Task Force Report

A comprehensive review of housing for pregnant sows

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In response to a resolution ratified by the AVMA House of Delegates and at the recommendation of the association's Animal Welfare Committee, the members of the Task Force on the Housing of Pregnant Sows conducted a thorough and objective review of the scientific evidence relating to the impact on the health and welfare of keeping breeding sows[a] in gestation stalls.[b] During their review, members of the Task Force evaluated more than 1,500 pages of peer-reviewed science. The following comprises their report and recommendations.

Assessing Animal Welfare

When evaluating how housing affects the welfare of pregnant sows, it is important to be clear about what is meant by animal welfare. Commonly expressed concerns include the following: 1) animals should function well in the sense of being healthy and thriving; 2) animals should feel well, especially by prevention of serious pain, hunger, fear, and other forms of suffering; and 3) animals should be able to live in a manner consistent with the nature of their species.[1]

Task Force members recognized that scientists, including veterinarians, approach animal welfare from different viewpoints and attribute various degrees of importance to each of these concerns on the basis of their education, training, experience, and personal values and the perspectives, morals, and ethical constructs of the society in which they live and work.[2-5] The ways in which other segments of society interpret animal welfare are likewise diverse. A study[6] conducted in The Netherlands found that producers tended to believe that health and normal biological function were evidence of good animal welfare, whereas consumers tended to focus on the animal's ability to live a reasonably natural life. A sampling of quotations by ethicists and social critics identified suffering and other affective states as central concerns.[7]

Although the degree of importance attributed to each of these elements may vary, Task Force members agreed that no assessment of animal welfare is complete unless all elements are considered. It is not satisfactory, for example, to judge the welfare of an animal on the basis of its physical health without regard for whether it is suffering or frustrated or to conclude that an animal that can engage in species-typical behavior has a good state of welfare without also carefully evaluating its health and physiologic function. In recognition of the need for a comprehensive approach, physiologic function, behavior, physical health, and production indices were used to evaluate the effects and appropriateness of the use of gestation stalls, compared with other systems, for housing pregnant sows. Because ethical perspectives may affect how scientific data are interpreted and because economics can affect whether and how resulting recommendations are implemented, researchers' and stakeholders' ethical viewpoints and the economics associated with conversion of housing systems were also considered during the Task Force's review.

Importance of Study Design in Evaluating Related Research

Choosing papers for review

To ensure their review was focused and robust, members of the Task Force evaluated only reports dealing with sow housing during gestation (ie, systems used for farrowing or lactation were not included), required that reports to be reviewed were published in refereed journals, and gave more weight to recent reports than to older ones because changes in genetics and approaches to management and feeding have great potential to influence welfare measures. In addition, Task Force members considered the importance of appropriate replication and confounding and how information from related studies could most appropriately be combined.

Replication

Conducting research on how best to house pregnant sows is difficult and expensive. Requirements for a large number of experimental animals, extensive facilities, and specialized labor for animal care and data collection make this work challenging. To reduce costs, some studies include a single gestation pen and assume that multiple animals can be sampled within the pen to achieve replication. Use of animals within a single pen is considered pseudoreplication and is less desirable than if the pens themselves are replicated.

Group pens usually house adult females of varying social status and different experiential histories. A pen is a single and unique environment, and how individual sows respond depends on conditions within the pen. Likewise, an individual gestation stall is a single unit, although a group of gestation stalls may be considered a contemporary group comprising sows with similar experiential histories. One can argue that a contemporary group of pregnant sows (ie, a collection of sows housed in several stalls and a group pen) would be a uniform block of animals that would provide the best unit to be replicated for a comparison of welfare effects; in fact, this was accomplished in a previous study.[8]

A single study including sows in an unreplicated group pen will not provide information about the welfare of sows housed in pens versus stalls with statistical certainty. However, multiple studies describing unreplicated and replicated pen treatments can be used to evaluate the effects of housing on sow welfare by considering each study as a single replicate (ie, a meta-analysis).[9]

Combining studies

An experiment (replicated or unreplicated) conducted at a single location during one point in time examines differences between applied conditions—in this case, housing systems. These applied conditions are commonly referred to as treatments. When the treatment is housing type (eg, individual gestation stalls vs group pens), any statistical analysis of results will automatically encompass other factors that may differ between housing types. These include, but are not limited to, differences in feeding system, floor type, bedding, management style and degree, and local environment. Because studies are conducted under particular sets of conditions, statistical conclusions from a single study apply only to that set of conditions. For this reason, the most useful conclusions will be drawn from an analysis that includes studies (replicated and unreplicated) run under many different sets of conditions but while addressing a general question (eg, the welfare effects of housing sows in stalls vs housing them in group pens). Task Force members applied these principles when conducting their review.

Evaluation by Component of Sow Response

Physiology

General principles—In mammals, a wide range of challenges (eg, cold temperatures, disease, and aggression) may produce a stress response involving increased secretion of hypothalamic **corticotrophin releasing factor** (**CRF**; factor or hormone) and **urocortin (UCN)**.[10,11] Secretion of hypothalamic CRF causes 2 parallel effects: activation of the sympathetic nervous system (including secretion of catecholamines) and activation of the **hypothalamic-pituitary-adrenal axis (HPA)**. Within the activated HPA, the pituitary secretes proopiomelanocortin, which is rapidly cleaved to release **adrenal corticotrophin releasing hormone (ACTH)**, β-endorphin, and other peptides. Release of ACTH into the bloodstream causes secretion of glucocorticoids. In the pig, the primary glucocorticoid secreted is cortisol. Elevation of cortisol within the blood negatively feeds back on hypothalamic CRF and ACTH to dampen the response of the HPA, unless the stressful event continues. β-Endorphin may exert analgesic and cognitive effects that may help animals cope when stressed.

Stress-induced secretion of hypothalamic CRF (and associated intermediate hormones) has important peripheral physiologic effects. Secretion of CRF will cause increased heart rate and blood pressure, reduced gut motility, dilation of pupils, and mobilization of nutrients such as glucose.[12,13] These physiologic responses help animals survive stressful experiences, such as predatory attacks.

Elevation of hypothalamic CRF and UCN and other neuropeptides (but generally not other hormones activated via the HPA) causes significant changes in animal behavior.[14] Activation of CRF receptors results in behavior associated with fear and anxiety[15] as well as stereotyped behavior.[16,17]

Stress also impacts immune system responses. In general, acute stress increases the number or percentage of neutrophils in the blood, while either not influencing or decreasing the relative number of circulating lymphocytes. The function of immune cells is also inhibited during stress. Examples include reductions in natural killer cell activity, lymphocyte response, and chemotaxis and phagocytosis of neutrophils.

Only a few studies have examined the effects of CRF on physiologic responses and behavior of pigs. In 3 published studies,[17-19] administration of hypothalamic CRF to young pigs resulted in extreme behavioral activation; fearful behavior; and, at high concentrations, suppression of the immune system, including neutrophil function and natural killer cell activity. Whereas the role of CRF in sows has not been specifically explored, it seems reasonable to expect that its effects on sows' physiologic responses and behavior would be similar to those observed in young pigs. In other words, when central CRF is activated as part of a stress response, sows would be expected to have high heart rates; increased peripheral concentrations of β-endorphin, ACTH, cortisol, and catecholamines; and suppressed immune measures. The absence of such alterations may indicate that the situation is not causing a physiologic stress response.

Peripheral physiologic measures—Researchers have measured concentrations of stress-related hormones in the peripheral circulation of sows housed in gestation stalls, tethers, and group pens. Difficulty in replicating group pens in some studies makes interpretation of data from studies conducted by use of a single pen challenging (as explained previously). Considering only those studies[20-24] in which units of analysis were replicated, no differences in serum cortisol concentrations were evident between sows housed in stalls and those housed in group pens. A previous study[24] involving replicated units did, however, reveal that group-housed sows having low social rank had higher serum cortisol concentrations. These results indicate that these studies were sensitive enough to detect differences in serum cortisol concentrations between sows housed individually and in groups, had such differences existed.

A special type of individual sow housing system is the turnaround stall. Whereas conventional stalls do not allow sows to turn around, turnaround stalls have an unusual semitriangular shape that permits sows to turn around in about the same space as required by conventional rectangular stalls. Sows housed in turnaround stalls had lower serum cortisol concentrations than sows in conventional stalls; however, their immune measures related to the stress response did not differ from those of sows housed in conventional stalls.[25]

Physiologic data have also been collected on pregnant gilts housed in individual bedded pens during gestation and then moved to either farrowing pens or crates.[26] Pregnant gilts moved to farrowing crates had higher concentrations of serum cortisol than those moved to farrowing pens. These results may indicate that moving to farrowing crates may cause a greater stress response if sows have been loose-housed during gestation than if they have previously been kept in stalls.

Among nonreplicated studies (ie, studies in which only one group pen was included), Zanella et al[27] found no significant differences in serum cortisol concentrations when penned and stalled sows were compared, although sows of low social rank had higher β-endorphin concentrations than sows with high social rank. Marchant et al[28] reported that sows in individual stalls had higher heart rates than did sows in a pen. In addition, Damm et al[29] reported no significant differences in circulating concentrations of prolactin, prostaglandin $F_{2\alpha}$, and oxytocin among periparturient gilts that had been housed in gestation stalls or pens. When sows in a single pen were categorized by dominance, sows with low social status had higher cortisol concentrations than did sows with high social status.[30]

Conclusions—Most research to date indicates that generally accepted physiologic measures of stress are similar for sows housed in individual gestation stalls and in group pens. On the basis of information available at this time, Task Force members considered it reasonable to conclude that stall housing is not more physiologically stressful to sows than group housing.

BEHAVIOR

General principles—Behavior serves as an interface between animals and their environments and is affected by internal and external factors. Behavior can be an indicator of welfare problems (eg, poor posture may be a sign of disease) or their absence or may precipitate or help avoid negative effects on welfare (eg, interactions between dominance, aggression, and injury). The various views described previously regarding what is necessary for good welfare all incorporate behavior in some fashion. Those who emphasize the physical aspects of welfare recognize that behavior plays a role in achieving good nutrition, adequate growth, physical fitness, temperature regulation, and effective production and in avoiding injury and disease. Those who emphasize the mental aspects of welfare look for preferences as expressed through behavior and use behavior as an indicator of psychologic state. Those who emphasize a natural approach use the ability to perform species-typical behavior within a natural environment as an indicator of good welfare.

Relatively few behavioral studies specifically address gestation stalls, although some research on sows in tether systems can provide information relevant to certain aspects of individual housing in general. Areas of behavioral inquiry and concern identified by the Task Force during its review included social interactions, available space and freedom of movement, feed restriction, stereotypic behavior, aggression, and opportunities for the sow to control her environment. Data from the scientific literature indicate that stalls and tethers have roughly similar effects on behavior when it comes to social interactions, available space and freedom of movement, feed restriction, aggression, and opportunities for the sow to control her environment. For stereotypies, the comparison is less straightforward and relevant distinctions are described later in this report.

Social interactions—Evidence gained from observing the behavior of domestic pigs in seminatural environments, wild pigs, and feral pigs indicates that sows normally live in relatively small groups of familiar individuals during pregnancy and after farrowing but isolate themselves a few days before parturition and for the first few days of lactation. Under extensive conditions, aggression is rare and affiliative behavior, such as grouping, mutual sniffing and grooming, social facilitation, and communal nesting, is common.[31]

Most housing systems currently in use for pregnant sows diverge from what is found in nature, relative to group size and composition, space allocation, and environmental complexity.[32] In any social group of pigs of any size, a dominance order is formed with some sows becoming dominant, intermediate, and subordinate. Some sows, particularly those on the losing end of aggressive encounters and that occupy lower dominance status, exhibit signs of stress in groups.[30]

Although individual housing does not conform to what is observed in nature, there is little in the literature to suggest that being housed individually is, by itself, aversive to sows as long as there is visual and other contact with other animals. In cold climates, sows naturally huddle together, and the inability to do so in individual housing systems may reduce thermal comfort. However, sows in free-access stall systems may choose to sleep in individual stalls rather than in physical contact with other sows. In some older housing systems, sows were kept in large, bedded individual pens where they could see and touch other sows through the bars of the pens. These sows often appeared to be content and comfortable even though they were housed individually. It is worth noting that pigs will work for social contact, although motivation for social contact is more elastic than motivation for food.[33]

Available space and freedom of movement— Where sows are kept individually, there is the additional concern of whether housing them in narrow stalls, which restrict normal movements such as walking and turning, has negative effects on their welfare. Indeed, public concern about how sows are housed most often relates to restrictions on sows' freedom of movement. Sometimes, particularly when sows are of high parity, the space provided is actually smaller than the body size of the sow.[9]

The behavior of sows is influenced by stall size in that sows move less and take longer to lie down in smaller stalls than in larger stalls.[34] Although difficulty in standing up and lying down may be mostly attributable to a lack of available space in which to do so, some researchers have suggested that lameness, reduced muscle tone and mass, reduced agility, and reduced bone strength result from inactivity and contribute to the problem.[35-37] Shifts in position may be further impeded by the hooves of the sow in the neighboring stall.

Gilts in turnaround stalls have been observed to turn a mean of 75 times every 24 hours.[25] Feral pigs travel 14% to 27% of the time, walking about 1 km/d, but this probably represents the travel necessary to obtain sufficient nutrition.[38] Most relevant to sow gestation housing concerns is a recent study[39] of the activity of pregnant sows in straw-bedded pens that were fed a restricted diet. These sows walked 1% to 3% of the time (approx 15 min/d) throughout gestation. Lying increased from 54% to 73% of the time by week 15 of gestation. Thus, the activity of sows is dependent on the level of nutrients they are provided (or must seek) and the complexity of their environment. When high-quality feed and water are readily available in a comfortable environment, sows are relatively inactive.

During parturition and early lactation, restriction of movement can help reduce the risk of sows injuring their piglets; hence, whatever trade-offs may be involved, there is a rationale for restriction of movement at that time. Preventing pregnant sows from walking or turning, however, appears to serve no direct animal health or welfare purpose.

Housing sows in stalls during pregnancy may help precondition them if parturition is to take place in a farrowing crate (ie, the move to the farrowing crate may be less stressful because the environments are similar). How much sows are stressed during this move, however, may depend on how long sows are given to become accustomed to farrowing crates. With sufficient adaptation time, restlessness of group-housed sows in farrowing crates may not be a problem. However, economic pressures may prevent sows from occupying farrowing facilities for a sufficient time before farrowing and lactation. One study[40] found mixed results. Sows previously housed in groups were more restless during farrowing in crates than those housed in stalls. However, group housing had benefits for welfare during the period immediately after introduction to the crates. Sows from group pens had improved maneuvering ability and comfort and fewer skin lesions than sows from stalls.

Feed restriction and environmental complexity— Some welfare problems affecting pregnant sows are related to feeding limited amounts of concentrated diets. Concentrated diets are fed in preference to bulkier, higher-fiber diets because the latter are more costly to formulate and transport. Digestion of concentrated diets also results in production of less manure, thereby reducing the amount of manure that must be managed. If concentrated diets were not limit-fed but instead fed ad libitum, sows would tend to become obese and experience related health problems. Options are to increase the amount of concentrates, but below ad libitum levels, or to add roughage. However, if high-fiber feeds are fed in larger volumes, more manure is produced. This can be problematic if the manure management system is not designed to handle the larger volume.

Sows that are limit-fed probably remain hungry for much of the day. Limiting feed exacerbates the effects of housing because it intensifies competition for food among sows housed in groups.[41-44] Limiting feed also appears to make sows restless and more motivated to forage for food,[45] a behavior that cannot be fulfilled in either stalls or pens that are not environmentally complex. In natural environments, motivation to forage leads to exploration; rooting in the soil or other substrates; and consumption of substantial quantities of roughage, such as grass or straw, other plant material, and soil. In stalls or pens without appropriate environmental complexity, hunger may lead to sows directing seemingly abnormal movements of their snouts or mouths toward objects in their environment. For example, if a nipple drinker is present, sows may play with it continually, withdrawing or using 2 to 3 times the amount of water they would normally use.[46] Results of previously reported experiments conducted by Matthews and Ladewig[33] indicate that motivation for food is an inelastic demand.

Pigs spend much of their time lying down. In free-range environments, they build communal nests.[31] In pens with bedded and unbedded areas, sows lie on the bedding unless the environmental temperature is high and use the unbedded portion as a dunging area.[47] Cortisol concentrations are higher in the absence of substrate,[48] and pigs appear to react positively to complexity. A study by Olsen et al[49] concluded that provision of additional roughage and shelter, even in an already complex environment, improved pigs' welfare as indicated by reduced aggression, varied use of living area (including outdoors), varied behavior (including play), and improved regulation of body temperature.

Stereotypic behavior—A stereotypy is defined as "a repeated, relatively invariate sequence of movements which has no obvious purpose."[46] Stereotypies (such as repetitive bar biting, rooting, and rubbing on pen surfaces) may be exhibited by sows kept in tethers; stalls; and small, barren pens.

Stereotypies are more often observed in stall-housed sows than in pen-housed sows.[50,51] Some researchers have observed similar frequencies of stereotypic behavior in sows housed in stalls and tethers.[51-53] Others have observed more stereotypies in stall-housed sows than in sows housed by use of girth tethers[54] and more behavior involving the mouth and snout in stall-housed sows than in sows housed by use of neck tethers.[55] Sows show some form of **oral-nasal-facial (ONF)** behavior in all environments—indoors and outdoors and in pens and stalls.[56] Sows in bedded pens chew bedding and pen surfaces, and sows kept outdoors chew sticks and stones. Some repetitive ONF behavior does appear to have a purpose, such as chewing bedding or grass; however, some apparently does not, and it is this behavior that has been classified as stereotypic.[56,57]

The proportion of the day that sows were observed to spend engaged in stereotypic behavior varied considerably among studies, from less than 1%[58] to as high as 26%[59] or 46%.[60] There was also considerable variation among individual sows (in one study,[45] the proportion of time spent engaged in stereotypic behavior ranged from 0% to 61%).

Some research suggests that stereotypies may have more to do with limit feeding and lack of opportunity for productive foraging than with restriction of movement.[41-43,45,61-63] In one study,[43] sows that were housed in tethers or group pens and fed 2 amounts of feed were compared. A similar level of repetitive behavior was observed in both environments when access to feed was restricted. Stereotypies can sometimes be reduced in sows housed in stalls by providing dietary bulk.[64] This, however, was not always successful,[65] indicating that the amount and type of fiber or interactions between production system and diet may induce higher or lower amounts of repetitive behavior. Reduction is more likely when sows are housed in pens with bedding that also provides dietary fiber[59,66] or when sows are provided food ad libitum.[48,67] Simply allowing sows to turn around did not reduce stereotypic behavior.[25]

Some early research indicated that stereotypic behavior may help sows cope with aversive environments.[60] Most subsequent work, however, indicates otherwise.[68,69] The evidence that stereotypies convey some benefit is indirect and contradictory. McGlone et al[54] found that sows housed in stalls exhibited more stereotypies than those housed by use of girth tethers, yet they subsequently had larger litters. von Borell and Hurnik[70] found that, among sows housed in stalls that exhibited stereotypies, there was a positive correlation between frequency of stereotypic behavior and litter size. Sows that did not exhibit stereotypies, however, had larger litters than those that did. Fraser and Broom[46] concluded that "stereotypies may be a means of alleviating the effects of adverse conditions, but this is by no means fully proven," and Dantzer[16] considers that in many cases, "the stereotypy has become a useless and energetically costly sign of brain function pathology. Whether or not they are of any help to the animal, true stereotypies are clearly an indicator of poor welfare." That stereotypies are an indication of welfare problems was a strong consensus among nearly all authors whose work was reviewed.[69,71-73]

Aggression—Aggression and resulting physical injury can be a severe problem in group-housed sows, particularly when sows are kept in the large groups necessary for economically viable use of electronic sow feeders[74] or when unfamiliar sows are mixed (eg, in forming new groups). In comparison of sows housed in gestation stalls with sows housed in group pens, problems with aggression were sometimes greater in tether stalls than in group pens[50,75] but were more often greater in group pens, compared with stalls.[22] In one case, aggression seen in tether stalls was eliminated by redesigning the partitions.[22,76] Aggression in group housing can be reduced through improved system design[58] or by use of better management techniques.[44,77,78]

One type of aggression of particular concern is vulva biting. This most commonly occurs between sows housed in group systems that use electronic sow feeders. When vulva biting occurs, it can be reduced, but apparently not eliminated, by improved management.[79-81] Certain group pen designs increase the risk of vulva biting. Feeding sows sequentially rather than simultaneously is one risk factor. Sows are social animals that, in nature, eat simultaneously when in social groups (eg, as they find a food site on the forest floor). Electronic sow feeding systems do not allow simultaneous feeding of sows; therefore, the risk of vulva biting and other aggressive behaviors among sows may be increased. Vulva biting is eliminated by housing sows in individual stalls.

Opportunities for control over the environment—Sows kept under extensive or seminatural conditions exercise control over their interactions with the environment. They use separate feeding, nesting, and defecation areas and adjust their location in accord with environmental conditions (eg, reacting to different temperatures by choosing wallows, sheltered places, or proximity to other pigs).[31] Sows housed in stalls cannot exercise the same control over their environment. They can use only minimal behavior to thermoregulate, cannot avoid sows that are aggressive or approach those with whom grooming relationships might be established, cannot flee a fear-producing stimulus, and cannot easily choose a place to lie down that is separate from where they defecate. Sows in confinement are also unable to avoid stimuli known to be aversive, such as the loud noises associated with feeders and cleaning equipment.[c] The welfare impact of the latter on sows, however, is unknown because they quickly habituate to repeated loud sounds.[82] In general, however, lack of control over stressful components of the environment suggests a reduction in welfare.

Conclusions—Gestation stalls, particularly when used in conjunction with feed restriction, may adversely affect welfare by restricting behavior, including foraging, movement, and postural changes. Stalls, however, do not appear to reduce welfare as much as tether systems. Stereotypies related to behavioral restriction can be reduced by providing bedding, foraging material, roughage, or a combination of these. Simply providing space to turn around is unlikely to resolve these repetitive, non–purpose-directed behavior patterns. Other factors contributing to poor welfare in stalls and small, unbedded pens include lack of exercise, lack of environmental complexity, lack of rooting/chewing materials, and an inability for the sow to exert control over her environment.

One of the most effective ways to curtail behavioral problems in sow housing systems is to increase feed availability. Some researchers have suggested that feed should be provided ad libitum. Because feeding motivation is so pronounced in sows, however, obesity may result from ad libitum feeding and create other health and welfare concerns. There is no evidence that providing a bulky diet would satisfy the sow's hunger drive since it solves only one component of satiety (gut fill) and does not change nutrient concentrations in the blood and tissue. Also, greater costs may be involved in handling larger amounts of fibrous manure in ways that do not create an environmental burden.

Aggression has been reported in all types of housing systems, but it is most often worse and sometimes severe in group housing. Vulva biting, one of the most common and serious aggressive interactions, most often occurs in group pens that do not allow for simultaneous feeding of sows (eg, those using electronic sow feeders). Unfortunately, no management techniques have been identified that reliably eliminate aggression. However, improvements in housing design and good management can help minimize aggressive interactions.

Health

General—Few peer-reviewed reports are available that provide useful comparative information about the effects of various housing systems on overall sow health. Several articles published by university extension services were identified, as were some non–peer-reviewed summaries of data from record databases, such as PigCHAMP,[d] but most of these did not meet the criteria set forth by the Task Force for inclusion in this review. Overall, it appears that both herd and individual health are affected more by daily management, pathogen exposure, geographic location, and biosecurity measures than by housing type.

Injuries—Peer-reviewed injury data are available, and in separate studies, Anil et al[83] and Gjein and Larssen[84] determined that injury rates were higher for sows housed in group pens than for sows housed in gestation stalls. In 2003, Anil et al[83] revealed that as sow weight increased, injury rate also increased in stall-housed sows but decreased in group-housed sows. Overall injury scores, however, were significantly higher in group-housed sows, compared with stall-housed sows. Gjein and Larssen[84] studied foot lesions in stall- versus group-housed sows. Sidewall cracks and heel lesions were the most common types of lesions found in both housing systems, but prevalence was significantly higher in loose-housed than confined sows.

Conclusions—Limited research conducted to date combined with industry experience indicates that, except for injuries, individual sow and herd health are primarily affected by factors other than housing system. Injury rate is lower for sows housed in gestation stalls, compared with sows housed in groups.

Production

Few peer-reviewed reports are available that provide a comprehensive comparison of sow housing systems with respect to production measures. In general, reports reviewed by the Task Force used gestation stalls as the point of reference for comparison to group housing. Gestation stalls included in related studies or reviews were either of a fixed size or were not described in sufficient detail so that the reader could determine whether stall size was varied to match sow size. The size of groups studied in group housing configurations varied, but the number of sows was always < 25. Feeding systems varied across group housing configurations. During their review of production effects, members of the Task Force considered estrus detection and weaning to estrus interval, farrowing rate, conception rate, and other production measures.

Estrus detection and weaning to estrus interval—England and Spurr[85] used rate of estrus detection to compare housing effects on production of sows and gilts when they were housed in groups of 8 to 12 or in stalls of fixed size. Estrus in multiparous sows was not affected by housing type, but there was an increase in the number of gilts exhibiting irregular estrus behavior in stalls. Gilts were less consistent in expression of estrus, compared with sows. Only gilts and sows exhibiting signs of estrus were placed with a boar, so failure to mate was associated with no signs of estrus.

Weaning to estrus interval was one of the more common measures compared in various housing systems. In one study,[86] multiparous sows were housed in individual gestation stalls of fixed size or in pens of 4 to 5 sows for a 2.5-year period. No postweaning housing effect on the weaning to estrus interval was observed.

Hemsworth[87] investigated the influence of housing system on the onset of estrus in weaned sows and found that the weaning to mating interval was decreased in sows in group housing, compared with those in individual housing, whereas farrowing rate was equivalent. There were significant interactions between housing system, farm, and weaning-to-estrus interval, indicating that management had an important effect on the weaning-to-estrus interval.

During a previous literature review[9] of housing effects on sow performance, a reduced weaning-to-estrus interval was identified for sows housed in stalls versus those housed in groups. Backus et al[52] found a decrease of 0.7 to 1.1 days in the weaning-to-estrus interval for sows housed in stalls versus those housed in groups.

Farrowing rate—Multivariate analysis was used in a retrospective epidemiologic study[88] of the 1992 through 1996 records of Finnish sow units to elucidate management factors by evaluating seasonal effects on rebreeding rate, farrowing rate, age of gilts at first mating, and litter size. The most significant variation in rebreeding rate was attributable to effects of season and year. Housing dry sows in groups increased the risk of rebreeding. Mean herd size for the Finnish herds was 39 sows.

Schmidt et al[86] reported a higher farrowing rate in sows housed in groups, compared with sows housed in stalls, when multiparous sows housed in different systems were studied over a 2.5-year period.

Results of a study[89] designed to determine the effects of feeding rate and type of housing (group or individual stalls) on farrowing rate revealed interactions between season and feeding rate after mating. In addition, housing sows individually after mating improved the farrowing rate significantly during the summer-autumn period.

Conception rate—Two research groups used conception rate to compare housing systems. Lynch et al[90] compared conception rates in group, tether, and stall housing and reported that group-housed sows had a much poorer performance attributable to a combination of failure to show estrus, lower conception ratio, and loss through injuries from fighting. England and Spurr[85] also used conception rate to compare housing effects on production of sows and gilts housed in groups of 8 to 12 versus in stalls of fixed size. Although gilts were less consistent in expression of estrus, compared with sows, of gilts mated, the percent conceiving did not differ significantly with respect to housing system.

Other production measures—In a previous review, McGlone et al[9] considered litter size, piglet birth weight, and weight gain in sows housed in stalls versus groups. Results of most studies evaluated indicated that whether sows were housed in stalls or in groups with electronic feeding had no effect on litter size. One paper reported an increase in the number of stillborn piglets in sows housed in groups with electronic feeding.

Group-housing systems that use electronic feeders have been found to be associated with reduced mean birth weight, compared with stall housing. No difference in total weight gain over the gestation period was identified in gilts housed in groups with electronic sow feeders versus those housed in stalls. However, increased individual variation in weight gain of gilts housed in groups with an electronic feeding system was observed.

Conclusions—In general, the peer-reviewed literature indicates that sows kept in stalls have equivalent production performance to sows kept in groups, with the exception of some group systems that use electronic sow feeders. Significant interactions among the effects of penning system, farm, and various production measures point to the importance of husbandry skills in ensuring sow welfare. Data from the literature support the hypothesis that there are differences in husbandry skills between farms and between caretakers that can affect production parameters equal to or more than type of housing.

Economics

In the United States, gestation stalls are the dominant housing system for pregnant sows. The industry has favored stalls over group housing because stalls increase caretaker productivity, require lower capital investment than group housing and associated automatic feeding systems, reduce sow aggression and injury, and are easier to manage than some indoor group housing systems. Recently, there has been public and scientific interest in moving toward group housing systems. Such a change comes with a price tag because some mechanism must be found to ensure that each sow in the group receives an adequate and individualized amount of feed. The required feeding systems increase construction, labor, and training costs. Legislative and regulatory mandates in some European Union countries have forced producers to move toward group housing. As a result, researchers in those countries have explored the economic consequences associated with these mandates.

In 1997, den Ouden et al[91] surveyed 7 Dutch experts on the likely technical and economic impacts of a wide range of animal welfare–motivated changes to their swine production system. Results of that survey indicate that a switch from the base system (stalls) to group housing would add 2.78 Dutch florins to the cost of each finished animal. These researchers also estimated that each slaughter-ready animal costs 357 Dutch florins to produce. This suggests that a switch to group housing would add 0.78% to the cost of each slaughter-ready animal.

The European Union Scientific Veterinary Committee also explored this issue in 1997[92] and determined that switching from stalls to group housing would cost an additional 2 eurocents/kg of finished product if producers were given < 10 years to comply or approximately 0.6 eurocents/kg of finished product if producers were permitted to replace existing stall housing as buildings needed to be replaced. If a production cost of 1 euro/kg is assumed, this translates to finished products costing 2% or 0.6% more, respectively.

In 2000, Turner[93] performed a meta-analysis of 5 European studies and calculated that a switch to group housing would add 1.5 eurocents/kg to pork production costs. This translates to a 1.5% increase in cost of production and is in agreement with results of other studies.

Authors of an analysis performed for the Danish National Committee for Pig Production in 2003 reported that sows housed in groups had, overall, 0.3 live pigs/litter fewer than those housed in stalls.[94] If we assume that each litter typically comprises 11 pigs, then 0.3 fewer pigs/litter translates into a 2.7% productivity loss. The authors of this study did not provide a total cost increase, but a 2.7% productivity loss likely increases total cost by more than the 0.6% to 2% increase in production cost previously reported and does not include construction or labor and training costs.

Summary and Recommendations

Given the number of variables and large variations in performance within both group and stall housing systems for pregnant sows, no one system is clearly better than others under all conditions and according to all criteria of animal welfare. The Task Force's review of the literature indicated the following with respect to physiology, behavior, health, and production:

- Physiology—Overall, gestation stalls do not induce a greater physiologic stress response in sows than do group housing systems.
- Behavior—Sows show different behavior when housed in gestation stalls, compared with some group pens, because of restricted movement, reduced caloric consumption, reduced opportunities to forage, absence of bedding, and restricted social interaction.
- Health—Rate of sow injury is reduced in gestation stall housing, compared with group housing. Industry experience indicates that other aspects of health are predominantly affected by factors other than housing system.
- Production—Sows kept in gestation stalls have production performance that does not differ from that of sows kept in groups.

It was also clear from the Task Force's review that housing systems cannot be considered in isolation from other important factors that influence animal welfare. These include the following:

- Management—Some housing systems can be expected to work well at one level of management but not at another.
- Feeding system—When concentrated diets are used, there is a need to limit feeding to avoid obesity-related health problems, but this can create chronic hunger, restlessness, motivation to forage, and competition for food. Systems that might work well with one feeding system may not work well with another.
- Environmental features—Certain environmental features allow sows to occupy their time and escape from aggressive group mates. How well a housing system functions may depend on whether such features are present.
- Type of sow—Important genetic differences in temperament exist between sows and affect how well sows function in different housing systems. There are also individual differences. A housing system that works well for more dominant animals may not be favorable for less dominant ones.

Effects on society must also be considered. Different sow housing systems have different impacts on environmental nutrient burden, food safety, and worker health and safety.

Considering all factors, all sow housing systems in current use have advantages and disadvantages for animal welfare. Current group systems allow freedom of movement and social interaction. However, these same systems, when they fail to work well, lead to problems, especially in the areas of aggression, injury, and uneven body condition. When they lack manipulable material, sows in group systems are also unable to forage. Current stall systems minimize aggression and injury, reduce competition, allow individual feeding, and assist in control of body condition. Stalls, however, also restrict movement, exercise, foraging behavior, and social interaction. Because the advantages and disadvantages of housing systems are qualitatively different, there is no simple or objective way to rank systems for overall welfare. There is no scientific way, for example, to say how much freedom of movement is equal to how much freedom from aggression or how many scratches are equal to how much frustration. In such cases, science can identify problems and find solutions but cannot calculate and compare overall welfare in very different systems.

Ideally, sow housing systems should do the following:

- Minimize aggression and competition among sows.
- Protect sows from detrimental effects associated with environmental extremes, particularly temperature extremes.
- Reduce exposure to hazards that result in injuries, pain, or disease.
- Provide every animal with daily access to appropriate amounts and types of food and water.
- Facilitate observation of individual sow appetite, respiratory rate, urination and defecation, and reproductive status by caretakers.
- Allow sows to express most normal patterns of behavior.

To address animal welfare in the long term, advantages of current housing systems should be retained while making improvements to overcome problems identified. Improvements should be adopted as soon as the technology is sound enough so that producers can adopt it with confidence, the skills needed to operate the systems are understood and available, and systems are economically viable.

Needs for Innovation and Research

Faced with uncertainty, it is a common response to call for further research before recommending action. In deciding whether to do this, Task Force members considered the role played by research and by industry innovation in shaping modern systems of swine housing.

Most major changes in swine housing systems during the past 50 years have resulted from industry innovation or commercial development, rather than independent scientific research. For example, farrowing crates were rapidly adopted as a form of housing during the 1950s and 1960s largely on the basis of industry innovation and experience. There was no substantial body of research that explored the effects of the crate before it was adopted. Rather, most research on farrowing crates was done later, mainly to compare farrowing crates with other options and to refine crate design. Similarly, gestation stalls, tethers, and electronic sow feeders were introduced by the industry and by equipment companies on the basis of their own developmental work. Most basic research comparing these with other systems began after the technology had come into commercial use. In fact, it is hard to find examples where major changes in sow housing arose from independent research. After the adoption of farrowing crates, substantial research was done for the purpose of developing alternatives. Despite favorable results in some cases, most options developed by researchers have had little commercial adoption.[95] Thus, sow housing appears to be an area where research generally follows, rather than leads to, major shifts in methods.

There is, of course, a role for research to fine-tune systems by identifying problems and finding ways to overcome them. Fine-tuning will be particularly important, given increasing concerns about animal welfare and the shortcomings identified in existing stall and group-housing systems for pregnant sows. As part of this approach, a better understanding of the mechanisms that create variation in sow welfare is needed and the physiologic underpinnings of behaviors that are used to assess welfare need to be more completely understood.

Given the historic relationship between research and industry innovation in sow housing, the Task Force believes it would be inappropriate to simply call for more research. The immediate need is for industry to advance housing and management practices in ways that will improve the welfare of sows while providing producers with practical and reliable methods.

a. "Sows" also refers to gilts unless otherwise indicated.
b. "Gestation stalls" are understood to be synonymous with gestation crates and distinct from farrowing crates.
c. Jensen P. *Confinement and continuous noise as environmental factors affecting communication in the domestic pig*. PhD thesis, Department of Animal Hygiene, Swedish University of Agricultural Sciences, Skara, 1983.
d. PigCHAMP Inc, Saint Paul, Minn.

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