> Nielsen BL, Thodberg K, Dybkjaer L, and Vestergaard EM. 2006. Feeding behaviour in pigs. In: Bels V (ed.), *Feeding in Domestic Vertebrates: from Structure to Behaviour* (Wallingford, U.K.: CAB International, pp. 156-78).
- <sup>151</sup> Stalder KJ, Karriker LV, and Johnson AK. 2007. The impact of gestation housing systems on sow longevity. In: *Proceedings of the Sow Housing Forum* (Des Moines, IA).  
[www.pork.org/Documents/Sow%20Housing%20Forum/Proceedings/KenStalder.pdf](http://www.pork.org/Documents/Sow%20Housing%20Forum/Proceedings/KenStalder.pdf). Accessed April 15, 2010.
- <sup>152</sup> Reese DE and Miller PS. 2006. Nutrient deficiencies and excesses. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine, 9th Edition* (Ames, IA: Blackwell Publishing, pp. 931-44).
- <sup>153</sup> Trottier NL and Johnston LJ. 2001. Feeding gilts during development and sows during gestation and lactation. In: Lewis AJ and Southern LL (eds.), *Swine Nutrition, 2nd Edition* (Boca Raton, FL: CRC Press, pp. 725-69).
- <sup>154</sup> Bergeron R, Meunier-Salaun MC, and Robert S. 2008. The welfare of pregnant and lactating sows. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 65-95).
- <sup>155</sup> Ramonet Y, Meunier-Salaun MC, and Dourmad JY. 1999. High-Fiber Diets in Pregnant Sows: Digestive Utilization and Effects on the Behavior of the Animals. *Journal of Animal Science* 77:591-9.
- <sup>156</sup> Nielsen BL, Thodberg K, Dybkjaer L, and Vestergaard EM. 2006. Feeding behaviour in pigs. In: Bels V (ed.), *Feeding in Domestic Vertebrates: from Structure to Behaviour* (Wallingford, U.K.: CAB International, pp. 156-78).
- <sup>157</sup> Stolba A, and Wood-Gush DGM. 1989. The behaviour of pigs in a semi-natural environment. *Animal Production* 48:419-25.
- <sup>158</sup> Petersen V. 1994. The development of feeding and investigatory behaviour in free-ranging domestic pigs during their first 18 weeks of life. *Applied Animal Behaviour Science* 42:87-98.
- <sup>159</sup> Bergeron R, Badnell-Waters AJ, Lambton S, and Mason G. 2006. Stereotypic oral behaviour in captive ungulates: foraging, diet and gastrointestinal function. In: Mason G and Rushen J (eds.), *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare, 2nd Edition* (Wallingford, U.K.: CAB International, pp. 19-57).
- <sup>160</sup> Hutson GD. 1992. A comparison of operant responding by farrowing sows for food and nest-building materials. *Applied Animal Behaviour Science* 34:221-30.
- <sup>161</sup> Lawrence AB and Illius AW. 1989. Methodology for measuring hunger and food needs using operant conditioning in the pig. *Applied Animal Behaviour Science* 24:273-85.
- <sup>162</sup> Nielsen BL, Thodberg K, Dybkjaer L, and Vestergaard EM. 2006. Feeding behaviour in pigs. In: Bels V (ed.), *Feeding in Domestic Vertebrates: from Structure to Behaviour* (Wallingford, U.K.: CAB International, pp. 156-78).
- <sup>163</sup> Gregory NG. 2007. *Animal Welfare and Meat Production, 2nd Edition* (Wallingford, U.K.: CABI, p. 100).
- <sup>164</sup> Ramonet Y, Meunier-Salaun MC, and Dourmad JY. 1999. High-Fiber Diets in Pregnant Sows: Digestive Utilization and Effects on the Behavior of the Animals. *Journal of Animal Science* 77:591-9.
- <sup>165</sup> Bergeron R, Bolduc J, Ramonet Y, Meunier-Salaun MC, Robert S. 2000. Feeding motivation and stereotypes in pregnant sows fed increasing levels of fibre and/or food. *Applied Animal Behaviour Science* 70:27-40.
- <sup>166</sup> Brouns F, Edwards SA, and English PR. 1994. Effect of dietary fibre and feeding system on activity and oral behaviour of group housed gilts. *Applied Animal Behaviour Science* 39:215-23.
- <sup>167</sup> Robert S, Bergeron R, Farmer C, and Meunier-Salaun MC. 2002. Does the number of daily meals affect feeding motivation and behaviour of gilts fed high-fibre diets? *Applied Animal Behaviour Science* 76:105-17.



- 
- <sup>168</sup> Ramonet Y, Robert S, Aumaitre A, Dourmad JY, and Meunier-Salaun MC. 2000. Influence of the nature of dietary fibre on digestive utilization, some metabolite and hormone profiles and the behaviour of pregnant sows. *Animal Science* 70:275-86.
- <sup>169</sup> Bergeron R, Meunier-Salaun MC, and Robert S. 2008. The welfare of pregnant and lactating sows. In: Faucitano L and Schaefer AL (eds.), *Welfare of Pigs from Birth to Slaughter* (Wageningen, The Netherlands: Wageningen Academic Publishers, pp. 65-95).
- <sup>170</sup> Amass SF and Baysinger A. 2006. Swine disease transmission and prevention. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine*, 9th Edition (Ames, IA: Blackwell Publishing, pp. 1075-98).
- <sup>171</sup> Gegner L. 2004. Hog production alternatives. National Sustainable Agriculture Information Service. [www.attra.ncat.org/attra-pub/PDF/hog.pdf](http://www.attra.ncat.org/attra-pub/PDF/hog.pdf). Accessed April 15, 2010.
- <sup>172</sup> Koketsu Y. 2000. Retrospective analysis of trends and production factors associated with sow mortality on swine-breeding farms in USA. *Preventive Veterinary Medicine* 46:249-56.
- <sup>173</sup> White M. 2009. NADIS BPEX Commentary – January 2009. [www.bpex.org.uk/downloads/297626/289167/Monthly%20commentary%20report.pdf](http://www.bpex.org.uk/downloads/297626/289167/Monthly%20commentary%20report.pdf). Accessed April 15, 2010.
- <sup>174</sup> Koketsu Y. 2000. Retrospective analysis of trends and production factors associated with sow mortality on swine-breeding farms in the USA. *Preventive Veterinary Medicine* 46:249-56.
- <sup>175</sup> White M. 2009. NADIS BPEX Commentary – January 2009. [www.bpex.org.uk/downloads/297626/289167/Monthly%20commentary%20report.pdf](http://www.bpex.org.uk/downloads/297626/289167/Monthly%20commentary%20report.pdf). Accessed April 15, 2010.
- <sup>176</sup> McGlone J and Pond W. 2003. *Pig Production: Biological Principles and Applications* (Clifton Park, NY: Delmar Learning, p. 291).
- <sup>177</sup> Koketsu Y. 2000. Retrospective analysis of trends and production factors associated with sow mortality on swine-breeding farms in the USA. *Preventive Veterinary Medicine* 46:249-56.
- <sup>178</sup> Henry SC, Tokach LM, Pretzer SD, and Geiger JO. 2000. Considerations on the increasing mortality rates in sow herds. The 16th International Pig Veterinary Society Congress (Melbourne, Australia, p. 294).
- <sup>179</sup> D'Allaire S and Drolet R. 2006. Longevity in breeding animals. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine*, 9th Edition (Ames, IA: Blackwell Publishing, pp. 1011-25).
- <sup>180</sup> U.S. Department of Agriculture Animal and Plant Health Inspection Service. 2008. Swine 2006 Part III: Reference of Swine Health, Productivity, and General Management in the United States, p. 5. [http://nahms.aphis.usda.gov/swine/swine2006/Swine2006\\_PartIII.pdf](http://nahms.aphis.usda.gov/swine/swine2006/Swine2006_PartIII.pdf). Accessed April 15, 2010.
- <sup>181</sup> U.S. Department of Agriculture Animal and Plant Health Inspection Service. 2002. Swine 2000 Part III: Reference of Swine Health & Environmental Management in the United States, 2000, p. 5. [http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2000/Swine2000\\_dr\\_PartIII.pdf](http://www.aphis.usda.gov/vs/ceah/ncahs/nahms/swine/swine2000/Swine2000_dr_PartIII.pdf). Accessed April 15, 2010.
- <sup>182</sup> Henry SC, Tokach LM, Pretzer SD, and Geiger JO. 2000. Considerations on the increasing mortality rates in sow herds. The 16th International Pig Veterinary Society Congress (Melbourne, Australia, p. 294).
- <sup>183</sup> D'Allaire S and Drolet R. 2006. Longevity in breeding animals. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine*, 9th Edition (Ames, IA: Blackwell Publishing, pp. 1011-25).
- <sup>184</sup> Drolet R, D'Allaire S, and Chagnon M. 1992. Some observations on cardiac failure in sows. *Canadian Veterinary Journal* 33:325-9.
- <sup>185</sup> D'Allaire S, Drolet R, and Brodeur D. 1996. Sow mortality associated with high ambient temperatures. *Canadian Veterinary Journal* 37:237-9.
- <sup>186</sup> Jensen P. 2002. Behaviour of pigs. In: Jensen P (ed.), *The Ethology of Domestic Animals* (Wallingford, U.K.: CABI Publishing, p. 162).
- <sup>187</sup> D'Allaire S, Drolet R, and Brodeur D. 1996. Sow mortality associated with high ambient temperatures. *Canadian Veterinary Journal* 37:237-9.
- <sup>188</sup> D'Allaire S and Drolet R. 2006. Longevity in breeding animals. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine*, 9th Edition (Ames, IA: Blackwell Publishing, pp. 1011-25).

- 
- <sup>189</sup> Nielsen BL, Thodberg K, Dybkjaer L, and Vestergaard EM. 2006. Feeding behaviour in pigs. In: Bels V (ed.), *Feeding in Domestic Vertebrates: from Structure to Behaviour* (Wallingford, U.K.: CAB International, pp. 156-78).
- <sup>190</sup> Drolet R and Dee SA. 2006. Diseases of the urinary system. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine, 9th Edition* (Ames, IA: Blackwell Publishing, pp. 199-217).
- <sup>191</sup> D'Allaire S and Drolet R. 2006. Longevity in breeding animals. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine, 9th Edition* (Ames, IA: Blackwell Publishing, pp. 1011-25).
- <sup>192</sup> D'Allaire S and Drolet R. 2006. Longevity in breeding animals. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine, 9th Edition* (Ames, IA: Blackwell Publishing, pp. 1011-25).
- <sup>193</sup> Gonyou HW, Lemay SP, and Zhang Y. 2006. Effects of the environment on productivity and disease. In: Straw BE, Zimmerman JJ, D'Allaire S, and Taylor DJ (eds.), *Diseases of Swine, 9th Edition* (Ames, IA: Blackwell Publishing, pp. 1027-38).
- <sup>194</sup> White M. 2009. NADIS BPEX Commentary – January 2009. [www.bpex.org.uk/downloads/297626/289167/Monthly%20commentary%20report.pdf](http://www.bpex.org.uk/downloads/297626/289167/Monthly%20commentary%20report.pdf). Accessed April 15, 2010.
- <sup>195</sup> Blackwell TE. 2004. Production practices and well-being: swine. In: Benson GJ and Rollin BE (eds.), *The Well-being of Farm Animals: Challenges and Solutions* (Ames, IA: Blackwell Publishing, p. 246).
- <sup>196</sup> Sutherland MA, Erlandson K, Connor JF, et al. 2008. Health of non-ambulatory, non-injured pigs at processing. *Livestock Science* 116:237-45.
- <sup>197</sup> Johnson N. 2006. Swine of the times. *Harper's*, May, pp. 47-56.
- <sup>198</sup> Pond WG and Mersmann HJ. 2001. *Biology of the Domestic Pig* (Ithaca, NY: Cornell University Press, p. 15).
- <sup>199</sup> Schmidt CR. 1990. Grzimek's Encyclopedia of Mammals, volume 5 (New York, NY: McGraw-Hill Publishing Company, p. 47).
- <sup>200</sup> Baxter SH. 1981. Welfare and the housing of the sow and suckling pigs. In: Sybesma W (ed.), *The Welfare of Pigs, A seminar in the EEC Programme of Coordination of Research on Animal Welfare*, Brussels (The Hague: Martinus Nijhoff Publishers, pp. 276-311), citing, Gundlach H. 1968. Brutfursorge Brutpflege, Verhaltensontogenese und Tagersperiodik beim Europaischen Wildschwein (*Sus Scrofa L.*). *Z. Tierpsychol.*, 25:955-95.
- <sup>201</sup> Lou Z and Hurnik JF. 1994. An ellipsoid farrowing crate: its ergonomical design and effects on pig productivity. *Journal of Animal Science* 72:2610-6.
- <sup>202</sup> Honeyman MS and Roush WB. 2002. The effects of outdoor farrowing hut type on prewean piglet mortality in Iowa. *American Journal of Alternative Agriculture* 17(2):92-5.
- <sup>203</sup> McGlone JJ and Morrow-Tesch J. 1990. Productivity and behavior of sows in level vs sloped farrowing pens and crates. *Journal of Animal Science* 68:82-7.
- <sup>204</sup> Collins ER, Kornegay ET, Bonnette ED. 1987. The effects of two confinement systems on the performance of nursing sows and their litters. *Applied Animal Behaviour Science* 17:51-9.
- <sup>205</sup> Layton R. 2008. Animal needs and commercial needs. In: Dawkins MS and Bonney R (eds.), *The Future of Animal Farming: Renewing the Ancient Contract* (Oxford, U.K.: Blackwell Publishing, pp.83-93).
- <sup>206</sup> Liptrap DO, Bailey JH, and O'Neal J. Baby pig management—birth to weaning. *Pork Industry Handbook* (West Lafayette, Indiana: Purdue University Cooperative Extension Service).

The Humane Society of the United States is the nation's largest animal protection organization—backed by 11 million Americans, or one of every 28. For more than a half-century, The HSUS has been fighting for the protection of all animals through advocacy, education, and hands-on programs. Celebrating animals and confronting cruelty. On the Web at [humanesociety.org](http://humanesociety.org).